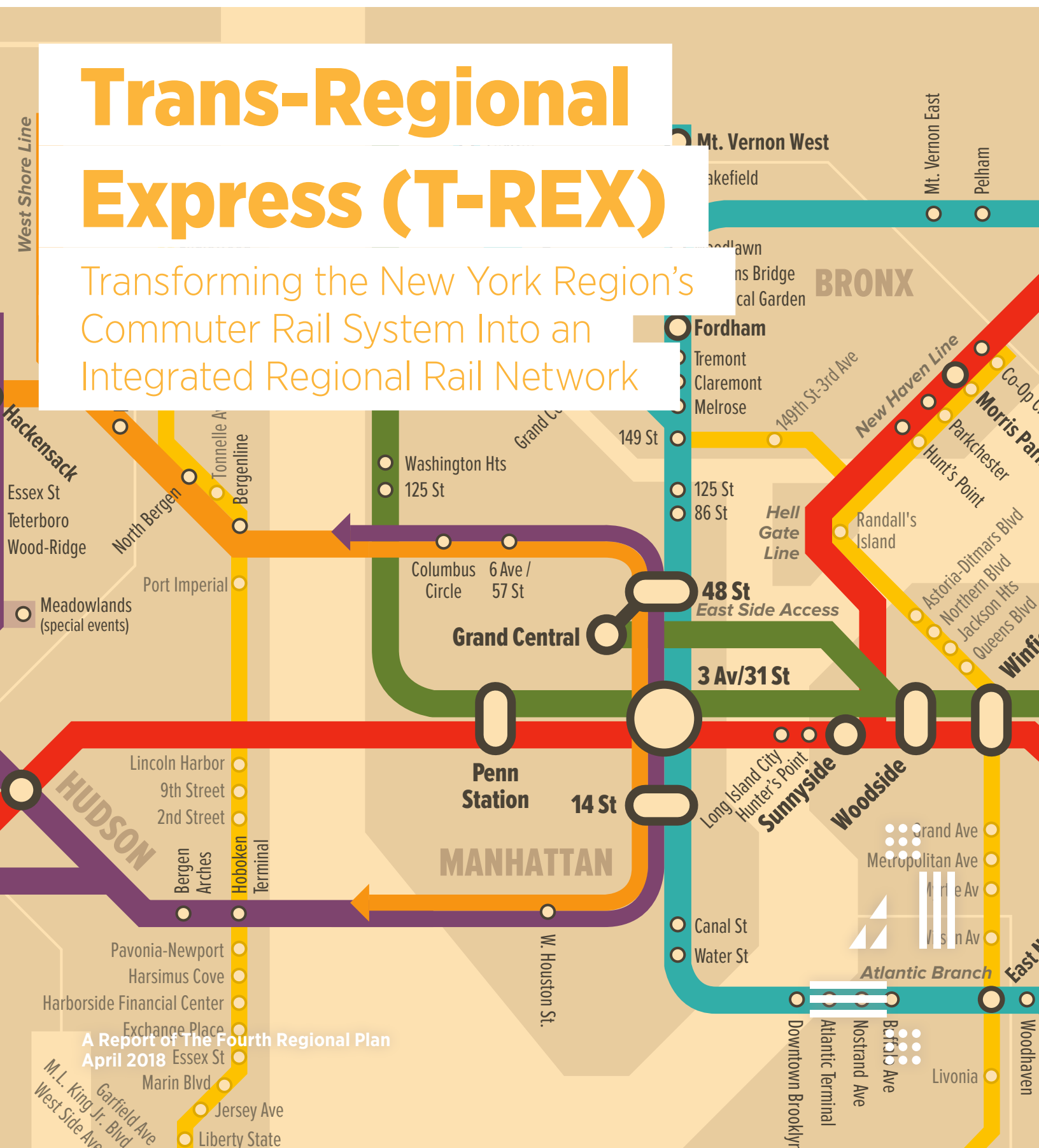




Regional Plan Association

Trans-Regional Express (T-REX)

Transforming the New York Region's
Commuter Rail System Into an
Integrated Regional Rail Network



A Report of The Fourth Regional Plan
April 2018

Acknowledgments

This report highlights key recommendations from RPA's Fourth Regional Plan for the New York-New Jersey-Connecticut metropolitan area.

View the full plan at fourthplan.org.

The Fourth Regional Plan has been made possible by

Major support from

The Ford Foundation

The JPB Foundation

The Robert Wood Johnson Foundation

The Rockefeller Foundation

Grants and donations from

Albert W. & Katharine E. Merck Charitable Fund

Anonymous

Fairfield County Community Foundation

Fund for the Environment and Urban Life/Oram Foundation

JM Kaplan Fund

Lincoln Institute of Land Policy

New York Community Trust

Rauch Foundation

Siemens

And additional support from

Rohit Aggarwala

Peter Bienstock

Brooklyn Greenway Initiative

Doris Duke Charitable Foundation

Emigrant Bank

Friends of Hudson River Park

Fund for New Jersey

Garfield Foundation

Greater Jamaica

Development Corporation

Town of Hackettstown

Laurance S. Rockefeller Fund

Leen Foundation

Lily Auchincloss Foundation

National Park Service

New Jersey Board of Public Utilities

New Jersey Highlands Council

New Jersey Institute of Technology

New York State Energy Research and Development Authority (NYSERDA)

Open Space Institute

PlaceWorks

Ralph E. Ogden Foundation

Robert Sterling Clark Foundation

Rutgers University

Shawangunk Valley

Conservancy

Stavros Niarchos Foundation

Suffolk County

Two Trees Foundation

Upper Manhattan Empowerment Zone

Volvo Research and Education Foundations
World Bank

We thank all our donors for their generous support of our work.

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Executive Summary

The New York-New Jersey-Connecticut region has an opportunity to support sustainable and equitable economic growth for future generations by building on a unique asset—the region’s extensive commuter rail network. This network, if optimized, can boost job and population growth both in the region’s core and in major centers throughout the region that have both the capacity and need for growth. Unfortunately, the commuter rail network we have today is aging, and not configured to adequately meet the evolving needs of the region’s residents. Today’s network leaves many parts of the region poorly served or without rail service at all. The system wasn’t designed to serve today’s travel patterns and has little capacity for future growth. Without a new design, substantial upgrades and governance changes, New York will fall farther behind the metropolitan areas that are investing in fully integrated metro systems, and fail to capitalize on this region’s global economic strengths.

This report, part of Regional Plan Association’s Fourth Regional Plan, describes how a strategic set of investments, phased over the next few decades, can combine the Long Island Railroad, Metro-North Railroad and New Jersey Transit into a unified system that vastly improves mobility throughout the region. It would address immediate priorities, including creating through service at Penn Station and relieving congestion across the Hudson River, while incrementally expanding the network and creating a modern regional rail system that could serve the tri-state area for a century or more. The resulting system, which we call Trans-Regional Express (T-REX), would provide frequent, consistent service, directly connect New Jersey, Long Island, the Mid-Hudson and Connecticut, and allow the region’s economy to continue growing.

The region has outgrown its commuter rail network.

The region’s three commuter railroads share an amalgamation of rail lines built largely by private railroads more than 100 years ago. This aging system was designed to get people in and out of Manhattan when the metropolitan area was less than half the size it is today. It poorly serves job centers outside of Manhattan, leaves many places without any rail service at all, isn’t configured to serve today’s 24-hour, multi-directional travel patterns, and is straining to serve the number of riders it has today, much less tomorrow. More specifically:

- ▶ Many assets—from stations and signals to tracks and interlockings—are well past their useful life or don’t meet modern standards.
- ▶ All service stubs end in Manhattan, preventing trains from traveling through from one part of the region to the other, and reducing the capacity of the system overall.
- ▶ While ridership is growing the fastest outside of morning and afternoon rush hours, service continues to be infrequent on most lines during those times.
- ▶ Reverse service into many job centers with strong growth potential, such as Bridgeport or Hicksville, is poor—and limits the ability of those downtowns to grow into major economic hubs. Some large downtowns such as Paterson have no direct service at all.
- ▶ Many residential areas with densities to support commuter rail service don’t have it, including much of Bergen, Passaic, and Monmouth counties.
- ▶ Service is too infrequent and/or too expensive for many residents in the Bronx, Brooklyn, Queens, Hudson, and Essex counties.



Paterson

Imagine a recent high school graduate living in Paterson, New Jersey, looking for work, and not owning a car.

Today it would take him on average 72 minutes to reach a job near midtown Manhattan, putting many of the job opportunities in this region out of reach. In fact, today there are about 65,900 jobs within a reasonable commute (30 minutes of Paterson). T-REX would reduce this travel time to 34 minutes, expanding this high school graduate's pool of job opportunities nearly threefold.

Imagine a single, corporate marketing director who lives in North Bergen.

With a lower cost of living and higher salary, she chooses to commute and works right across the Hudson River for a major company in Manhattan.

Currently, her commute into New York City, by bus and then subway to Midtown East, is on average 50 minutes. Annually, that's a cost of \$6,120 - which seems completely overpriced for a commute that is close to an hour.

With the T-REX, her commute would become 9 minutes, shaving off 41 minutes. Additionally, traveling to the new Midtown East station at 48th Street from North Bergen would take 11 minutes instead of the current 50 minutes. The cost would be significantly lower, given the costs for the specific travel zone.

T-REX Will Help Regional Residents Save Time, Money

The Bronx

Williams Bridge

Imagine a medical assistant living in Gun Hill Houses in the Bronx working in the Financial District.

She currently has three transit options: the subway, the bus, or Metro North. Each has its trade-offs.

The bus and subway are the cheapest, at \$1452 annually, but the bus would take an hour and half each way (assuming normal traffic) and the subway would take nearly an hour each way. Metro-North costs almost a third more, at \$2,496 (assuming she can afford a monthly Metro-North pass on top of other commuting expenses), but reduces her travel time to around 28 minutes, saving her an hour a day.

With the T-REX, this person would get to Lower Manhattan in half the time, around the same price as she would pay to take the subway into Manhattan.

Midtown West

34 min

from 72

48th St/3rd Ave/GCT

Midtown East

11 min

from 50

Lower Manhattan

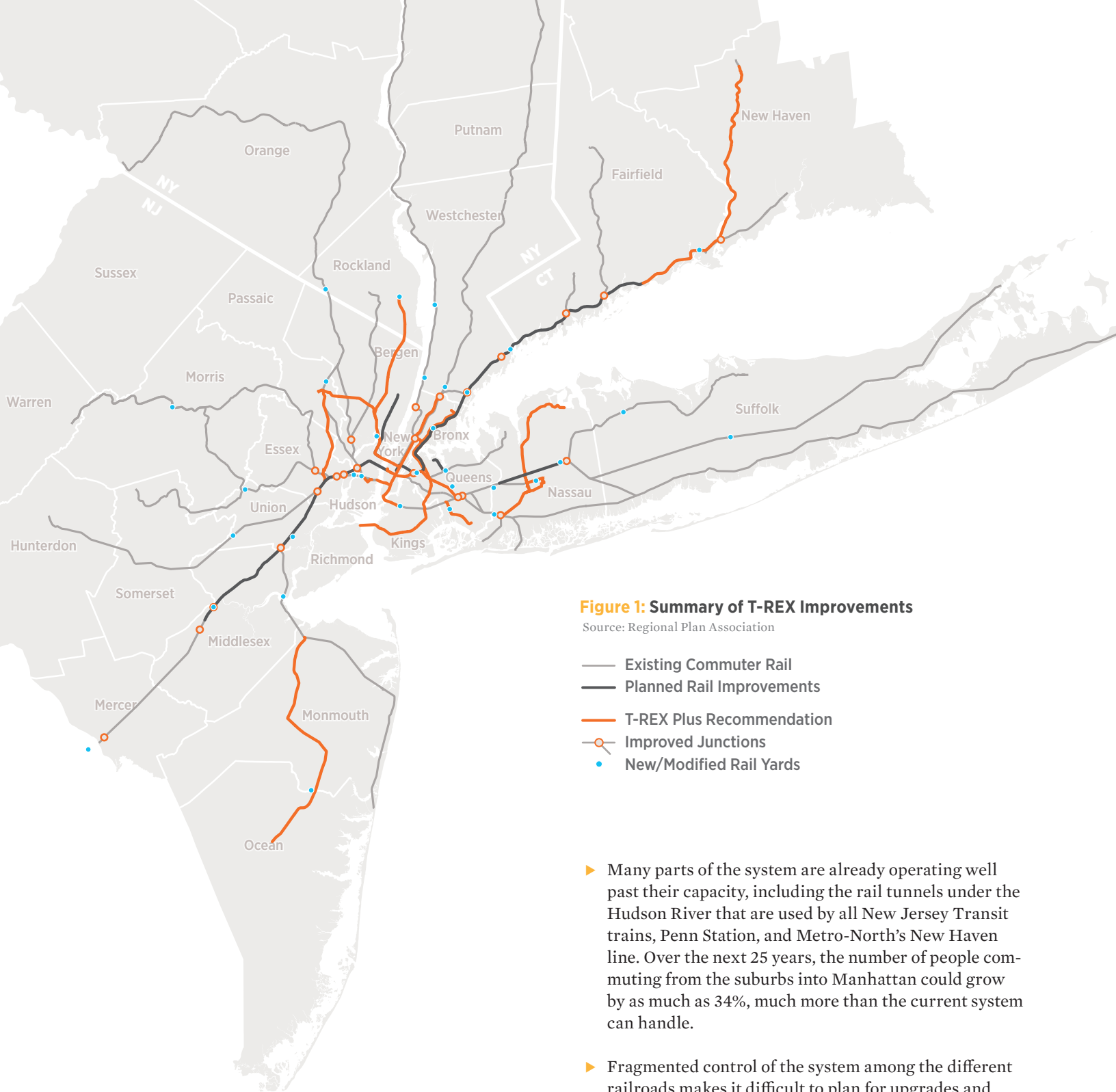
28 min

from 65

Columbus Circle


North Bergen

Water St



- ▶ Many parts of the system are already operating well past their capacity, including the rail tunnels under the Hudson River that are used by all New Jersey Transit trains, Penn Station, and Metro-North's New Haven line. Over the next 25 years, the number of people commuting from the suburbs into Manhattan could grow by as much as 34%, much more than the current system can handle.
- ▶ Fragmented control of the system among the different railroads makes it difficult to plan for upgrades and repairs or provide holistic, integrated service.

Many of New York City's peers, such as Paris and London, have transformed their traditional commuter rail systems to run more like urban metro systems. With more frequent and convenient service to, in, and through the city centers, those systems have increased businesses' access to a large and varied labor pool. They have also given residents access to more jobs and more housing choices.



The region's three commuter lines should be converted in phases into a unified system with increased capacity, expanded options, and reduced travel times.

The region must modernize, integrate, and expand its commuter rail network to keep up with a growing region, as well as changing technology and service demands. Unifying the network into a Trans-Regional Express service will require major infrastructure upgrades to integrate and expand its different components. Some actions, like building additional tunnels under the Hudson and creating a more functional Penn Station, address urgent needs and should begin immediately. Others will take a decade or more to be planned and approved. But all improvements should be designed as part of a comprehensive vision to allow future projects to rationalize and synchronize service as they expand capacity.

Based on an analysis of existing deficiencies, future demand, and the need for additional capacity, a fully integrated regional rail system could be built in three phases.

Phase One, The Crosstown Line: Creating Through-Running Service from New Jersey to Long Island

The Crosstown line builds on Amtrak's Gateway plans to build new rail tunnels under the Hudson River and expand Penn Station. It also builds on the infrastructure needed to achieve the Federal Railroad Administration's vision for intercity and regional rail service in the Northeast Corridor. RPA's Fourth Regional Plan proposes those tunnels and tracks be extended to build new tunnels under the East River to provide a new Crosstown service between New Jersey and Long Island. Instead of a terminal, Amtrak's proposed Penn South would become a through-running station with two tubes extending east to Queens. A new station on 31st Street and Third Avenue would provide suburban commuters access to southeast Midtown. The Crosstown line will address the immediate crisis of declining service across the Hudson while creating a range of new benefits:

- ▶ It would provide capacity for six to nine more trains per hour from New Jersey than the Gateway project as it is currently planned, and result in a total of 30 to 33 more trains from both New Jersey and Long Island into Penn Station.

- ▶ New Jersey Transit riders would have direct service to Manhattan's East Side, and Long Island Rail Road riders would have a second East Side destination, in addition to the Grand Central LIRR station currently under construction.
- ▶ The additional capacity could allow old rail lines to be reactivated, and large parts of Monmouth, Ocean, and Middlesex counties could gain direct rail access into Manhattan.¹
- ▶ New Jersey commuters would be able to go directly to Jamaica to board the JFK AirTrain, and LIRR riders could travel directly to the rail stop for Newark Airport.
- ▶ The additional East River tunnels would provide greater resiliency in case of flooding, terrorism, or other disruptions.
- ▶ The Crosstown Line would provide direct service from New Jersey to Queens and Long Island employment centers, and it would provide direct service from Long Island, East Bronx and Westchester to New Jersey employment centers.

Phase Two: New Trans-Hudson and East Side Service

Before 2040, it is expected that the Gateway/Crosstown tunnels will also be at capacity. And even though 2040 sounds like a long way off, planning and building infrastructure of this scale can take decades, so planning should start immediately for the next set of trans-Hudson tunnels. Additional rail tunnels from Union City, NJ, to 57th Street in Midtown would provide the next trans-Hudson capacity expansion after Crosstown reaches full capacity. New tunnels at 57th Street would also allow for the restoration of passenger service on the West Shore line, a portion of the Northern Branch line, and the Susquehanna lines in Bergen, Passaic, and Rockland counties. These areas are almost exclusively served by express buses today. The completion of this portion of the system would help reduce the demand for express buses which, along with bus intercept facilities along the T-REX in New Jersey, could enable the Port Authority to replace its current bus terminal with a smaller Manhattan facility or eventually eliminate it entirely.

Beyond providing new rail service to many New Jersey communities, this second phase of the proposed regional rail network would provide a new north-south transit service on the East Side of Manhattan from 57th Street, running south under Third Avenue, and making four to five stops to Lower Manhattan, a corridor that currently is only served by the Lexington Avenue Subway. This service could obviate the need to construct the lower portions of the Second Avenue Subway. This "Manhattan Spine" would have an easy transfer to the Crosstown line via a new hub

¹ This improvement could also take place as part of phase two.

station located at 31st St and Third Ave, allowing a seamless transfer between the Crosstown and the new service that would run along 57th Street and down Third Avenue.

The Manhattan Spine would continue to run downtown, stopping at Fulton and Water Street, and then into Downtown Brooklyn, where a transfer would be available to the Long Island Rail Road at Atlantic Terminal. This portion of the line would provide robust and speedy rail transit service to parts of outer Brooklyn and southeastern Queens, which currently have limited transit options. A short extension to JFK Airport would also be made using part of the existing Rockaway Beach Branch line, south of the Atlantic Branch, along with the construction of a short new segment with two new stations at the airport.

These investments would result in benefits that would reverberate throughout the region:

- ▶ They would provide transit capacity to support the continued expansion of the region's economy.
- ▶ Service would be vastly improved with much shorter travel times for residents of Bergen, Passaic, and Rockland counties.
- ▶ Crowding would be reduced at Penn Station.
- ▶ They should eliminate or defer the need to build a large bus terminal in Manhattan.
- ▶ They could potentially eliminate or defer the need for building the lower portions of the Second Avenue Subway.
- ▶ Direct service would connect New Jersey, Manhattan, Brooklyn, Queens, and JFK Airport.

Phase Three: Completing a Fully Interconnected Regional Rail Network.

The final phase of constructing the regional rail system would entail completing the uptown portion of the Manhattan Spine to connect to the Bronx, Westchester, the Hudson Valley, and Connecticut, and the lower trans-Hudson tunnels that would complete a "Jersey Loop" that connects to service in the north to Hudson County.

The uptown portion of the Spine would provide relief for Metro-North's Park Ave Tunnel, which currently runs at capacity. The completion of Penn Access, a project to add tracks and stations on the Hell Gate line so that Metro-North Railroad's New Haven line trains can directly access Penn Station, should reduce stress on the Park Avenue Tunnel, buying some time for Metro-North. But the project will not ultimately divert any riders bound for the East Side. The uptown portion of the Manhattan Spine, however, would provide relief, paralleling the Park Ave Tunnel along Third Avenue, providing a new express track through the Bronx from Mott Haven to Woodlawn, and seamlessly connecting the Mid-Hudson and Connecticut into the new regional rail system.

The lower leg of the Jersey Loop would provide a third new set of trans-Hudson tunnels, reducing future congestion, improving access to Hudson County, creating opportunities for more direct travel within the region, and providing additional redundancy. The construction of this new tunnel could also serve as a replacement for the Uptown PATH, which has tunnels over a century old, small stations, inefficient junctions, and a terminal at Hoboken that limits capacity and performance and is costly to maintain. On the New Jersey side of the Hudson River, the tunnels would lead to a station at Hoboken/Newport and a new station in Jersey City Heights via the Bergen Arches, eventually connecting into the existing NJ Transit system.

This expansion would allow for the complete unification of the regional rail network with the following improvements:

- ▶ For Metro-North riders, it would create less crowding, improved reliability, and more service.
- ▶ It would provide direct access through Manhattan from Westchester, the Mid-Hudson, and Connecticut, to New Jersey, Long Island, and Lower Manhattan.
- ▶ Bronx residents would have much improved transit service in the Third Avenue corridor, which has very poor service today.
- ▶ There would be direct access to JFK Airport from the Bronx, Westchester, Mid-Hudson, and Connecticut.
- ▶ There would be expanded service for residents of Hudson County and reduced crowding for New Jersey Transit riders at Penn Station.
- ▶ It would eliminate the need to replace the PATH Uptown line.
- ▶ It could defer the need to extend NYC subways or rebuild PATH in-kind across the Hudson River.
- ▶ It would allow bus service to be enhanced in areas and markets that rail cannot reach and that are best served by bus (i.e. portions of Hudson County).
- ▶ There would be a modal shift from bus to regional rail and subway to regional rail to accommodate future growth and relieve overcrowding on the bus and subway networks.

Use the new system to provide frequent service in all directions.

The physical connections described above would allow for transformative improvements to rail service. Instead of long wait times, passengers in the Bronx, Queens, Hudson, Westchester, and Nassau counties would have access to more subway-like frequencies — in both directions. Passengers in Bergen, Passaic, Monmouth, Hudson and Essex counties would have access to the rail network with consistent service. Finally, a trans-regional limited express

service would offer faster speeds, lower fares and more direct service between major hubs—from New Haven to Trenton, and from Poughkeepsie to Ronkonkoma.

All of these services would be overlaid in a Trans-Regional Express (T-REX) system that combines the territories of all three commuter railroads, and complements and connects to the New York City subways and PATH.

In much of the region there would be a consistent level of service: every 15 minutes throughout the day and every 10 minutes during the traditional peak periods. Such a schedule would reduce the physical stress placed on the system and make it a viable transit option throughout the day, not just during the peaks.

The system could be constructed and managed by combining the existing railroads into one operating agency, or by creating a regional coordinating entity that would be responsible for coordinating schedules, fares, and operations among the three railroads. The service could be operated by the public sector or by private concessions, similar to the London Overground.

While creation of the T-REX system would be one of the largest public works projects undertaken since the early 20th century, its wide-ranging and lasting benefits would far exceed the costs.

The regional rail network would dramatically increase rail capacity across the Hudson River and provide additional layers of redundancy for the region's transit system. It would bring rail service to currently unserved areas of New Jersey and greatly expand service for Connecticut, Long Island and the Mid-Hudson. It would improve the region's rail service by standardizing fares, headways, service routings, rolling stock, and transfer arrangements to create a coherent and integrated system. The three new core trunk lines would operate with a frequency of up to 2.5 minutes in the peak and 5 minutes in the off-peak, providing service similar to Manhattan subway lines. Travel times would be reduced from well over an hour to less than half an hour for many commuters, and traveling would be far more predictable. The system as a whole would be significantly more

resilient with multiple options for rerouting service or taking alternative routes. As a result, the region would be able to attract and sustainably accommodate far more economic growth. Economic opportunity would expand as many residents who can't reach or afford rail service today would be able to use it on a regular basis.

The dramatic improvement in regional accessibility and ease of travel that would result from the development of a regional rail network would lead to a large array of benefits. The value of the time that people would save from shorter travel times alone is conservatively estimated at \$3.4 billion per year. In addition to the value of time savings, improved productivity would expand the region's economy as workers have access to far more job opportunities and employers have access to a much larger labor pool. For example, a resident of Paterson, NJ would be able to reach 2.9 million jobs in just over 30 minutes with the proposed rail network, a ten-fold increase from the number of jobs that can be reached by transit today. Both existing and new residents of the region would have a many more choices for where they can live with a reasonable commute, increasing the region's attractiveness and competitiveness.

In addition to the economic, resilience and equity benefits, the region would be a healthier place to live. By shifting an estimated 400,000 trips from road to rail, it would improve health by reducing air pollution and making it easier to walk or bike. It would also be more accessible to people with a range of physical abilities.

To make the costs of these improvements feasible, reforms to bring down project costs such as those proposed in RPA's *Building Rail Transit Projects Better for Less* will be needed. Without these reforms, the cost of the proposed rail improvements are conservatively estimated at \$71.4 billion, or \$2.4 billion per year if constructed in 30 years, still a worthwhile investment but one that would be difficult to finance.² However, implementing this regional rail program does provide opportunities for savings from economies of scale and standardized construction practices, and by obviating the need for other projects. For example, the regional rail system would make it possible to build a smaller PABT than currently planned and could obviate the need for the southern portion of SAS, saving tens of billions of dollars. The sources of revenue would need to include substantial federal revenue, as well as dedicated revenue from new sources, such as mileage-based fees for automobile and truck travel or carbon pricing as proposed in the Fourth Regional Plan.

² The estimate does not reflect total rail capital needs over the next 30 years, as the estimate excludes Gateway, NEC FUTURE elements, and basic infrastructure renewal (state of good repair).

Introduction

The region's commuter rail system is an amalgamation of the various private railroads that were laid down over one hundred years ago. Much of this infrastructure was taken over decades later by the public sector when the private companies became insolvent in the 1960-1970's due to competition from automobiles and air travel. The public commuter rail system that exists today is comprised mostly of this legacy infrastructure, from its antiquated signals to the aging bridges — some over 100 years old. This out-moded rail system struggles to carry hundreds of thousands of commuters on a daily basis. It has a critical role in connecting the region's central business district (CBD) to the hundreds of residential communities throughout the metropolitan area in New Jersey, Long Island, Connecticut and the Lower Hudson Valley. With a combined 390 stations³ and over 2,000 miles of track, it is the nation's largest and farthest reaching commuter rail network. The system consists of three separate railroads — the Long Island Railroad, Metro-North Railroad and New Jersey Transit Rail — organized along geographic and state administrative boundaries.

The system is oriented to predominately serve peak-direction commuters to termini in the CBD. In order to meet the extraordinary needs of the rush hour, the service is highly customized toward maximizing the number of people and trains that operate in the peak 60 minutes in the peak direction of travel, sacrificing regularity, flexibility and the ability to offer better service in the shoulders of the peak period and in the reverse-peak direction. Off-peak, reverse and weekend service is infrequent and most riders need to rely on a timetable — even for peak service.

The extreme focus on the peak makes our commuter railroads ill-equipped to handle the increasing diversity of travel patterns associated with non-traditional work hours, multi-worker households and car-free lifestyles. This is in contrast to many of New York's peer cities, such as Paris and London, which are moving towards creating rationalized systems that run in from the suburbs, through the core, and back out again. While in the core, these systems tend to function like metros, operating at regular intervals and providing needed capacity for the city's transit system while offering multiple egress points for those riding in

from the suburbs. These through-running regional rail lines also open up new commuting patterns for suburban and city residents by running through the city instead of terminating in its center.

This report of the Fourth Regional Plan (4RP) first surveys the railroads — their infrastructure, policies and organization. It then describes a vision for a regional rail network and service. Finally, it recommends the investments, physical interventions and policies that will be needed to serve the residents of the region, identifying what must be replaced, upgraded, and/or constructed to ensure a reliable regional rail system with the capacity to serve anticipated growth to 2040 and beyond.

These recommendations have been developed to include currently planned projects such as the new Trans-Hudson tunnels (Gateway) and Metro-North Penn Access, leveraging these investments to provide even greater benefits than they would on their own. They also build upon RPA's prior regional plans, such the 1996 plan for the Regional Express system, and research completed as part of its more recent *Transit Leadership Summit* — a four year effort to collect “best practices” from seventeen peer cities. RPA also was the client and participated in a 2015 University of Pennsylvania Planning Studio that proposed a through-running “CrossRail” service for the New York-New Jersey metropolitan area.

³ This excludes the NJT Atlantic City line, which is not part of the regional rail network.

Survey and Evaluation of Existing and Planned Infrastructure

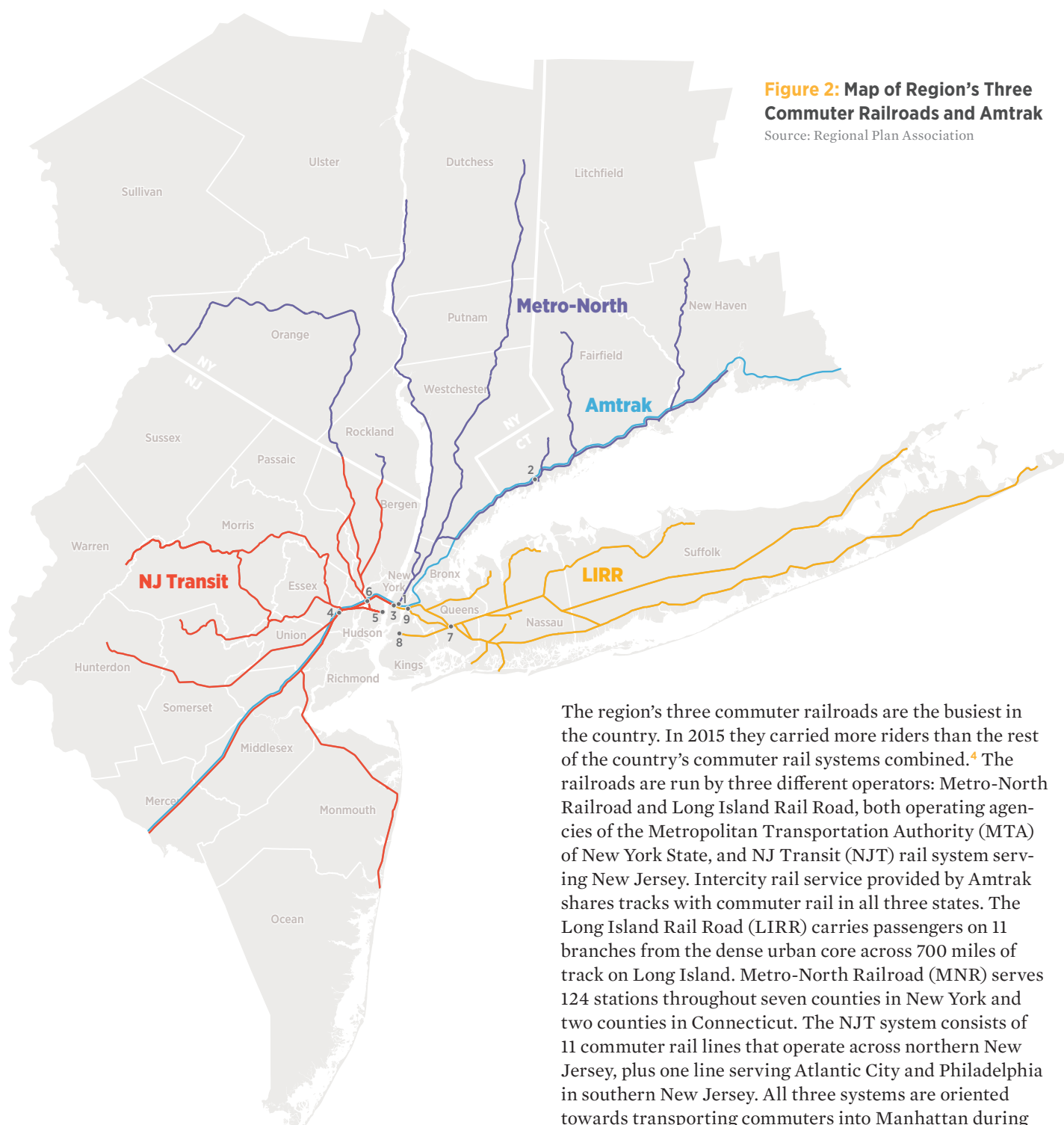


Figure 2: Map of Region's Three Commuter Railroads and Amtrak
Source: Regional Plan Association

The region's three commuter railroads are the busiest in the country. In 2015 they carried more riders than the rest of the country's commuter rail systems combined.⁴ The railroads are run by three different operators: Metro-North Railroad and Long Island Rail Road, both operating agencies of the Metropolitan Transportation Authority (MTA) of New York State, and NJ Transit (NJT) rail system serving New Jersey. Intercity rail service provided by Amtrak shares tracks with commuter rail in all three states. The Long Island Rail Road (LIRR) carries passengers on 11 branches from the dense urban core across 700 miles of track on Long Island. Metro-North Railroad (MNR) serves 124 stations throughout seven counties in New York and two counties in Connecticut. The NJT system consists of 11 commuter rail lines that operate across northern New Jersey, plus one line serving Atlantic City and Philadelphia in southern New Jersey. All three systems are oriented towards transporting commuters into Manhattan during the weekday morning peak and back out during the evening

⁴ "Public Transportation Ridership Report." APTA, March 02, 2016. <http://www.apta.com/resources/statistics/Documents/Ridership/2015-q4-ridership-APTA.pdf>.

Table 1: Profile of the Region's Three Commuter Railroads

	New Jersey Transit	Metro North	Long Island Railroad
Track Mileage	660**	787	700+
Number of Stations (owned)	142	124	123
Percent Accessible Stations*	43%	64%	84%
Annual Ridership (Millions)	89.2	86.5	89.3
Electrification Type	12 kV 25 Hz and 25 kv 25 Hz Catenary	700V DC Third Rail. Top Contact, 12.5 kV 60 Hz Catenary	750 V DC Third Rail, Bottom Contact
Percent Electrified	41%	55%	47%
# of Lines and Branches	11***	7	12
# Lines with Direct Service to Manhattan	6	6	12

*Accessible stations offer autonomy for individuals with mobility impairments, but may not comply with requirements for visual and hearing impairments.

**544.4 track miles without Amtrak owned and operated NEC.

***Princeton branch included in NEC. Includes Meadowlands Rail Line.

Source: RPA Analysis

peak. Each railroad contains a unique mix of infrastructure on which it relies to provide service, which are summarized in this section.

Terminals, Major Stations and Intermodal Hubs

Of all the pieces of infrastructure that make up the region's rail system, perhaps none are more visible to the general riding public than its stations and terminals. There are 390 stations in the region's rail system with the majority of them intended to provide rail service from residential communities in suburban areas to central employment locations, particularly the Manhattan central business district. Among them, there are a handful of stations that are critical to the functionality of the network. These generally are larger terminals, stations where multiple lines terminate, and major hub stations, which serve multiple lines and connect riders to other modes. The following section details the most critical rail facilities in the region, each of which is facing its own set of challenges.

1. Grand Central Terminal

Grand Central Terminal (GCT) is the crown jewel of the Metro-North system and has existed in its current form since 1913. GCT is located on a superblock in Manhattan's east midtown and is situated between Lexington and Vanderbilt Avenues and from 42nd to 45th Street. The terminal was the largest rail facility in the world at the time of its construction and still has the most train platforms of any terminal world-wide.⁵ The terminal has direct connections to five subway lines, with a total of five services..

⁵ Roberts, Sam. "The Birth of Grand Central Terminal." *The New York Times*, January 18, 2013. <http://www.nytimes.com/2013/01/20/nyregion/the-birth-of-grand-central-terminal-100-years-later.html?pagewanted=all>.

GCT was originally designed for intercity and commuter rail services, its upper level designated for long-distance trains and lower level for commuters. Long distance service ended in 1991 when Amtrak moved all of its operations to Penn Station after the Empire Connection — a new rail tunnel from Penn Station to the West Side Railroad — was constructed. Today, all 44 platforms are used by commuters on the Metro-North Railroad, which signed a long-term lease for GCT that terminates in 2274. The MTA has spent over \$77 million to renovate the terminal. In 2015 the terminal saw over 200,000 daily passengers make use of the hundreds of trains that operate to and from it.⁶ This level of service is beginning to strain the capacity of the Park Avenue Tunnel, which is the four-track mainline that feeds all Metro-North traffic into GCT.⁷ Currently, three of the tunnel's four tracks are operated in the peak direction during the morning and evening commutes while the fourth provides reverse service. East Side Access, a project to construct a new terminal for the Long Island Rail Road one hundred feet beneath GCT is scheduled for completion in 2022 and will add to the number of commuters who circulate through the existing terminal complex.

2. Stamford Transportation Center

The Stamford Transportation Center is the busiest Metro-North station other than Grand Central Terminal. It abuts I-95 in Stamford, Connecticut, about an hour train ride from Grand Central and provides connections between Metro-North, Amtrak's Northeast Corridor services, limited Shore Line East commuter rail service, and local and inter-city bus lines. Unlike other smaller stations on the New Haven Line, the station sees a very high level of reverse commuters thanks to its location on the southern border of downtown Stamford, which provides easy access to many of the office facilities located there. In fact, of the

⁶ MTA, 2015.

⁷ "Getting Back on Track." (Regional Plan Association, January 2014), p.22. <http://library.rpa.org/pdf/RPA-Getting-Back-on-Track.pdf>.

station's 14,610 average weekday boardings in 2015, a full 5,350, or 37%, were in reverse direction. This rate is in stark contrast to the rest of the New Haven Line where the vast majority of stations see between 5-10% of their boardings in the reverse direction.⁸ The Stamford rail station is very generic in its design and undersized relative to the large number of commuters that rely on it daily. It bridges two major parts of the city that is separated by the expressway and remains a major redevelopment opportunity that could include an existing structure parking facility that is slated to be demolished and replaced due to its poor condition.

3. New York Penn Station

At the street-level, the original Beaux-Arts Penn Station, constructed in 1910, was similar to the scale and grandeur of GCT. However, in the mid-1960's the magnificent station with its soaring waiting room and train shed, sitting on the superblock between Seventh and Eighth Avenue and 31st to 33rd Streets, was replaced with Madison Square Garden and several office buildings at the surface. The entire station was scaled back and placed completely underground, with only the platforms and tracks essentially unchanged— no longer receiving any natural light or air. The station was originally designed by the Pennsylvania Railroad as its premier intercity terminal and this is reflected in the configuration of its platforms, which except for one platform all are narrow.⁹ Today, it serves as the major New York City terminus for the New Jersey and the Long Island commuter railroads and for through services operated by Amtrak, the intercity carrier.

The station is undersized for the demands placed on it today. It is at capacity and has insufficient vertical and horizontal circulation elements to serve the over 400,000 people that pass through Penn Station and adjacent subway stations each day.¹⁰ Its concourse and platforms are undersized, since it was originally designed for intercity service and not for the heavy commuter flows making it hard for riders to reach the station's six subway lines. Additionally, the tunnels leading into the station from New Jersey and Queens operate at full capacity during peak periods, placing a hard limit on the number of trains that can make use of the station. There are currently efforts underway to help remedy these constraints, most notably Amtrak's Gateway project, which would construct two new tunnels under the Hudson River and expand Penn Station, adding more tracks and platforms. There have also been proposals to reconfigure Penn Station's concourse and open the station up once again to light and air by relocating the Madison Square Garden complex and redeveloping buildings at the street-level.

⁸ Mount Vernon East actually sees 39% of its boardings in the reverse direction but only had 2,749 boardings each week day in 2015.

⁹ The wide platform (between tracks #18 and #19) was constructed to support a shuttle service between the new station and Jamaica station for its subsidiary Long Island Railroad.

¹⁰ "Trends & Opportunities: How Changes in Ridership, Population, and Employment Should Guide Future Metropolitan Transit Planning." Real Transit, July 2013. <http://www.realttransit.org/trendsandopportunities2013.pdf>.

4. Newark Penn Station

Newark Penn Station is New Jersey's busiest inter-modal facility as defined by daily rail boardings. It serves Amtrak and New Jersey Transit trains, and connects to the Newark Subway, PATH, and multiple local, regional, and inter-city bus services.¹¹ One of its primary uses is as a transfer point for commuters to PATH from NJT rail lines in central New Jersey to reach work destinations in lower Manhattan. Much of the station has been refurbished and even improved, such as its modern air conditioned bus waiting areas. However, the capacity of the station is restricted by the tracks leading from the North River Tunnel portal in North Bergen to Newark. Currently, only two tracks connect the tunnels to Newark, although the Highline project (a component of the Gateway program) plans to increase this number to four. Additionally, the bridges carrying these tracks are old and cause numerous delays. The most glaring of these is the Portal Bridge, which carries over 150,000 people each day and has been called the "Achilles Heel of the Northeast Corridor" due to its propensity to cause delays when opened for boat traffic.^{12,13} Opportunities abound to further improve Newark Penn Station. One such proposal would create a new southern entrance from the platforms, using the abandoned New Jersey Central right-of-way that runs above the NEC, to provide better access to Prudential Center, a sports arena, and further open up access to several major redevelopment areas in downtown Newark near the station.

5. Hoboken Terminal

Hoboken Terminal is New Jersey's third busiest rail station, with over 16,000 boardings per day in 2015, and serves almost all of NJT's rail lines, a Metro-North rail line (Port Jervis), the Hudson-Bergen Light Rail, PATH, local ferries, and local bus services. One of its primary uses is a transfer point for commuters to PATH and ferries from NJT (and western MNR) rail lines in northern New Jersey to reach their destinations in Manhattan. The terminal also encompasses an adjacent storage yard used by NJT. The location of the yard and terminal, while useful operationally, renders both of them susceptible to sea level rise because of their proximity adjacent to the Hudson River; a vulnerability that was clearly demonstrated when the facility was inundated during Hurricane Sandy in 2013. There have been many proposals made over the years to take advantage of the air-rights over the terminal and its yards through an overbuild redevelopment. However, the vulnerability of the facility to storm surge and sea-level rise has shifted the focus to creating a more resilient terminal for the 21st Century. NJT is currently exploring various options to protect the existing terminal and improve the resiliency of the railroad.

¹¹ NJT, 2015.

¹² Porter, David. "New Jersey's Portal Bridge, Bane of the Northeast Corridor, Is Due for Upgrade." *Washington Post*, November 15, 2014. https://www.washingtonpost.com/politics/new-jerseys-portal-bridge-bane-of-the-northeast-corridor-is-due-for-upgrade/2014/11/15/36c34662-6d1e-11e4-a31c-77759f9c1eacc_story.html.

¹³ Currently, the Coast Guard requires water traffic to be given priority at the bridges.

6. Secaucus Junction

Secaucus Junction is NJT's largest transfer facility and is located at the confluence of all of NJT's rail lines with the exception of the Atlantic City branch. The station was constructed in 2003 to allow for passengers of the Main, Bergen, and Pascack Valley lines, running on the lower level of the station, to transfer to trains travelling to Penn Station along the Northeast Corridor, which runs on the upper level of the station. Prior to the construction of the Junction, riders using these lines had to ride to Hoboken and take a ferry or PATH train to reach Manhattan. While the station is not heavily used as an embarkation point, it is one of the busiest stations in the NJT system when transfers are taken into account — almost 20,000 riders transferred between lines at the Junction in 2015.¹⁴ Given its centrality to the NJT rail system, various improvements and connections to the station have been proposed including an extension of the 7 or L subway lines from Manhattan to the station. There are also currently plans to create a connection between the upper and lower level tracks to allow for direct one seat riders from the Main, Bergen, and Pascack Valley lines into Penn Station. However, there is no time line for the project.

7. Jamaica Station

Jamaica station is the largest intermodal hub in the Long Island Rail Road system. Located in Queens, just several miles east of the East River portals to New York City, all of the LIRR lines with the exception of the Port Washington branch pass through Jamaica Station. Many riders utilize the station to transfer between LIRR lines to reach their final destination. In addition to the LIRR, Jamaica also provides connections to three subway services, local buses, and the AirTrain to JFK Airport. The convergence of trains at Jamaica makes it a chokepoint in the LIRR system — the slow approach to the station is referred to by many riders as the “Jamaica Crawl.” Much of the station's rail infrastructure is configured as it was when the station was originally built. However, as part of the East Side Access project the MTA is building a new platform for the future Atlantic Terminal shuttle between Jamaica and Atlantic Avenue in Downtown Brooklyn and is re-configuring the junction tracks adjacent to the station to allow for more efficient and faster train operations.¹⁵

8. Atlantic Terminal

While the majority the LIRR's train traffic is directed to New York Penn Station, Atlantic Terminal serves as a secondary terminal providing direct service to downtown Brooklyn. About half of the terminal's riders travel onwards to Manhattan via the Terminal's nine subway service connections while around 40% stay in Brooklyn.¹⁶ However, only 12% of LIRR riders alight at Atlantic Terminal,

indicating the preference of Long Island commuters for a “one-seat ride” to Manhattan.¹⁷ The MTA currently plans to terminate direct Long Island commuter rail service to Atlantic Terminal as part of the East Side Access project, replacing it with a shuttle that would run between Jamaica and the former terminal, as described above. Trains from Long Island branches that now run to Brooklyn will instead operate to the new terminal at Grand Central, increasing the number of one-seat ride opportunities to midtown Manhattan. The Atlantic Terminal shuttle service would preserve the connection for LIRR customers to Downtown Brooklyn and to the subway lines that serve Lower Manhattan, albeit as a two-seat ride versus the one-seat option that some enjoy today. The popularity of the Barclay's Center has made some of these plans uncertain. However, a more rapid transit service along the Atlantic Branch, the LIRR line spanning the terminal and Jamaica station, has been proposed for decades, including in several plans put forth by RPA.^{18,19}

9. Hunterspoint Avenue and Long Island City

A short branch off of the LIRR main line to Penn Station runs from the Sunnyside area of western Queens to an LIRR rail yard at Long Island City, with an intermediate station at Hunterspoint Avenue where transfers are available to the #7 subway line. LIRR trains with diesel locomotives from the non-electrified branch lines operate on this route during weekday rush hours — towards Long Island City in the morning and returning in the evening, supplementing the peak service to Manhattan.

In addition to the above nine terminals/stations, there are others throughout the region that, while not as critical to the network's functionality, are still are noteworthy because of their status as a hub station, their high levels of ridership, or their physical infrastructure (e.g. yard access). These include Union Station (New Haven) in Connecticut; Suffern, Spring Valley, Waldwick, Jersey Avenue (New Brunswick) and Trenton in New Jersey and West of the Hudson; Croton Harmon, Poughkeepsie, White Plains, New Rochelle and Port Chester in the Lower Hudson Valley; and Mineola, Hicksville and Ronkonkoma in Long Island.

Rail Cars

Riders directly experience the commuter railroad through its rail cars, which are where they spend the majority of their travel time. There is little doubt that the quality of the car can affect the customer's perceptions.²⁰ Further-

¹⁴ NJT, 2015.

¹⁵ The construction of a new platform “F” at Jamaica and the associated changes to the existing interlockings will eliminate conflicts between trains bound for Atlantic Avenue Terminal and those bound for Manhattan.

¹⁶ “Long Island Railroad Origin & Destination Study Survey Results.” LIRR, Spring 2006.

¹⁷ “2015 Ridership Book.” LIRR, 2015. <http://web.mta.info/mta/news/books/docs/2015-LIRR-Ridership-Book.pdf>.

¹⁸ “Metrolink: New Transit for New York.” Regional Plan Association, 1999. <http://library.rpa.org/pdf/RPA-Metrolink-New-Transit-for-New-York.pdf>.

¹⁹ “Tomorrow's Transit.” Regional Plan Association, 2008. <http://library.rpa.org/pdf/RPA-Tomorrows-Transit.pdf>.

²⁰ “Transit Capacity and Quality of Service Manual, 3rd Edition.” Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_165ch-04.pdf.

Table 2: Selected Major Stations

Station	Sector	Operator	Ridership	Yard Access	Yards/Maintenance Facilities	Hub?	Connections
Union (New Haven)	CT	MNR	*3,249	No		Yes	Amtrak, Intercity Bus, Shore Line East
Croton Harmon	HV-E	MNR	*4,170	Yes	Metro North's Main Repair Shops	Yes	Amtrak
Poughkeepsie	HV-E	MNR	*1,684	No		Yes	Amtrak
White Plains	HV-E	MNR	*11,125	No		Yes	Intercity Bus
New Rochelle	HV-E	MNR	*5,301	No		Yes	Amtrak, Intercity Bus
Port Chester	HV-E	MNR	*2,945	No		Yes	Local Bus
Suffern	HV-W	NJT/MNR	*718	No		No	Local Bus
Spring Valley	HV-W	NJT/MNR	*170	Yes	Woodbine yard	No	Local Bus
Waldwick	NJ	NJT	*504	Yes	Waldwick Yard	No	Local Bus
Jersey Avenue	NJ	NJT	*1,443	No		No	Local Bus
Trenton	NJ	NJT	*4,422	Yes	Morrisville Yard	Yes	Amtrak, RiverLINE, SEPTA
Mineola	LI	LIRR	**6,627	No		Yes	Local Bus
Hicksville	LI	LIRR	**10,821	No		Yes	Local Bus
Ronkonkoma	LI	LIRR	**7,724	Yes	Ronkonkoma Yard	Yes	Local Bus

* 2015 avg. weekday boardings, ** 2012-2014 avg. weekday boardings

Source: RPA Analysis, NJT and MTA

more, well-maintained rail cars don't just provide a better customer environment but avoid breakdowns and increase reliability.

The line-haul capacity of a rail line is partially determined by the size of a car. It is also determined by how many cars can be strung together in trains and how many trains can operate per unit of time. These factors point to the many ways that capacity can be increased — larger cars, longer trains, longer platforms, more quickly accelerating and decelerating rolling stock, and signals that allow closer operations.

Over the past decades, both Metro-North and Long Island Rail Road have made a concerted effort to replace the rolling stock used on their inner and most heavily trafficked lines with modern “Electric-Multiple Unit” (EMU) train cars, upgrading and expanding the size of the earlier fleets that were primarily comprised of non-powered cars and locomotives. EMU trains are comprised of multiple cars which are all self-propelled via electric motive power. EMU's are quieter and produce less pollution than their diesel counterparts. They are also able to accelerate and decelerate faster and have greater redundancy than conventional commuter trains that are pushed or pulled by locomotives — allowing for increased average speed and reliability on routes with more frequent stops (e.g. commuter rail type services). Adopting this equipment to a greater extent throughout their systems has allowed for Metro-North and the Long Island Rail Road to increase their line-haul capacity by using the EMU's better performance to run a more efficient and frequent service. It has also required them to make their stations high-level platforms, an expensive undertaking.

New Jersey Transit maintains only limited use of EMU's; most of its train fleet relies upon a locomotive (diesel or electric) for their motive power. NJ Transit has also increased the capacity of its trains by replacing single level cars with multi-level rail cars that add an additional 20% carrying capacity. These cars have been popular with the public and NJT is working to introduce them to all of their lines. However, these cars can only increase capacity so much and do not, by themselves, solve NJT's capacity shortfall. They are also responsible for increased platform crowding at Penn Station and reduced performance (e.g. acceleration and deceleration) because they must be pushed or pulled by a locomotive. The recent crowding increases on Penn Station's platforms clearly illustrates how increasing capacity in one part of the system without a commensurate increase in another can shift bottlenecks instead of systematically addressing the underlying deficiencies that caused them.

A compromise between increasing the line haul capacity of a railroad via the use of EMUs and increasing the person capacity of a trainset via multi-level coaches are open gangway trains. These trainsets are comprised of self-propelled units (i.e. EMUs) but feature open gangways between cars allowing for additional standing space for riders. An example train interior from the London Overground, a metro-like regional rail system which makes use of these types of trains, is shown below. The increase in capacity resulting from the open gangways is readily apparent. While the seats on this specific train are arranged longitudinally, one could apply the same open gangway concept to our commuter rail trains and their side by side seating arrangements to open the space between train cars up to passengers.

Trains sets such as these allow for an increase in train capacity by opening up the area between train cars to passengers while also maintaining the EMU performance characteristics which allow for frequent service. While no trains of this type are currently operated in the region, they are a possible solution to the problem of serving the increasing demand the region's railroads expect to see.

Figure 3: London Overground Train-set with Open Gangways



Photo: Peter Skuce

Structures

The region's railroads make use of bridges and tunnels to span roadways, and geographic features such as valleys, ridges, and major bodies of water. Many of these structures are older, some dating back a century or more, and most of these crossings lack redundancy. As a result, when these structures fail or must be repaired, their outage is immediately felt by riders. It is because of the severity of the delays or prolonged outages associated with rehabilitating these structures that agencies have tended to put off this critical work despite its importance to the system. Many of the region's rail bridges and tunnels are in need of extensive rehabilitation or complete replacement.

Many of the region's most fragile and unreliable structures are movable bridges built around the end of the 19th century and the beginning of the 20th century. These bridges were constructed to allow the railroads to traverse the region's many waterways and were designed to be opened to allow for water traffic to pass. While state of the art at the time of their construction, these bridges are now one of the main causes of infrastructure related delays for certain parts of the system. Metro-North's New Haven Line, which runs along the coast of the Long Island Sound, features over 100 movable and non-movable bridges. In 2010, the bridges along the New Haven Line malfunctioned a full 10% of

the times they were opened.²¹ Along the Northeast Corridor, the infamous Portal Bridge caused delays for Amtrak and NJTransit 250 times between the beginning of 2013 and fall of 2014.²² Repairing or replacing these aging and troublesome structures is crucial to the proper functioning of the region's rail system.

Power

Only 47%²³ of the region's rail system has been electrified, however, this portion carries 80% of its ridership. These lines tend to be concentrated in the core of the system because of the greater performance afforded by electrification and include all lines leading into Penn Station and Grand Central because the facilities are underground.²⁴ Electrified rail lines result in higher levels of performance than non-electrified lines. This is because they allow them to run EMU trainsets with their more aggressive acceleration profiles. Electrification also reduces local carbon and particulate emissions by eliminating the need for diesel locomotives.

Table 3 details the region's rail lines and the percentage of them which are electrified along with the avg. weekday boardings for each line. The two MTA systems (MNR, LIRR) have electrified almost all of their lines which serve more than around 6,000 riders daily with the exception of the Ronkonkoma branch of the LIRR. In contrast, NJT has two lines, the Main/Bergen and Raritan Valley lines, which collectively serve over 50,000 riders a day but still lack electrification. Other lines in the NJT system which serve large numbers of riders, such as the Morristown line, are only partially electrified.

Properly maintained electrical infrastructure is crucial to the rail system operating at a high level of service. This was evident during the catastrophic power failure on Metro North's New Haven line in the fall of 2013. Following the failure of a major power feeder line, the service, which served over 130,000 inbound and outbound riders per day in 2015, was essentially brought to a halt with only a smattering of hourly diesel trains and buses to try and fill the void.^{25,26,27} Continuing to maintain the infrastructure currently in place and expanding the portion of the system that is electrified is instrumental to service reliability,

²¹ "Getting Back on Track." (Regional Plan Association, January 2014), p.17. <http://library.rpa.org/pdf/RPA-Getting-Back-on-Track.pdf>.

²² McGeehan, Patrick. "104-Year-Old Portal Bridge Presents \$900 Million Problem for Rail Commuters." *The New York Times*, September 25, 2014. <https://www.nytimes.com/2014/09/26/nyregion/portal-bridge-presents-northeast-rail-commuters-with-a-104-year-old-problem.html>.

²³ RPA Analysis.

²⁴ Diesel trains are not allowed, except for emergencies and service disruptions, to run into either Terminal because of the fumes produced by the trains.

²⁵ MTA, 2015.

²⁶ Flegenheimer, Matt, and Patrick McGeehan. "Con Edison May Have Caused Metro-North Line's Power Loss." *The New York Times*, September 30, 2013. <https://www.nytimes.com/2013/10/01/nyregion/con-edison-may-have-caused-metro-north-lines-power-loss.html>.

²⁷ "Getting Back on Track." Regional Plan Association, January 2014. <http://library.rpa.org/pdf/RPA-Getting-Back-on-Track.pdf>.

improving the performance and interconnectivity of slower branch lines, and reducing generation of greenhouse gas emissions by diesel locomotives.

Yards

Railroads require large parcels of land throughout the region to store and maintain their fleets. Without adequate and properly placed rail yards, the full capacity (throughput) of the system will be compromised.

Since they service large pieces of moving machinery, rail yards tend to be considered an undesirable addition to a neighborhood and their creation or expansion is often opposed by communities. As a result, many of our rail system's existing train yards have been in place for many decades and there have been few additions in recent years. Unfortunately, some were placed in areas no longer considered optimal to supporting a modern commuter service while others have been "fenced in" by development and do not have the space to grow to meet future or even the existing demand that has been placed on the system. There is substantial pressure to redevelop under-utilized portions of existing rail yards in the region's core, which threatens to place limits on how much service might be increased in the future.

Table 3: Electrification of NJT, MNR, and LIRR Rail Lines

Railroad	Lines	Avg. Weekday Boardings*	Electrification Type	Extent of Electrification	Percent of Line Electrified
New Jersey Transit	Northeast Corridor	121,950	12 kV 25 Hz Catenary	Entire Line	100%
	North Jersey Coast	24,150	12 kV 25 Hz Catenary North of Matawan 25kV 60 Hz Catenary Matawan to Long Branch	North of Long Branch	65%
	Pascack Valley	9,501	None	None	0%
	Main-Bergen County	30,150	None	None	0%
	Montclair-Boonton	17,600	25 kV 60 Hz AC Catenary**	East of Montclair State University, small segment of Dover Yard	22%
	Morris & Essex	55,687	25 kV 60 Hz AC Catenary	East of Dover Station	65%
	Gladstone Branch	3,113	25 kV 60 Hz AC Catenary	Entire Line	100%
	Raritan Valley	22,950	None	None	0%
	Atlantic City	2,550	None	None	0%
Metro North	New Haven	125,845	12.5 kV 60 Hz AC Catenary north of Mt Vernon East 750V DC Bottom Contact 3rd Rail south of Pelham	Entire Line	100%
	New Canaan Branch	2,467	12.5 kV 60 Hz AC Catenary	Entire Line	100%
	Danbury Branch	1,322	None***	None	0%
	Waterbury Branch	458	None	None	0%
	Harlem	92,375	750 V DC bottom contact 3rd rail	South of Brewster	66%
	Hudson	53,085	750V DC bottom contact 3rd rail	South of Croton - Harmon	45%
	Port Jervis	1,941	None	None	0%
Long Island Railroad	City Terminal	177,967	750 V DC top contact 3rd rail	Entire Line	100%
	Babylon	37,063	750 V DC top contact 3rd rail	Entire Line	100%
	Port Jefferson	39,184	750 V DC top contact 3rd rail	West of Huntington	44%
	Port Washington	23,101	750 V DC top contact 3rd rail	Entire Line	100%
	Ronkonkoma	19,948	750 V DC top contact 3rd rail	West of Ronkonkoma	40%
	Far Rockaway	10,787	750 V DC top contact 3rd rail	Entire Line	100%
	Long Beach	7,834	750 V DC top contact 3rd rail	Entire Line	100%
	Hempstead	6,897	750 V DC top contact 3rd rail	Entire Line	100%
	Montauk	3,417	None	None	0%
	Oyster Bay	2,781	750 V DC top contact 3rd rail	East Williston to Mineola	8%
	West Hempstead	1,556	750 V DC top contact 3rd rail	Entire Line	100%

*2015 boardings MNR/NJT, 2012-2014 LIRR

** Line electrified at 25 kV 60 Hz to Hoboken Terminal. Trains to NYP change to 12 kV 25Hz at Swift Interlocking

*** Electrification of southern end of Danbury Branch underway as part of Norwalk Dock Yard rehabilitation

Source: RPA Analysis

Complicating matters further, some yards are in areas that are at a high risk of being flooded as climate change causes our seas to rise and storm surges to become more frequent. This was shown during Hurricane Sandy, which flooded New Jersey Transit’s Hoboken and Meadowlands yard facilities, causing millions of dollars of damage to cars and wayside infrastructure. While there were some facilities that were spared, many will become more vulnerable as sea levels continue to rise. Finding new locations for these yards will be a major challenge facing the railroads over the coming decades.

As demand for rail service grows with the population of the region, expansion of existing yards and locations for new ones must be examined to provide the capacity to meet demand.

Junctions/Interlockings

Many riders conceptualize rail systems as a set of straight lines connecting various points on a map. While this is partially correct, railroads actually consist of many complex networks of rail lines with tracks that are merging, splitting and crossing each other. Places where this takes place are called junctions or interlockings; both rely on switches to allow trains to move to different tracks. This infrastructure is crucial in determining the realistic capacity of a rail line. Sub-optimally designed at-grade junctions can restrict a line’s capacity by requiring trains to slow down and/or stop as they pass through to allow other trains to pass. Doing so forces following trains and those on merging lines to slow down, resulting in delays. Modern, grade separated, junctions are capable of allowing trains to merge with other lines without slowing. Yet, much of our region’s rail infrastructure was built in an era of slower trains, containing junctions that are at-grade with sub-optimal geometries, switches, signals, or other issues. Replacing these antiquated junctions is very expensive and complex since a reasonable level of service must be maintained during the project. Furthermore, many of these infrastructure pieces are in dense areas that don’t have the land to fully grade separate the junctions readily available — necessitating property buyouts or takings.

Interlockings are a collection of more than one junction and are generally located at the convergence of many lines, major stations, rail yards, and other locations where trains may be making many conflicting movements. Interlockings encode a set of logical rules into mechanical and electronic infrastructure to ensure that no conflicting train movements can occur. These pieces of infrastructure are extremely complex and absolutely vital to the safety of a rail system. As with single junctions, sub-optimally designed interlockings can hinder the performance of a railroad. For example, the at-grade Shell Interlocking which services all Metro-North New Haven Line trains and

Table 4: Rail Yards by County

County	State	# Yards	# Vulnerable to SLR
Suffolk	NY	6	1
Queens	NY	5	3
Hudson	NJ	2	2
Nassau	NY	2	1
New Haven	CT	2	1
Middlesex	NJ	2	0
Morris	NJ	2	0
Somerset	NJ	2	0
Rockland	NY	2	0
Bronx	NY	1	1
Fairfield	CT	1	1
Ocean	NJ	1	1
Manhattan	NY	1	1
Westchester	NY	1	1
Brooklyn	NY	1	0
Orange	NY	1	0
Bergen	NJ	1	0
Monmouth	NJ	1	0
Passaic	NJ	1	0
Union	NJ	1	0
Bucks	PA	1	0
Total	-	37	13

Source: RPA Analysis

all Amtrak NEC/Acela trains north of New York restricts speeds to 30mph on the majority of its tracks, forcing trains to slow down as they approach the interlocking.²⁸

Table 5 summarizes the existing junctions and interlockings throughout the region which restrict train speeds and throughput. Improving these pieces of infrastructure will enable the railroads to provide faster and more reliable service.

²⁸ “Getting Back on Track.” (Regional Plan Association, January 2014), p.18. <http://library.rpa.org/pdf/RPA-Getting-Back-on-Track.pdf>.

Figure 4: Map of Commuter Rail System Constraints

Source: Regional Plan Association

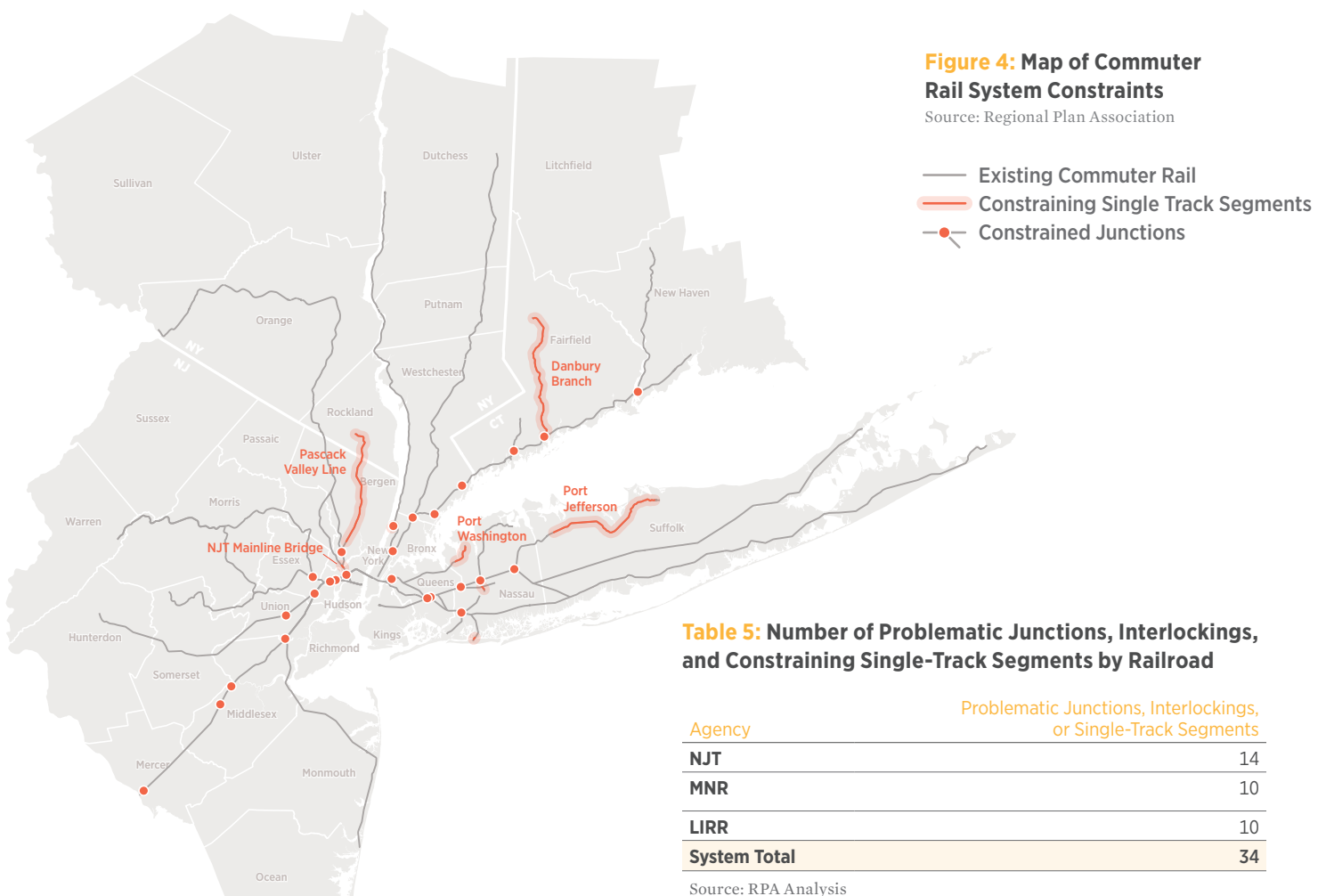


Table 5: Number of Problematic Junctions, Interlockings, and Constraining Single-Track Segments by Railroad

Agency	Problematic Junctions, Interlockings, or Single-Track Segments
NJT	14
MNR	10
LIRR	10
System Total	34

Source: RPA Analysis

A Network Under Pressure

The region's aging commuter rail network is buckling under the pressure of increasing ridership and deferred maintenance. The growth in commuter rail ridership over the past years has placed extreme demands on a system that is not physically designed to meet them, and has the potential to greatly limit the region's growth and success. This is compounded by the state of good repair and modernization backlog throughout the network, which includes numerous critical structures, stations, power and signal systems.

One of the fastest growing segments of riders in the system, trans-Hudson riders travelling from New Jersey to New York, has increased by 27% from 1990-2010.¹ This increase has been encouraged by infrastructure investments in New Jersey that allowed for improved access to Penn Station. Since 1996, three major rail projects have been completed by NJ Transit, each of which dramatically improved the NJ Transit system's access to New York Penn Station. The first of these was the Midtown Direct (the Kearny Connection),

finished in 1996, which provided direct service into Penn Station for the Morris and Essex line allowing its riders to avoid transferring to a PATH train or ferry at Hoboken to reach Manhattan.² In 2002, the Montclair Connection, a project originally proposed by RPA in 1929, was completed to combine the Montclair and Boonton lines. This connection provided direct service to New York Penn Station for Montclair and Boonton branch riders.³ Finally, in 2003, the Secaucus Junction was completed, which enabled Bergen County line, Main Line and Pascack Valley line riders serving Bergen, Passaic, Rockland and Orange counties to transfer to the Northeast Corridor trains into New York Penn Station, allowing these riders to avoid the Hoboken transfer for their trips into midtown Manhattan. The Secaucus Junction also provided new possibilities for rail travel within New Jersey using many combinations of nine NJT rail lines previously inaccessible to one another. These three improvements have greatly improved the quality of service provided to New Jersey rail riders destined for Manhattan, resulting in dramatic increases in ridership.

¹ 2010 U.S. Census, cited in "Crossing the Hudson." (Regional Plan Association, August 2017), p.7. <http://library.rpa.org/pdf/RPA-Crossing-the-Hudson.pdf>.

² Perez-Pena, Richard. "Kearny Link Is Finished, Reducing Trip by Rail." *The New York Times*, May 28, 1996. <https://www.nytimes.com/1996/05/28/nyregion/kearny-link-is-finished-reducing-trip-by-rail.html>.

³ "Introducing Midtown Direct: The Montclair-Boonton Line." NJT, September 2002. <http://www.njtransit.com/pdf/montclair-boonton-brochure.pdf>.

No new rail links have been built to traverse the Hudson River to accommodate this demand. Originally, the Access to the Region's Core (ARC) project was intended to provide two new tunnels underneath the Hudson River leading to a new terminal underneath 34th Street. The project was cancelled by New Jersey's Governor, Chris Christie, in 2010. The Christie administration canceled the project over concerns about cost overruns, a claim which has been disputed by the Federal Transit Administration and the Government Accountability Office.⁴ As a result of ARC's cancellation, the North River Tunnels used by NJ Transit and Amtrak to traverse the Hudson River currently carry as many trains as is possible during the peak (24 per hour). Furthermore, they are in need of repair after Hurricane Sandy which flooded the tunnels with corrosive salt water. In an attempt to ease this bottleneck, higher capacity multi-level rail cars have been introduced. However, these cars have increased platform congestion and passenger delays at New York Penn Station, which has not been expanded to accommodate them. Buses have also been used to fill the void in capacity, in just the past 5 years bus ridership has increased by 20% across the Hudson, adding another 200 buses (in addition to the 7,600) into the Manhattan CBD daily from west of Hudson locations.

Figure 5: NJTransit Trainset Comprised of Multi-level Cars



Photo: Adam E. Moreira

In New York and Connecticut, Metro-North's New Haven line operates at or near capacity in many of the Line's key segments including at Grand Central Terminal, Shell Interlocking, and Bridgeport, CT.⁵ This service currently carries over 40 million commuter rail trips each year and is projected to carry over 57 million by 2030.^{6,7} Originally built in the 1800's, the New Haven Line is peppered with outmoded movable bridges. State of the art when built, they now get stuck in place around 10% of the time they're opened, causing delays up and down the Line.⁸ Replace-

ment of these bridges has been delayed for years because of insufficient funding. While it is possible that Metro-North and Connecticut can maintain the bridges at some level of functionality for the foreseeable future, they will continue to malfunction and impact the service reliability.

A Fragmented Network

The operation of the current rail system by three separate public entities is both a relic of the system's private corporate origin and the region's fragmented administrative governance structures. The region's railroads are each operated differently, each with separate unions and negotiated labor agreements and incompatible infrastructure, such as different forms of electrification systems. Metro-North uses both overhead catenary and under-running third rail while its sister agency, the Long Island Railroad is equipped for only over-running third rail power. New Jersey Transit relies solely on overhead catenary, of a different voltage than Metro-North's system, for the electrified portions of its systems.⁹ Thus, any train running between these systems must be compatible with up to four different forms of electrical power system infrastructure. Currently, no rolling stock can operate on all four systems. However, the Metro-North's M8 can operate on both types of third rail and the catenary that exists west of Penn Station while New Jersey Transit's ALP-46 locomotive can operate on the catenary systems east and west of Penn Station but not on either third rail system.¹⁰ These different power systems make through-running at Penn Station, sharing of rolling stock and other operational efficiencies between the agencies impractical today.¹¹ Any truly cohesive and integrated service would require either an extension of one type of power system or a new piece of train equipment that can handle all four power systems seamlessly. Other physical barriers to regional integration exist throughout the system, such as New Jersey Transit's numerous low-level platform stations which are incompatible with most Metro-North and Long Island Rail Road rolling stock.¹²

In addition to the physical impediments to creating a unified rail service, there are operational ones as well. For example, each of the region's three railroads currently maintains its own ticketing regime. The vending machines, ticket media, and prices of each regime are, for the most part, incompatible with the others. Beyond the incompatible fare structures, the railroads also do not make any

⁴ "Commuter Rail: Potential Impacts and Cost Estimates for the Cancelled Hudson River Tunnel Project." U.S. Government Accountability Office, March 2012. <http://www.gao.gov/assets/590/589192.pdf>.

⁵ RPA, Getting Back on Track. Pg. 18.

⁶ "V:\Projects\528_Mobility\Agency.Data\Region\MTA\MNR\Station_counts\2015 Annual Ridership Report_Final.pdf"

⁷ RPA, Getting Back on Track. Pg. 25

⁸ Bridges were stuck 70 out of 747 times in 2010. RPA, Getting Back On Track, pg. 17

⁹ "Getting Back on Track." (Regional Plan Association, January 2014), p.23. <http://library.rpa.org/pdf/RPA-Getting-Back-on-Track.pdf>.

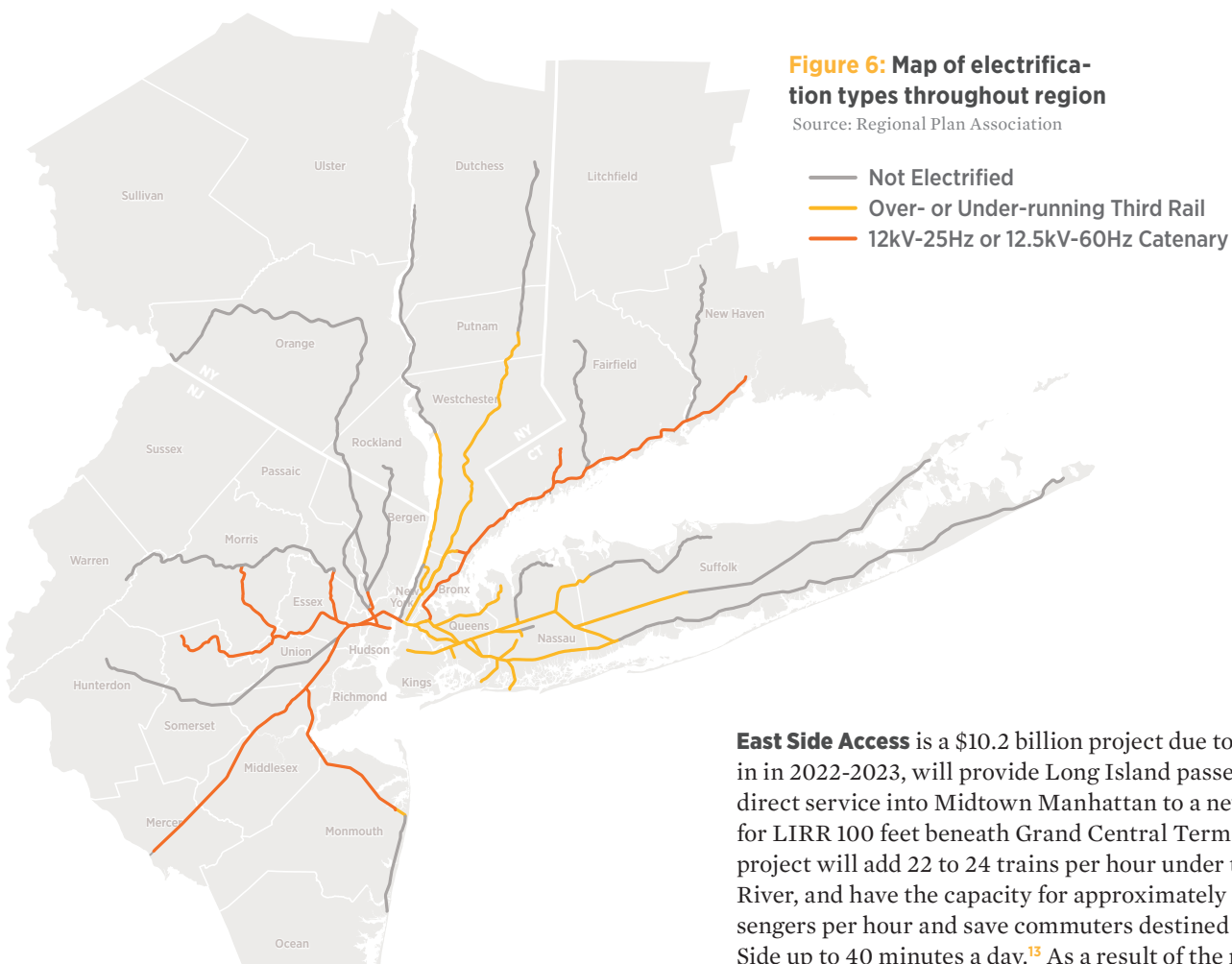
¹⁰ *Railroad.net*. <http://www.railroad.net/forums/viewtopic.php?f=67&t=157224&start=30>

¹¹ NJ Transit and Metro-North run a "proof of concept" train to MetLife Stadium in the Meadowlands from New Haven for Giants and Jets games using NJ Transit equipment.

¹² Metro-North and the Long Island Rail Road each have only one low-level platform stop, Breakneck Ridge and Belmont Park, respectively. Both are for special uses and do not have regular service. In contrast, NJT has 97 low level platform stations, 68% of their stations, all used on a daily basis.

Figure 6: Map of electrification types throughout region

Source: Regional Plan Association



attempt to coordinate schedules or transfers. For example, riders looking to travel between New Jersey and Long Island can do so by transferring between NJT and LIRR at Penn Station but there is no guarantee that the train required for the second leg of the journey will not be pulling out of the station as they arrive. The Byzantine process of purchasing multiple tickets and identifying viable transfer options serves as a very strong disincentive to riders considering using the railroad to travel throughout the region.

Planned or Underway Capital Improvements

While there is a tremendous backlog of capital improvement projects throughout the rail system, there are six major initiatives currently in planning or underway that will help improve the network's redundancy, efficiency, reliability, speed, and capacity.

East Side Access is a \$10.2 billion project due to be complete in 2022-2023, will provide Long Island passengers with direct service into Midtown Manhattan to a new terminal for LIRR 100 feet beneath Grand Central Terminal. This project will add 22 to 24 trains per hour under the East River, and have the capacity for approximately 24,000 passengers per hour and save commuters destined to the East Side up to 40 minutes a day.¹³ As a result of the redistribution of trains from Penn Station, some capacity will also be freed up at Penn Station for the New Haven Line via Penn Access and possibly for direct service to JFK airport.

Penn Access is a \$740 million expansion project, will extend Metro North's New Haven line service through the eastern Bronx, running over the Hell Gate Bridge and terminating at Penn Station New York via the East River tunnels. The project includes four new Metro North stations in the Bronx (Co-op City, Morris Park, Parkchester, and Hunts Point) and has proposed doubling the number of tracks along a right-of-way currently used today exclusively by Amtrak and freight trains. Penn Access will improve access to Midtown Manhattan for Bronx residents that are poorly served and have limited transit options today, including Co-op City East — a residential complex that's home to over 50,000 people. Perhaps, as importantly, it will enable reverse commuting for Bronx residents to jobs on the New Haven line in Westchester County and southwest Connecticut.

LIRR Main Line Third Track is a \$2 billion expansion project that will add a third track to the Long Island Rail Road's Main Line between Floral Park and Hicksville. This section of track is currently operated at full capacity during the peak periods, with both tracks operated in the peak direc-

¹³ Getting Back on Track." (Regional Plan Association, January 2014), p.23. <http://library.rpa.org/pdf/RPA-Getting-Back-on-Track.pdf>.

tion. Doing so prevents LIRR from running reverse peak service — keeping the system from being used by those not destined for Manhattan. Furthermore, operating at full capacity makes the entire LIRR system extremely susceptible to delays when incidents occur along this section of track. The project will also eliminate seven at-grade crossings along the Main Line, separating the railroad from surface street traffic. This will increase safety by eliminating potential collisions, reduce auto congestion and increase train speeds through the corridor.

LIRR Main Line Double Track is a \$388 million project to add a second track to the Main Line between Farmingdale and Ronkonkoma which is underway and slated to be completed in 2018. Currently, only two sections of the Main Line east of Farmingdale have two tracks: the tracks between Deer Park and Brentwood stations and Central Islip station. The lack of a second track for the majority of this section of the Main Line prevents a true bi-directional service from being run since trains going in opposite directions can only pass each other at two places. Completion of the second track will improve the line's reliability and allow for LIRR to run an increase service to areas east of Farmingdale, even more so once the Third Track project is completed.

Gateway is a planned program of rail improvement projects along the North East Corridor (NEC) from Newark Penn Station to New York Penn station being led by Amtrak, NJ Transit and the Federal Railroad Administration, including new Hudson River tunnels. The construction of these tunnels will not only provide much needed capacity (once Penn Station is expanded) but will add a layer of redundancy to the existing North River tunnels that serve New York Penn Station. Because of severe damage from Superstorm Sandy the tunnels are prone to equipment failures. Not only are the tunnels the cause of existing delays but they are in danger of closing for extended periods, which would be catastrophic for the economy of both states.¹⁴ Construction of new tunnels under the Hudson River will allow for the existing North River tunnels to be repaired without a severe degradation of service.

The program also contains multiple bridge and right of way improvements to the stretch of track running from Newark Penn Station to the entrance to the new Hudson Tunnels. These include the expansion of the Northeast Corridor from two tracks to four from Newark to the Palisades, the replacement of the Portal Bridge and expansion of the Secaucus station.

The Gateway program would also enable the construction of the Bergen Loop, a track connection between the upper and lower levels of Secaucus Junction. The creation of this connection would allow for direct service into Penn Station for riders of the Main, Bergen, and Pascack Valley Lines

while the Gateway program would create the capacity along the Northeast Corridor and in Penn Station to accommodate the additional service. The four counties served by the affected lines would likely also see a shift from bus ridership to rail ridership with the completion of the Loop, reducing congestion in the Lincoln Tunnel.

Additionally, the Gateway Program will look at an expansion of Penn Station. The current station is the busiest rail station in North America and features narrow platforms and concourses, irregular signage, and a lack of waiting space. These issues not only negatively impact the experiences of the station's riders but also practically limit its capacity by causing severe pedestrian movement issues. Expanding the station is critical for Penn Station to accommodate the increase in capacity that will arrive with two new Hudson River tunnels. Any expansion of Penn Station must be designed for through running and improved station circulation and connections. More detailed recommendation for Penn Station, including existing and planned improvements to the facility, can be found in RPA's Penn Station brief in the Appendix of its *Crossing the Hudson* report that was released in 2017. The overall Gateway program is expected to cost more than \$20 billion and be completed in the mid-2020's. The first stage of the program, constructing a new Portal Bridge and the new Hudson River tunnels at the combined cost \$14.4 billion, is anticipated to begin in late 2018.

NEC FUTURE is a project of the Federal Railroad Administration (FRA) to develop a long-range vision for passenger rail service and capital investment in the Northeast Corridor between Washington, DC and Boston. The project includes a programmatic environmental impact assessment, and a Federal Record of Decision was published in 2017. The selected vision calls for growing the role of rail in the corridor, serving a greater share of intercity travel markets and regional commuters to the major cities within the corridor. It also looks to serve new markets and deliver new types of service, including through-running regional rail, and a frequent and affordable limited-stop service that would fill the gap between current Amtrak and commuter rail service. These new service types are consistent with the regional rail services that are envisioned in the RPA Fourth Regional Plan. Within the greater New York metropolitan area, the NEC FUTURE vision includes expanding the capacity of the corridor by building two new main tracks for most of the way between North Brunswick, NJ and Green's Farms, CT, including new tunnels under the Hudson and East Rivers and an expansion of the capacity of New York Penn Station.

¹⁴ "Hudson Tunnel Project Environmental Impact Statement Scoping Document." Hudson Tunnel Project, April 2016. <http://www.hudsonstunnelproject.com/documents/Hudson%20Tunnel%20Project%20Scoping%20Document%204-27-16%20FINAL.PDF>.

Survey and Evaluation of Current Service

The region's three commuter rail operators have calibrated their service plans as well as their infrastructure to maximize throughput during the traditional "peak of the peak" hour. This approach to service planning started to emerge in the post-World War II era during the mid-1900's and then accelerated after the bankruptcy of the private railroads when the government took over and rationalized the network for commuters. In the 1950s, most people that used the railroad were suburban commuters who adhered to "9am to 5pm" work day. They and their families made little use of the railroads at other times and to other places, relying instead on automobiles for most of their discretionary travel. However, more recently this pattern has begun to change as more riders travel during the "shoulders" of the peak periods due to more flexible work schedules and also use the railroads more for non-work travel in the off-peak period (mid-day and weekends, for example).

This change in travel patterns appears to be driven by several factors. First, the "millennial" generation, generally defined as those born between 1980 and 2000, now make up 22% of the regional population.¹⁵ This generation has shown a proclivity to use transit — 20% of millennials use public transit once a week or more compared with the older generation of Gen Xers (7%) and an even older generation of Baby Boomers (10%).¹⁶ As its members enter the workforce they are more likely to rely on transit to get to work as well as to make discretionary trips. Secondly, more riders are arriving at and leaving work outside of the "standard" 9AM-5PM workday.¹⁷ Some of these riders may be trying to avoid the congestion present during the peak and would revert back to a normal commute if it was reduced. Nevertheless, this trend will likely continue as technology enables workers to perform their work remotely with even greater ease and the economy continues to move away from a shift-based one and towards the "gig" economy where workers perform tasks on demand throughout the day.¹⁸

¹⁵ Cotey, Angela. "New York's MTA Analyzes Millennial, Baby Boomer Travel Trends to Determine Future Investments." *Progressive Railroading*. Accessed December 4, 2017. <http://www.progressiverailroading.com/mobile/details.asp?id=37647>.

¹⁶ Schwartz, Samuel I., and William Rosen. *Street Smart: The Rise of Cities and the Fall of Cars*. New York: *PublicAffairs*, 2015.

¹⁷ "The Future of Work." (Regional Plan Association, February 26, 2016), p. 7. <http://library.rpa.org/pdf/RPA-4RP-Whitepaper-The-Future-of-Work.pdf>.

¹⁸ Hogan, By Elka Torpey and Andrew. "Working in a Gig Economy : Career Outlook: U.S. Bureau of Labor Statistics." *Bureau of Labor Statistics*. Accessed December 4, 2017. <https://www.bls.gov/careeroutlook/2016/article/what-is-the-gig-economy.htm>.

These trends make it quite clear that a more flexible and even service must be provided to the system's riders even while continuing to meet the needs of the traditional peak period market between the Manhattan central business district and the suburbs.

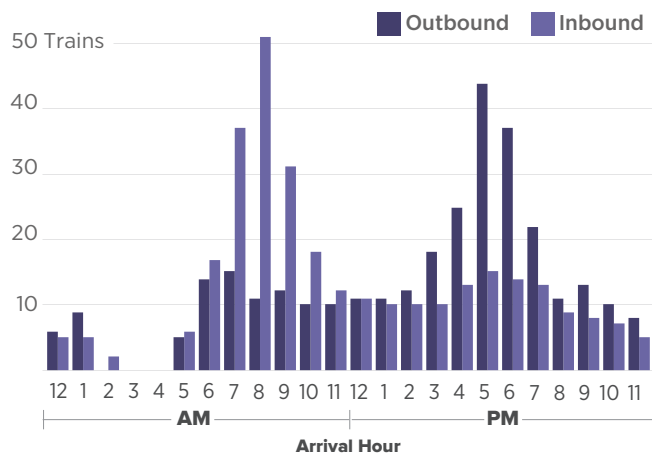
Service Oriented Around the "Peak-of-the-Peak"

An analysis of the scheduled service at all 390 of the region's commuter rail stations was done to gain a baseline understanding of the service offered by the commuter rail system today. The analysis identified where service is deficient with respect to frequency of trains at every station in the commuter rail network throughout the day in the inbound and outbound directions.

It was immediately evident that all three railroads provide the highest level of service (lowest headways) during the traditional peak periods and directions (AM inbound, PM outbound). Generally speaking, the service during these periods is 2-3 times better than during the middle of the day. Furthermore, service in the peak direction is of a much higher level than service in the reverse peak direction (AM outbound, PM inbound). These variations in service provision are depicted in Figures 7, 8 and 9 for each of the region's main terminals (Penn Station and Grand Central), however, the pattern is present throughout the region.

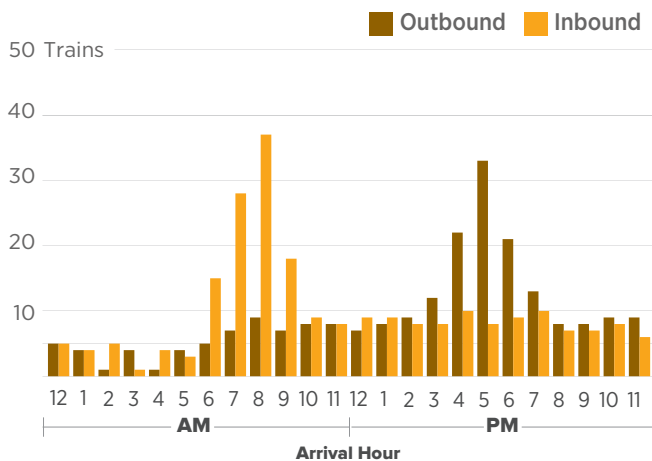
This variation in service is to be expected as the railroads have adopted their physical and operational components to maximize throughput during these time periods. LIRR's West Side yards is an example of this adaptation. It was placed on the West Side of Manhattan to store LIRR trains after arriving during the morning inbound peak to better serve the afternoon outbound peak. The practical impact of these service restrictions is that they limit the use of the railroads during non-peak times for intra-regional work trips that require flexibility in work schedules and for non-work trips.

Figure 7: Metro-North Service in Grand Central



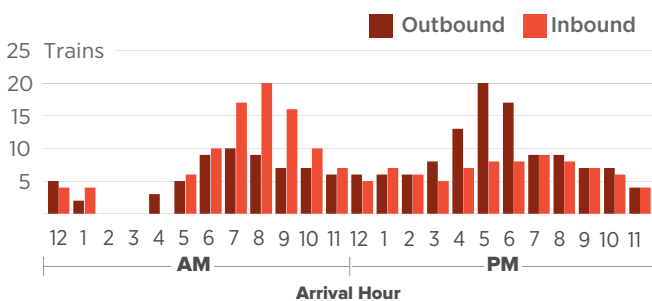
Source: RPA Analysis and MNR Weekday Schedules

Figure 8: LIRR Service in Penn Station



Source: RPA Analysis and LIRR Weekday Schedules

Figure 9: NJT Service in Penn Station



Source: RPA Analysis and NJT Weekday Schedules

A third phenomenon identified was the result of the railroad's focus on serving the peak of the peak. Specifically, the urban and inner core stations on the Metro-North and Long Island Rail Road systems receive a lower level of service than suburban ones despite the fact that all trains travelling to Penn Station or Grand Central must pass by them. This discrepancy in service can be explained by the lack of rail capacity in the core and the operating practice in place by both Metro-North and the Long Island Rail Road to provide faster service from the suburbs to the core. The combination of this policy and lack of capacity necessitates skipping inner urban stations because there is not enough room on the tracks for both local trains to serve urban stations and express trains to serve suburban ones.

Commuter rail is fastest and most reliable transit option from most suburban counties to Manhattan. The outer boroughs of New York City generally have subway and/or bus alternatives. Therefore, scarce capacity on these systems is allocated to the suburbs. City riders are discouraged by relatively infrequent service intervals and fares that are much higher than the subway — covered in greater detail in the following section. Eliminating the capacity constraints through the construction of additional rail infrastructure would allow for the railroads to serve both markets.

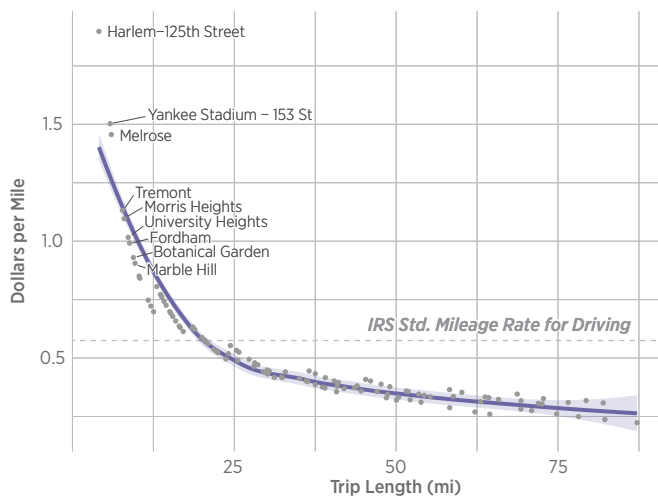
The region's rail system is predominately focused on serving riders living in the suburbs who work a traditional 9AM-5PM job in Manhattan's central business district. For many other uses, such as intra-regional work trips and reverse commuting, it is clear that the railroads are deficient at best and almost unusable at worst.

An Inequitable Service

Throughout the region there are communities poorly served by the railroads because of a legacy of disinvestment and fragmented rail planning, even though they have the densities and commutation patterns to support rail service. Other places, such as Queens Village in Queens and Melrose in the Bronx, are fortunate enough to have a rail station but local residents are discouraged, as noted earlier, through infrequent service and higher fares from making use of this infrastructure. As a result, riders in these areas, which are often low-income neighborhoods, must cope with overcrowded subway rides and multiple transfers. Figure 13 highlights areas without subway service but which have access to a commuter rail station.¹⁹ Improving service and reducing fares would help give residents of these areas a more transit-like service and essentially extend the subway to them without the need for new infrastructure.

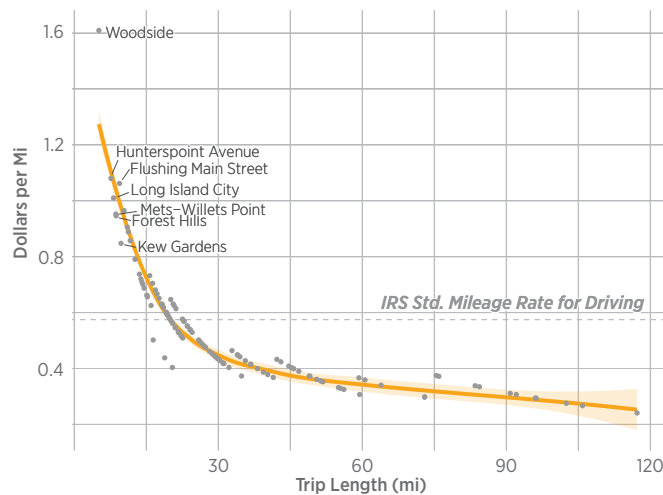
¹⁹ Available subway service is a 1/3 mi walkshed around a subway station while commuter rail service is a 1/2 mile walkshed

Figure 10: Metro-North Peak One Way Ticket Cost per Mile



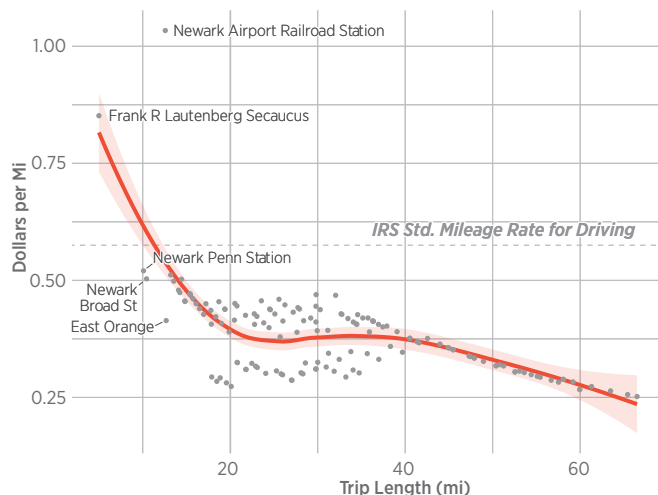
Source: RPA Analysis

Figure 11: LIRR Peak One Way Ticket Cost per Mile



Source: RPA Analysis

Figure 12: NJTransit Peak One Way Ticket Cost per Mile



Source: RPA Analysis

The system's fare policies are the key to providing an equitable service to all of the region's residents. As they currently stand, these policies favor riders travelling longer distances in the peak time and direction, specifically the riders traveling from the region's wealthier suburbs. When fares are taken as a function of trip mileage (shown for all three railroads in Figures 10, 11 and 12), it shows that suburban riders are actually charged less than riders in the less affluent boroughs of Queens, Brooklyn and the Bronx as well as the inner portions of New Jersey. Furthermore, the residents of the inner portions of the region are charged more on a per mileage basis than the IRS standard driving reimbursement rate (54 cents/mile).

This inequity is further compounded by the large discounts given to those riders more likely to have the resources to pay the high price for a monthly pass. When viewed on a per trip basis, these tickets are cheaper than the single fare tickets more likely to be used by lower income riders. It should be unsurprising then that stations which are located in dense inner-core areas see such low ridership, even in places where other transit options are unattractive.

However, the answer is not to simply increase fares for one group of riders to subsidize another. Such a simplistic strategy could discourage the overall use of public transit and encourage riders to shift to personal automobiles, something our highways cannot physically accommodate nor is a desirable public policy outcome. Instead, the solution lies in restructuring the system's fare policies in ways that would promote ridership, such as through the expansion of the City Ticket program.²⁰ Fare discounts or targeted "social fares" would need to be paid for either through state or municipal subsidies or through reforms to the railroad's funding structures, such as real estate value capture policies, discussed in greater detail in the governance recommendations of the Fourth Regional Plan.

The argument is often made that the trains passing through the inner core are full and lowering the fares would lead to overcrowding. However, some trains have space to accommodate additional riders as they pass through the inner core. A recent report by the New York City Transit Riders Council found that over 20,000 seats are empty on Long Island Rail Road trains between southeast Queens and Jamaica and 20,000 seats are free on trains between Jamaica and Penn Station during each of the peak periods.²¹ These seats could likely be filled by adopting more equitable fare and service policies, potentially increasing the overall revenues of the railroad while giving travelers an affordable and more direct service.

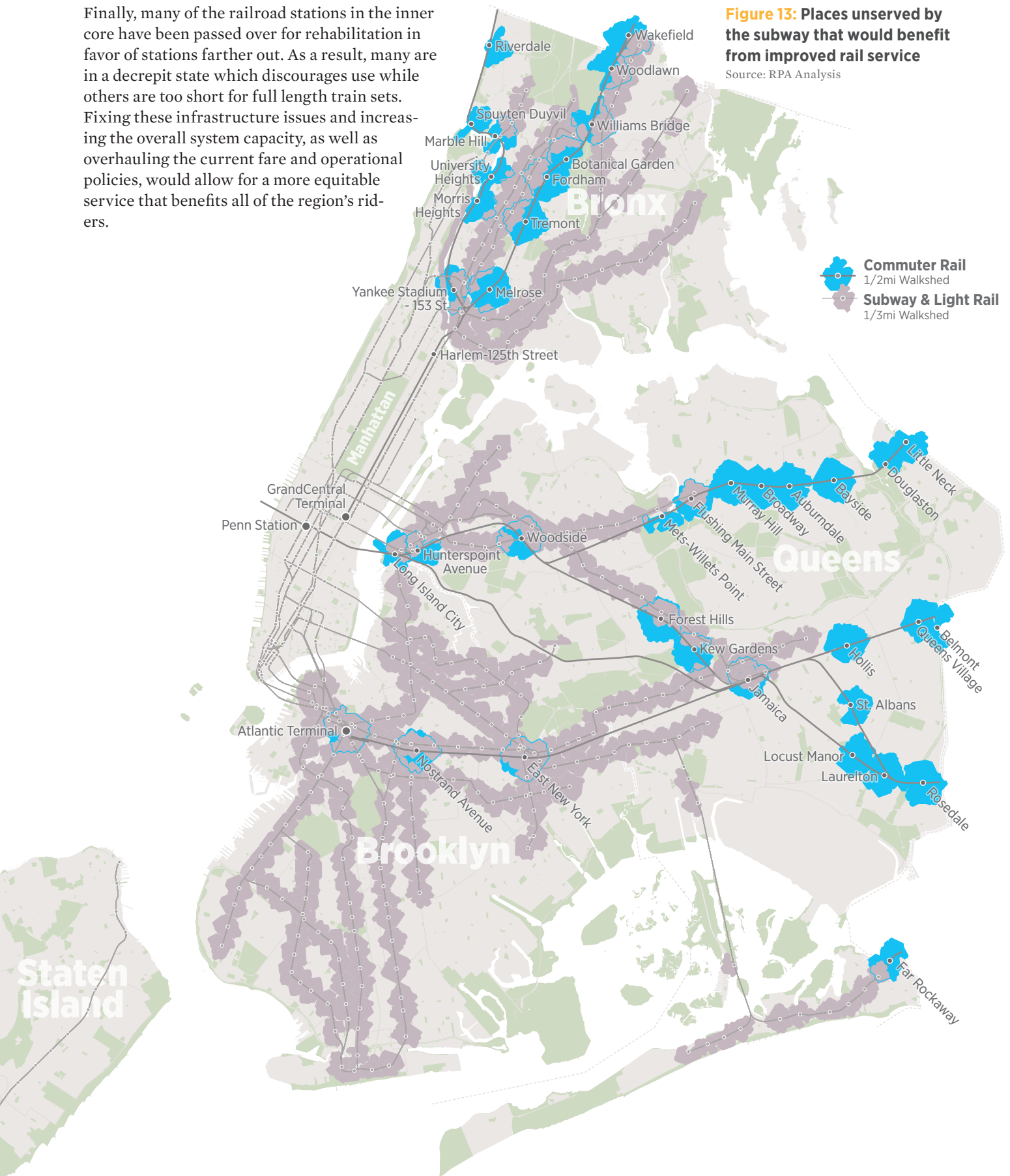
²⁰ The MTA is currently reviewing these findings and might end up revising some of these figures. The MTA's City Ticket program offers lower priced tickets for travel within New York City on Metro-North or the LIRR during the weekends.

²¹ "Freedom Ticket: Southeast Queens Proof of Concept." New York City Transit Riders Council, December 2015. <http://www.pcac.org/wp-content/uploads/2015/12/Freedom-Ticket-reduced.pdf>.

Finally, many of the railroad stations in the inner core have been passed over for rehabilitation in favor of stations farther out. As a result, many are in a decrepit state which discourages use while others are too short for full length train sets. Fixing these infrastructure issues and increasing the overall system capacity, as well as overhauling the current fare and operational policies, would allow for a more equitable service that benefits all of the region's riders.

Figure 13: Places unserved by the subway that would benefit from improved rail service

Source: RPA Analysis



Evaluation of Future Demand and Supply

The region is poised to grow substantially over the next several decades. Forecasts vary, but natural population increase, continued immigration and the region's economic assets—its diverse, high-skill workforce, several strong industries from technology to tourism, its extensive transportation network, and its position in the global economy—make it likely the long-term expansion of the region's economy and population will continue. To a large extent, the pace of growth is likely to be determined by how much housing and infrastructure capacity expands to meet expected demand. How growth will affect household incomes, health and the environment across different geographies, incomes, races and ethnicities will be affected by the type and location of new development and infrastructure.

RPA forecasts completed for the Fourth Regional Plan project that there is likely to be sufficient demand for another 3.7 million residents and 1.9 million jobs between 2015 and 2040, a rate of growth similar to what the region experienced from 1990 to 2015, but that it would take a substantial increase in housing production and infrastructure investment to meet this demand. Even at current rates of investment, the region could still expect to add another 1.8 million people and 850,000 jobs. After evaluating alternative scenarios, RPA projected jobs, housing and population in locations where new development is both likely to go and that would produce the greatest improvements in economic opportunity, health equity, affordability, energy efficiency and climate resilience.²²

A travel demand model was developed to evaluate how this projected increase would impact the demand for future public transit service. The model projected growth in work trips throughout the 31-county RPA region.

For the region to continue to grow sustainably and equitably into the 21st century, our transportation system must be able to handle almost 1.5 million work trips and an even greater number of discretionary trips.²³ The growth of the last few decades has already pushed our existing infra-

structure to the limit, resulting in increased delays and travel times. The lack of redundancy in our current system means that when riders do experience delays or outages, they have no other options for reaching their destination. If we don't expand our rail system, these delays will continue to worsen and our region's growth will be hamstrung by the inability of the region's rail system to accommodate additional trips.

These problems aren't unique to New York; other global cities have also experienced major growth in population and jobs. RPA's regional rail proposal detailed in the following sections would keep pace with the actions taken by other regions, increasing capacity and regularizing service, and allowing the New York region to comfortably accommodate its projected growth while increasing travel options, resiliency and transit access, and encouraging a shift from automobiles to rail.

The Demand Model Overview

The work trip model consists of two parts: 1) a gravity distribution model based on changes in the spatial distribution of the region's population and jobs and changes in the travel times among the 273 zones in the region and 2) a mode choice model that accounts for the relative travel times by auto and transit, on the ease of transfers within the transit mode, and on automobile tolls.²⁴ The calibrated model was applied to the demand-driven forecast described above (RPA Vision), as well a supply-constrained scenario based on current housing and infrastructure investment trends (Current Trends).

The travel demand model estimated the distribution and mode choice of work trips by auto, transit, walk, and bicycle work trips. "Trips" to work at home were also accounted for. While it would have been desirable to develop models for other trip purposes, the poor quality of the data because of limited travel surveys and modal definition resulted in reliance on the work trip model. While the trip to work and return home constitutes a minority of all trips, its

²² "Charting a New Course: A Vision for a Successful Region." Regional Plan Association, May 2016. <http://library.rpa.org/pdf/RPA-Charting-a-New-Course.pdf>.

²³ RPA's demand model only projected future work trips. However, non-work travel has been estimated through various survey such as the 2009 *National Household Travel Survey* to make-up 70% of total trip making.

concentration in the peak period and its regular occurrence makes its characteristics an indispensable tool for evaluating future travel needs. However, it is recognized that many trips to work occur in times other than the traditional morning and evening peak periods, and while some trips in the peak periods are for non-work purposes there is a growing share of trips made during off-peak times. Nonetheless, the use of a model estimate simulates, albeit imperfectly the demand in the peak periods. In the future, better survey data of trips for other purposes and of diurnal distributions of both work and non-work trips would provide the basis for more refined models.

The following describes the result of applying the models to the two 2040 growth scenarios. The projections for the number of work trips and the number of transit, auto, walk, and bike trips are provided as a baseline for how the trip to work would change by the four modes in the absence of new projects or programs, other than major transportation projects either completed since 2015 or projects that the transportation agencies have committed to complete. This baseline was used to evaluate the impact of the regional rail program detailed in this report.²⁵ Later, following the full discussion of the proposed rail projects, their impact on work trip patterns and modal choices is presented.

In Table 6 the 2015 and projected work trips for the two scenarios are shown for the region.²⁶ Today, the share of trips by transit stands at 27.1% and it will inch up to 28.5% in the Vision scenario, largely a result of the shift of population and jobs to the core and regional centers.²⁷ Even with this small shift, the number of trips using transit would grow by over a half million in the region — over a million counting the return home from work—but the auto trip growth would climb too, by almost 800,000 twice a day. However, the region’s roads, especially those in the core, are also unable to handle such a large influx of travel. Such an increase in vehicular travel would be an undesirable outcome from an environmental, public health and social equity perspective. This will result in untenable levels of congestion on the region’s roads and railways, jeopardizing long-term economic growth. To avoid pushing these trips onto the roadways the existing transit infrastructure must be improved even as we add to it judiciously to provide new connectivity and increase the effectiveness of the system. Because the impact of any new and uncommitted transit projects as well as more transit-oriented designs of communities are not accounted for in these modal projections,

²⁵ These include the Second Avenue subway Phase I which opened late last year and the LIRR East Side Access project, Penn Station Access for Metro North’s New Haven line, and the Amtrak/NJT Hudson River rail tunnel (Gateway).
²⁶ Note that the number of work trips grows by just over 1.46 million work trips for the RPA Vision scenario, which is less than the job growth anticipated of 1.8 million. The gap is explained by three factors: 4.7% of population lives in the region but works outside of it; 6.4% of people are employed in the region but live outside of it and 5% of the population holds multiple jobs.
²⁷ Note also the work at home component hardly grows. Continued changes in technology suggest that this volume will grow substantially, cutting into the shares by the other modes.

Without new transit investment, there could be half million more daily transit work trips by 2040 and almost 800,000 more auto commuters on the road each day.

Table 6: Baseline Work Trips in the Region: 2015 and Projected to 2040 Without New Transit Investments

Trips	Total	Transit	Auto
2015	9,995,254	2,709,121	6,318,072
Current Trends — 2040	10,608,553	2,921,537	6,702,426
RPA Vision — 2040	11,455,398	3,269,774	7,108,782

% by Mode			
2015	100.0	27.1	63.2
Current Trends — 2040	100.0	27.5	63.2
RPA Vision — 2040	100.0	28.5	62.1

# Change from 2015			
Current Trends — 2040	613,299	212,416	384,354
RPA Vision — 2040	1,460,144	560,653	790,710

% Change from 2015			
Current Trends — 2040	6.1	7.8	6.1
RPA Vision — 2040	14.6	20.7	12.5

Note: Transit plus auto entries do not add to “Total” since “Total” includes walk, bike and work at home trips.
Source: RPA Analysis

they represent not a forecast, but a challenge to limit auto growth by establishing transit options to attract more riders and creating transit/walk/bike oriented communities.

Demand for Travel in the Region, by Sector

To establish a baseline to explore the impact of RPA’s Vision forecast requires a look into the demand projected at greater geographic detail. In Tables 7 to 13, the trips are stratified by six markets, all affected in varying degree by transforming the commuter rail system and related improvements proposed here. These markets are also impacted by the surface transit system and subway upgrades and expansions recommended in the RPA’s Fourth Regional Plan.

The analysis begins by examining the commuter market from outside New York City to the Manhattan CBD and primarily served by the three commuter rail systems and in New Jersey, by commuter buses and PATH.

- Outside of NYC to Manhattan CBD
- Boroughs to Manhattan CBD
- Borough to Borough (other than to Manhattan CBD)
- Outside NYC to NYC (other than Manhattan CBD)

Within suburban areas alone there could be 600,000 more auto commuters in 2040. Transit service in NYC would need to accommodate 300,000 more people traveling to work in 2040 than it does today.

Table 7: Baseline Work Trips in the Region by Six Markets: 2015 and RPA Vision Projected to 2040

	Work Trip	Total	Transit	Auto
2015	SUB to CBD	510,775	386,570	123,708
	NYC to CBD	1,352,454	1,062,592	138,634
	NYC to NYC	1,956,196	855,959	743,299
	SUB to NYC	330,226	71,883	257,879
	NYC to SUB	272,189	76,684	194,409
	SUB to SUB	5,573,414	255,432	4,860,142
	Total	9,995,254	2,709,121	6,318,072
RPA Vision 2040	SUB to CBD	683,417	535,933	146,959
	NYC to CBD	1,435,046	1,134,831	133,858
	NYC to NYC	2,197,061	1,003,472	808,697
	SUB to NYC	482,331	122,364	359,340
	NYC to SUB	309,376	93,615	214,820
	SUB to SUB	6,346,773	379,029	5,444,265
	Total	11,454,005	3,269,244	7,107,938
Modal Shares 2015	SUB to CBD	100.0	75.7	24.2
	NYC to CBD	100.0	78.6	10.3
	NYC to NYC	100.0	43.8	38.0
	SUB to NYC	100.0	21.8	78.1
	NYC to SUB	100.0	28.2	71.4
	SUB to SUB	100.0	4.6	87.2
	Total	100.0	27.1	63.2
Modal Shares RPA Vision 2040	SUB to CBD	100.0	78.4	21.5
	NYC to CBD	100.0	76.1	8.2
	NYC to NYC	100.0	45.7	36.8
	SUB to NYC	100.0	25.4	74.5
	NYC to SUB	100.0	30.3	69.4
	SUB to SUB	100.0	6.0	85.8
	Total	100.0	28.2	61.9
% Change RPA Vision 2040 Over 2015	SUB to CBD	33.8	38.6	18.8
	NYC to CBD	6.1	6.8	-3.4
	NYC to NYC	12.3	17.2	8.8
	SUB to NYC	46.1	70.2	39.3
	NYC to SUB	13.7	22.1	10.5
	SUB to SUB	13.9	48.4	12.0
	Total	14.6	20.7	12.5

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

170,000 more suburbanites could travel to work in Manhattan in 2040 with greatest growth from NJ and LI; more transit capacity will be needed from those sectors to prevent a large increase in auto trips.

Table 8: Additional Work Trips from Suburbs to Manhattan CBD with RPA 2040 Vision

	Suburb of Residence	Total	Transit	Auto
2015	Long Island	120,435	89,354	31,058
	Connecticut	28,587	22,240	6,340
	HV East	76,853	55,318	21,508
	HV West	22,383	14,426	7,952
	New Jersey	262,517	205,232	56,851
	Total	510,775	386,570	123,708
RPA Vision 2040	Long Island	179,400	141,561	37,813
	Connecticut	39,312	31,279	8,025
	HV East	94,400	69,838	24,533
	HV West	25,806	17,335	8,466
	New Jersey	344,500	275,919	68,122
	Total	683,417	535,933	146,959
Modal Share 2015	Long Island	100.0	74.2	25.8
	Connecticut	100.0	77.8	22.2
	HV East	100.0	72.0	28.0
	HV West	100.0	64.5	35.5
	New Jersey	100.0	78.2	21.7
	Total	100.0	75.7	24.2
Modal Shares RPA Vision 2040	Long Island	100.0	78.9	21.1
	Connecticut	100.0	79.6	20.4
	HV East	100.0	74.0	26.0
	HV West	100.0	67.2	32.8
	New Jersey	100.0	80.1	19.8
	Total	100.0	78.4	21.5
% Change RPA Vision 2040 Over 2015	Long Island	49.0	58.4	21.7
	Connecticut	37.5	40.6	26.6
	HV East	22.8	26.2	14.1
	HV West	15.3	20.2	6.5
	New Jersey	31.2	34.4	19.8
	Total	33.8	38.6	18.8

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

Queens and the Bronx would add more trips to Manhattan CBD than the other boroughs.

Table 9: Additional Work Trips from NYC to Manhattan CBD with RPA 2040 Vision

	Borough of Residence	Total	Transit	Auto
2015	Total	1,352,454	1,062,592	138,634
	Manhattan CBD	276,066	128,801	19,218
	Upper Manhattan	249,238	209,246	21,368
	Bronx	137,100	122,865	13,802
	Brooklyn	338,257	302,252	33,686
	Queens	304,727	266,535	36,542
	Staten Island	47,066	32,893	14,018
RPA Vision 2040	Total	1,435,245	1,134,831	133,858
	Manhattan CBD	301,682	142,683	18,794
	Upper Manhattan	278,563	236,160	20,917
	Bronx	138,945	126,532	11,980
	Brooklyn	325,802	293,723	29,848
	Queens	330,525	292,637	35,881
	Staten Island	59,728	43,096	16,438
Modal Share 2015	Total	100.0	78.6	10.3
	Manhattan CBD	100.0	46.7	7.0
	Upper Manhattan	100.0	84.0	8.6
	Bronx	100.0	89.6	10.1
	Brooklyn	100.0	89.4	10.0
	Queens	100.0	87.5	12.0
	Staten Island	100.0	69.9	29.8
Modal Shares RPA Vision 2040	Total	100.0	79.1	9.3
	Manhattan CBD	100.0	47.3	6.2
	Upper Manhattan	100.0	84.8	7.5
	Bronx	100.0	91.1	8.6
	Brooklyn	100.0	90.2	9.2
	Queens	100.0	88.5	10.9
	Staten Island	100.0	72.2	27.5
% Change RPA Vision 2040 Over 2015	Total	6.1	6.8	-3.4
	Manhattan CBD	9.3	10.8	-2.2
	Upper Manhattan	11.8	12.9	-2.1
	Bronx	1.3	3.0	-13.2
	Brooklyn	-3.7	-2.8	-11.4
	Queens	8.5	9.8	-1.8
	Staten Island	26.9	31.0	17.3

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

Commutation within Queens and within Brooklyn and travel to upper Manhattan would grow the most, suggesting the need for local transit improvements.

Table 10: Additional Work Trips within NYC Boroughs with RPA 2040 Vision

Home	Work	Total	Transit	Auto
Queens	Queens	56,292	35,546	12,592
Brooklyn	Brooklyn	67,826	41,802	11,183
Bronx	Queens	10,462	128	8,837
Bronx	Brooklyn	13,316	4,163	8,702
Staten Island	Brooklyn	6,472	(1,779)	7,705
Brooklyn	Bronx	7,393	1,878	5,220
Queens	Bronx	3,924	(1,649)	4,402
Queens	Manhattan non-CBD	17,169	14,581	2,390
Staten Island	Manhattan non-CBD	4,223	2,223	1,989
Staten Island	Queens	1,519	(223)	1,700
Bronx	Staten Island	1,746	339	1,316
Staten Island	Bronx	1,148	59	1,071
Queens	Staten Island	721	(62)	731
Brooklyn	Manhattan non-CBD	7,162	6,599	524
Manhattan non-CBD	Bronx	3,355	3,029	273
Manhattan non-CBD	Queens	1,924	1,635	263
Manhattan non-CBD	Brooklyn	2,969	2,733	216
Manhattan non-CBD	Staten Island	348	209	136
Staten Island	Staten Island	3,254	2,351	(11)
Brooklyn	Staten Island	(1,323)	(1,405)	(197)
Manhattan non-CBD	Manhattan non-CBD	342	3,507	(598)
Brooklyn	Queens	3,114	3,405	(612)
Bronx	Bronx	9,854	10,660	(775)
Bronx	Manhattan non-CBD	(1,426)	466	(1,870)
Queens	Brooklyn	1,591	3,990	(2,355)
Total		223,375	134,187	62,831

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

- NYC to Outside NYC
- Outside NYC to Outside NYC

Outside NYC to the Manhattan Central Business District

In Table 8 the work trips projected for workers living in the suburban sectors to the Manhattan CBD are arrayed and organized by the geographic sectors of Long Island, Connecticut, Hudson Valley East, Hudson Valley West, and New Jersey. Today, just over one half million workers living outside the City travel to the Manhattan CBD south of 60th Street; that number is expected to swell by 34% or 172,000, mostly from New Jersey and Long Island. Much of that growth would be on transit, an increase of 39%, and much of it handled by the LIRR's East Side Access project from the east and Gateway from the west, but the growth in auto commuters would still be 23,000, or a 19% increase. Over half of these would be starting their day west of the Hudson, either in New Jersey or the New York counties west of the Hudson. While the growth will come from all sectors, addressing the capacity needs on transit and making it more attractive to the auto commuter will be necessary to handle 2040 commuters to the Manhattan CBD.

Of greatest concern is the New Jersey and Hudson Valley West to the CBD market. Currently, all of the Hudson River crossings serving this market, with the exception of downtown PATH, operate at capacity. As evidenced by the frequent delays on the XBL and NJ Transit there is hardly enough capacity to meet current demand, let alone the additional 85,000 transit riders projected to use the crossings by 2040. Further complicating matters, many of the River's transit crossings such as the North River Tunnel (NJ Transit and Amtrak) and uptown PATH are in dire need of rehabilitation because of their age and damage from Hurricane Sandy, yet there are no redundant crossings to allow them to be closed for repairs.

The Gateway project is currently being planned as a way to address the issues with the North River tunnels. However, when completed the project will not provide any immediate capacity benefits as the tunnels will be shut down for a period of years for repairs. Furthermore, the project simply parallels the existing right of way and does not do anything to increase access and does little to provide alternatives for those using PATH or buses to cross the rivers.

The other commuter rail systems—Metro-North from the north and the Long Island Railroad from Long Island — also have or will have capacity issues. Both are pursuing near term projects to help address them (Metro North's Penn Access and the LIRR East Side Access and Main Line Third Track). These projects do not necessarily add peak hour capacity — Penn Access is designed to give Metro North's New Haven line access to the west side of Manhattan and will exacerbate Penn Station capacity problems, while reducing the capacity problem a bit at Grand Central

Terminal. The third track is primarily aimed at adding reverse service not now possible. Only East Side Access adds capacity, expanding services to Grand Central Terminal. But the added demands in the peak from the north and east will necessitate further capacity expansion. Without additional investment it is unlikely that the railroads will be in a position to handle the projected increase in usage and attract some auto users without experiencing service degradation.

The Boroughs to the CBD

Although the needs of intra-NYC to the CBD and within the boroughs are largely treated in the other RPA recommendations for improved subway and surface transit, transit in these markets can be supplemented by the regional rail network. In Table 9 the 2015 and the 2040 RPA Vision projections for work trip to the Manhattan CBD from the five boroughs are shown. The first section of the table summarizes the totals for all five boroughs to the CBD and the remaining sections detail each borough, separating upper Manhattan and the CBD. Currently, 76.1% of all trips are on transit,²⁸ and are projected to remain at that level absent any changes in the transit network. Auto trips will drop slightly and walking and biking will grow faster, a result of further densification in the CBD. More transit capacity will be needed. In absolute terms the increase in transit trips will be greatest from Upper Manhattan, followed by Queens, the CBD, Staten Island, and the Bronx. These needs represent a challenge that could be addressed in part by augmenting the subway network in the city by leveraging its underused commuter rail system that runs through almost all of the places noted above.

Borough to Borough Trips (other than to Manhattan CBD)

While the number of work trips to the Manhattan CBD will grow by over 250,000 — 80,000 from inside the New York City and 173,000 from outside, an almost equal number of trips (223,000) will be added for trips within and among the five boroughs, as shown in Table 10. Travel between the outer boroughs in New York City is a market which for too long has been neglected by the rail network. The subway system is oriented to carry people to and from Manhattan while the commuter rail system orients its scheduling and fare structure to suburban users, with few stations and little service within the boroughs. Under the RPA Vision development scenario, much of the City's growth in jobs and population is allocated to centers within the boroughs like Downtown Brooklyn and Jamaica. This scenario projects that 134,000 additional trips would be added by transit, but that requires the regional rail, subway and bus transit be provided and made more attractive to serve this market. Moreover, with 62,000 auto-based work trips projected, transit upgrades would have to attract much of that auto market too.

²⁸ This is somewhat deceiving, brought down by the high share of walking trips for people living in the CBD. Transit shares from Upper Manhattan, the Bronx, Brooklyn and Queens range from 84% to 90%.

Suburban work trips into the four (non-Manhattan) boroughs are largely made by autos today, but an added 150,000 trips in these markets will require better transit options to prevent worsening auto congestion.

Table 11: Additional Work Trips from Suburbs to NYC Boroughs with RPA 2040 Vision

Home	Current		2040 RPA Vision		Added 2040 from 2015			
	Total	% Transit	Total	% Transit	Total	Transit	Auto	% Transit
Long Island	154,935	16.2	207,815	20.2	52,880	16,932	35,939	32.0
Connecticut	7,369	32.6	12,275	35.9	4,906	2,000	2,906	40.8
Hudson Valley East	58,657	21.2	90,542	22.8	31,885	8,214	23,546	25.8
Hudson Valley West	22,205	18.6	28,464	20.4	6,259	1,689	4,570	27.0
New Jersey	87,060	32.0	143,234	34.6	56,174	21,646	34,500	38.5
Total	330,226	21.8	482,331	25.4	152,105	50,481	101,460	33.2

Note: Transit plus auto entries do not add to “Total” since “Total” includes walk, bike and work at home trips.

Source:

“Reverse” trips from NYC to Suburbs will grow slowly, but better transit could increase the # of trips and % of trips by transit.

Table 12: Additional “Reverse” Work Trips from NYC to Suburbs with RPA 2040 Vision

Sector	Current		2040 RPA Vision		Added 2040 from 2015			
	Total	% Transit	Total	% Transit	Total	Transit	Auto	% Transit
LI	110,354	21.5	127,367	23.4	17,013	6,080	10,972	35.7
CT	8,952	33.1	9,568	34.9	616	371	245	60.2
HV-E	57,091	24.8	58,706	26.8	1,615	1,553	153	96.1
HV-W	4,913	17.8	8,887	15.2	3,974	474	3,499	11.9
NJ	73,056	34.5	80,681	36.7	7,625	4,387	3,261	57.5
Total	254,366	26.3	285,209	28.0	30,843	12,865	18,130	41.7

Note: Transit plus auto entries do not add to “Total” since “Total” includes walk, bike and work at home trips.

Source: RPA Analysis

In Table 10 the borough to borough volumes are shown ranked by the added number of auto trips expected. The greatest growth in the borough pairs are within the boroughs and in adjacent pairs on the Bronx, Queens, Brooklyn, Staten Island axis. More than half of the anticipated transit growth is within the boroughs of Queens and Brooklyn, and while it is expected that RPA’s recommendations for surface transit and the subways will contribute to a shift to transit use in the boroughs, leveraging and augmenting commuter rail in the boroughs, with more trains stopping within the boroughs, would shift more commuters to transit as well.

Outside NYC to NYC (excluding the Manhattan CBD)

The market from the suburbs to New York City (other than to the Manhattan CBD) presents a unique challenge. Suburban residents are accustomed to driving. The transit system, particularly the commuter rail network is oriented to getting suburbanites to Manhattan. Not surprisingly, as shown in Table 11 only a little more than one in five in this market ride transit now, and although the share will grow

to about one in four as regional centers and more compact development takes hold, the auto volumes are likely to grow too, which will further clog both suburban and urban highways. These markets are primarily between suburban counties adjacent to New York City — Nassau to Queens and Brooklyn, Westchester to the Bronx, and the close in New Jersey counties to upper Manhattan. A regional rail system could be designed to serve these markets while serving the Manhattan CBD too.

The Reverse Commute to the Suburbs

The work trip data for a far smaller market, the reverse commute from NYC to the suburbs, is arrayed in Table 12. Only 30,000 additional trips are at stake and today, only a quarter of them are on transit. As with the “inbound” commutes to NYC from the suburbs, a regional rail system that used existing commuter rail infrastructure, with more frequent and swifter service could capture a higher share of the market.

Intra-Suburban Market

The last market in the region, the suburban to suburban work trip is the largest and represents the biggest challenge: over half of the 10 million work trips in the region are within and between suburbs, and as shown in Table 13, most are by automobile, and that will be very difficult to change, with auto trips to work growing by almost 600,000. The saving grace is the size of the market: it makes a massive target for transit service that can connect the suburb to the regional centers with job concentrations. As shown in Table 13 the sectors that can capture the largest growth in transit are the sectors with more traditional downtowns embedded in the suburban landscape, like the Hudson Valley east, New Jersey and Connecticut. A regional rail network could build on that as well.

Work travel within suburbs is likely to remain mostly by auto, but better transit options along with increased vehicle occupancy rates (on-demand pooling services) could give people a better choice and help keep road congestion in check.

Table 13: Additional Suburbs Only Work Trips from with RPA 2040 Vision

	Suburb of Residence	Total	Transit	Auto
2015	Long Island	1,036,180	26,858	938,272
	Connecticut	805,304	28,419	709,350
	HV East	429,616	17,837	363,922
	HV West	303,335	2,538	268,295
	New Jersey	2,806,303	170,256	2,397,444
	Total	5,573,414	255,432	4,860,142
RPA Vision 2040	Long Island	1,132,503	36,070	1,018,869
	Connecticut	921,800	42,133	801,376
	HV East	491,546	29,146	408,986
	HV West	328,376	3,442	289,154
	New Jersey	3,244,205	254,441	2,711,660
	Total	6,346,773	379,029	5,444,265
Modal Share 2015	Long Island	100.0	2.6	90.6
	Connecticut	100.0	3.5	88.1
	HV East	100.0	4.2	84.7
	HV West	100.0	0.8	88.4
	New Jersey	100.0	6.1	85.4
	Total	100.0	4.6	87.2
Modal Shares RPA Vision 2040	Long Island	100.0	3.2	90.0
	Connecticut	100.0	4.6	86.9
	HV East	100.0	5.9	83.2
	HV West	100.0	1.0	88.1
	New Jersey	100.0	7.8	83.6
	Total	100.0	6.0	85.8
% Change RPA Vision 2040 Over 2015	Long Island	9.3	34.3	8.6
	Connecticut	14.5	48.3	13.0
	HV East	14.4	63.4	12.4
	HV West	8.3	35.6	7.8
	New Jersey	15.6	49.4	13.1
	Total	13.9	48.4	12.0

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

A Plan for Transforming the Region's Commuter Rail Network

Today, the region's commuter rail system struggles to provide a reliable and frequent service. RPA proposes to reorient and transform the region's conventional commuter rail network to better serve the needs of a variety of users and to attract more riders to rail. This new regional rail network, which would include policy changes, capital investments to expand capacity, and entirely new service offerings, would be called the Trans-Regional Express or T-REX.

T-REX offers the potential to broadly improve rail transit access and mobility across the entire region and focus improvements on many corridors, cities and portions of the region that lack good transit connections and that do not perform as well economically as the core or the traditional commuter suburbs. At the same time, the T-REX concept remedies the many service and equity deficiencies of the current commuter rail system. A regional rail system would serve a similar geography, but would feature services that are reconfigured to better accommodate the growing market of non-traditional peak trips, a more equitable fare structure, greater capacity to support projected growth while maintaining reliable service, more direct access to major employment centers, and through-running to better connect all sectors around the core of the region. Such a system is not unique; many railroads in other countries adhere to this kind of thinking when planning their systems.²⁹ These railroads provide a through-running service with more frequent and predictable headways throughout the day and not one predominately oriented towards maximizing throughput for just a handful of hours in the morning and afternoon.

The T-REX concept was developed to meet specific objectives and adheres to the Fourth Regional Plan's goals for a more prosperous, equitable, healthy and sustainable region. These objectives, as detail in the following list, would make the region more productive and competitive by reducing travel times, making more efficient use of land and labor, and improving the attractiveness of the region as a place to live and work. They would result in a region where more people have access to more job opportunities and can afford reliable and convenient transportation. People would walk

more, have less stressful commutes and breathe cleaner air. Fewer greenhouse gases would be emitted from cars and trucks and the region would use less energy per person.

- ▶ **Achieve regular and more frequent patterns of service:** Move towards a headway based service so travelers know they have a train coming rather than a schedule-based approach where they depend on catching a train at a specific time making service more convenient and less anxiety inducing.
- ▶ **Ensure sufficient capacity exists to meet anticipated demand AND maintain sustainable/reliable headways:** Instead of operating on the edge of the system's practical capacity, create enough transportation capacity to exceed expected demand to provide an operating cushion and buffer to absorb some additional growth beyond a project's design year.
- ▶ **Provide more direct access within major employment centers:** Limit the need for regional rail users to transfer to local transit, allowing them to instead walk or bike their "last mile."
- ▶ **Create links that foster through-running and better connections between regional centers:** Create new services that "punch" through the congested core to improve mobility through Manhattan to all sectors, reducing the need for auto trips and focusing on increasing intra-regional mobility at all times instead of only to the CBD at peak periods.
- ▶ **Establish limited stop patterns focused on important regional hubs:** Support and connect vital regional centers, better connecting them with each other and the region population and encouraging more dense development.
- ▶ **Provide for greater redundancy and resiliency:** Eliminate single points of failure in the network, places with little excess capacity or redundant connections, which can cause system wide disruptions when they fail.

²⁹ Examples include Zurich's S-bahn, Berlin's Regionalbahn, Paris' RER, and others.

- **Rationalize service and fare policy to maximize the use of the system and further improve access:** Create a more equitable and affordable rail system for urban and inner ring intra-suburban commuters.
- **Incorporate “best practices” from peer cities that have modernized their commuter rail network to serve both traditional commuter and urban users:** Evaluate and adopt innovative and proven practices from projects and systems such as the Elizabeth Line in London, RER in Paris and Tokyo’s integrated commuter and metro system.

The success of this proposal hinges on a governance model that will enable the integration and coordination of services, create a rational regional fare structure, and safeguard proper funding for expansion and maintenance projects. There are multiple ways of accomplishing this, including combining the three railroads into one entity or creating a fourth “umbrella” entity responsible for coordinating the operational policies and capital investments of each system. However, the most critical aspect of governance reform is that from the customer’s perspective the operation and design of the system appear seamless, specifically, the system’s wayfinding, scheduling, and fares must all appear the same to riders no matter their location in the region.

The Elements of “Regularized” Service

The T-REX system would regularize service to provide consistent and predictable headways throughout the day. It would feature some baseline level of service that exists throughout the course of the day, such as a train every 15 minutes (4 trains/hour) all day in both directions on major branch lines and a train every 5 minutes (12 trains/hour) on trunk lines within the core of the region.

Scheduling services with regular train intervals makes the service simpler for operators to run and for passengers to use. From the passenger point of view, having a regularized schedule provides a level of confidence that a train will show up at the station at a predictable time. Thus, it is easier to have a more flexible travelling schedule since there is no danger of missing the “last train” or the train which makes a required connection. Furthermore, running a regularized service allows for operators to provide more sensible transfers to other lines and services as trains arrive on a predictable schedule. From an operator’s standpoint, running a regularized service decreases the logistical complexities associated with running a railroad. By making train movements predictable and reducing the

variety of unique service patterns, operators can reduce the number of conflicting movements and increase their ability to respond to unforeseen service disruptions.

Service Layering

The additional peak service that is added to the baseline regularized service plan is called service layering. Service layering adds trains to the baseline service levels to meet a period of intensified demand (e.g. the peak commute or a sporting event). However, unlike the current service planning paradigm where this demand is typically met through additional trains fit into a non-predictable slot, possibly with a new stopping pattern, this additional service is provided in a regularized fashion which decreases the schedule’s headways. A hypothetical regularized service plan with layering might run trains every 15 minutes all day in both directions (4 trains/hour) with an additional 4 trains per hour during “layered” during the peak period in the peak direction to cut the headway in half (8 trains/hour) to 7.5 minutes. Such a simple plan is a stark contrast to current service planning which aims to maximize each train’s utilization under the assumption that people will only make one trip inbound and one trip outbound in a day. Thus, little attention is paid to creating a service which facilitates additional trips as each passenger has their “train” (e.g. the 8:07AM express) which best suits their commute that they take every day. Such layering schemes can result in a “flatter” peak but it is typically one that can be maintained for a longer period of time.

Service Hierarchy

T-REX also incorporates the concept of service hierarchies. Currently, many trains are run with unique service and stopping patterns that can make it hard for passengers to identify if a train is a local or express and which stops it services. Instead of this framework, the regional rail network provides a hierarchy comprised of three service types (described in further detail below) which will provide a more transit-like service in New York City and the inner suburbs, a zonal express system similar to the current commuter rail service in the outer suburbs, and an inter-regional service that will provide connections between major regional centers and serve longer-distance travel markets within and beyond the New York region. These three services will overlap each other to allow for easy connections and provide a simple yet robust level of service throughout the region.

Defining Service Zones

A set of four geographic service zones were defined as the basis for determining the appropriate characteristics for the new T-REX service. The zones help to define the elements of regularized service where a rider will always know what service level they can expect based on their location and the time of day. The zones were created after

Table 14: Service Zone Characteristics

Ring	# Stations	Service Area*	2015 Population Density	2015 Job Density	2040 Population Density	2040 Job Density	Avg Weekday Boardings	Avg Distance (mi)	Land Use
1	47	17.39	34,896	42,044	42,199	50,887	171,147	10.55	Urban
2	137	765.20	7,195	3,035	8,529	3,656	235,620	21.35	Inner Suburban
3	151	1,910.92	2,476	1,475	2,936	1,680	168,181	39.55	Outer Suburban
4	52	883.35	1,080	501	1,262	569	12,150	69.48	Exurban
Total	387	3576.86	3,298	1,765	3,910	2,068	587,098	33.67	NA

*1/2 mi walkshed for zone 1, 5 mi drive shed for 2, 3, 4

Source: RPA Analysis

an examination of the characteristics of all of the commuter rail stations in the region including the current and projected population density of the station's commute shed, average weekday boardings, and distance from the region's core. After identifying service zones based on current land use and service characteristics, they were modified to represent RPA's vision for how the region should develop and how service should be structured. The four distinct groupings among the region's rail current stations, detailed in Table 14, are:

► **Zone 1:** The inner core. This zone is comprised of stations in New York City or the urban portions of Northern New Jersey. These areas are quite dense and many stations in this zone may overlap with other mass transit systems such as the subway or PATH, which offer frequent but more local (slower) service.

- Average (current) travel time to Terminal in New York City: 29 minutes
- Example Stations: Fordham, Jamaica, Newark Penn

► **Zone 2:** The "older" inner suburbs. This zone is comprised of the closer in towns that sprung up along the newly built rail lines during the late 1800's and early 1900's. They are typically denser, more walkable, and oriented around the local rail station. Most trains serving these stations are local trains that originate at the inner portion of Zone 3.

- Average travel time to Terminal in New York City: 47 minutes
- Example Stations: Pelham, Laurelton, Walnut Street (Montclair)

► **Zone 3:** The "newer" outer suburbs. These towns were developed in the 20th century after the rise of the automobile. They are typically less dense than Zone 2 towns and are much more decentralized. Many stations in this region are large park-and-ride stations meant to draw riders from a large commute shed who reach the station via personal automobile. Stations in this zone typically feature express train service to reduce the time required to reach New York.

- Average travel time to Terminal in New York City: 77 minutes
- Example Stations: Bridgeport, Ronkonkoma, Aberdeen-Matawan

► **Zone 4:** Exurban areas. These towns are lower density communities or regional centers which are not as well connected to the region's core and New York City. Residents of these areas may not commute every day and instead use the system to travel to New York as necessary.

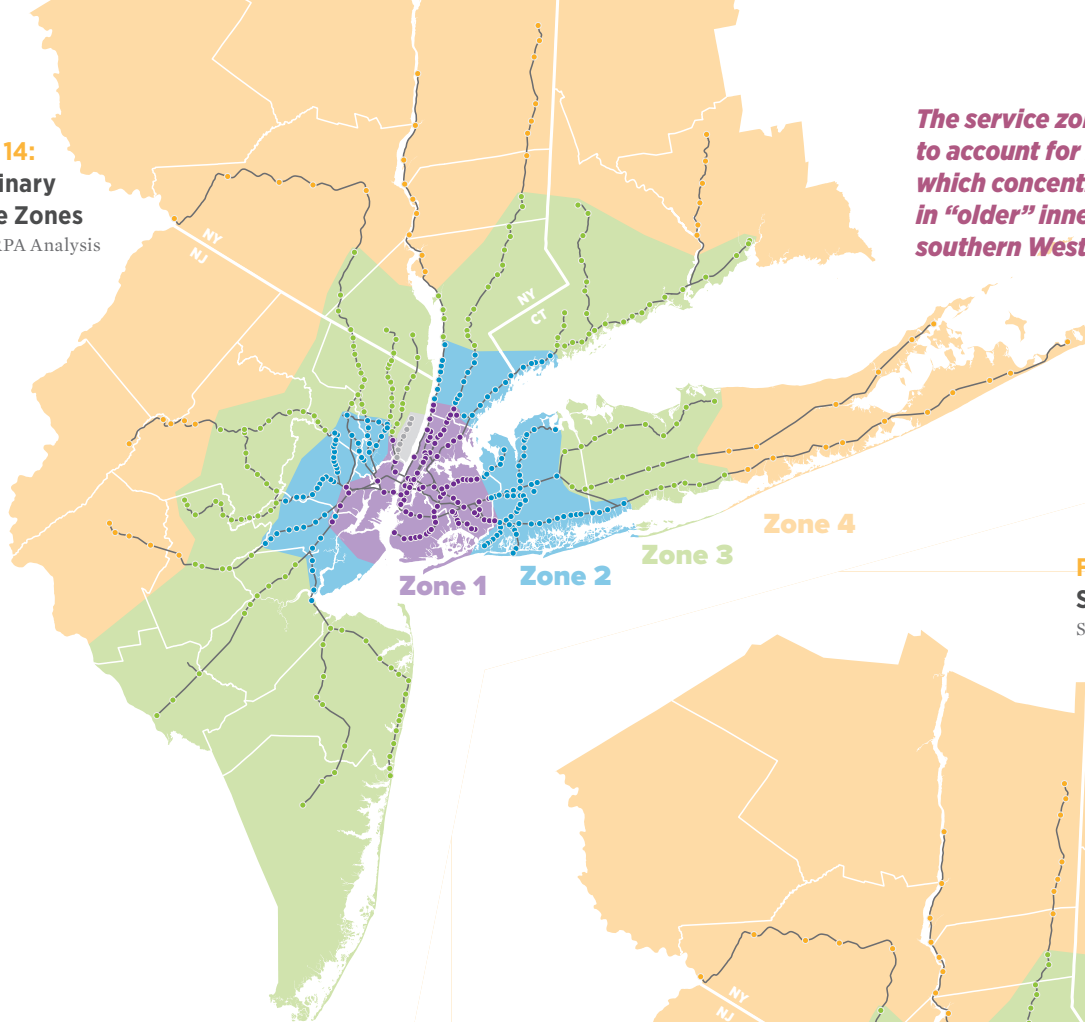
- Average travel time to Terminal in New York City: 125 minutes
- Example Stations: Peekskill, Montauk, Netcong

As is evident from Figure 14, the zones are organized as approximately concentric zones radiating from the region's core (New York City). As one progresses out through these zones, there is a clear decrease in population and job density which is well correlated with the mean distance from New York for the stations in each zone.³⁰ This decrease in job and population density provided a natural scale on which to create the zones since the ability of a station to support a higher level of rail service is strongly related to the intensity of the surrounding land uses.

The mean weekday boardings for the stations in each zone deviate from these correlations. The number of average weekday boardings for the 47 stations in Zone 1 is only slightly higher than the number of boardings for Zone 3 and much less than the number for Zone 2 despite Zone 1 being the zone closest to the core and with the highest densities. The likely explanations for the lack of ridership include the lower levels of service given to Zone 1 stations, which are typically skipped over by express trains heading for Zones 2 and 3, and in some cases the availability of subway service. Additionally, fares at the stations are much higher than subway or PATH fares which discourage riders with access to those systems from using the regional rail. Changes to address these issues are discussed in the headways and fare structure of RPA's proposed service.

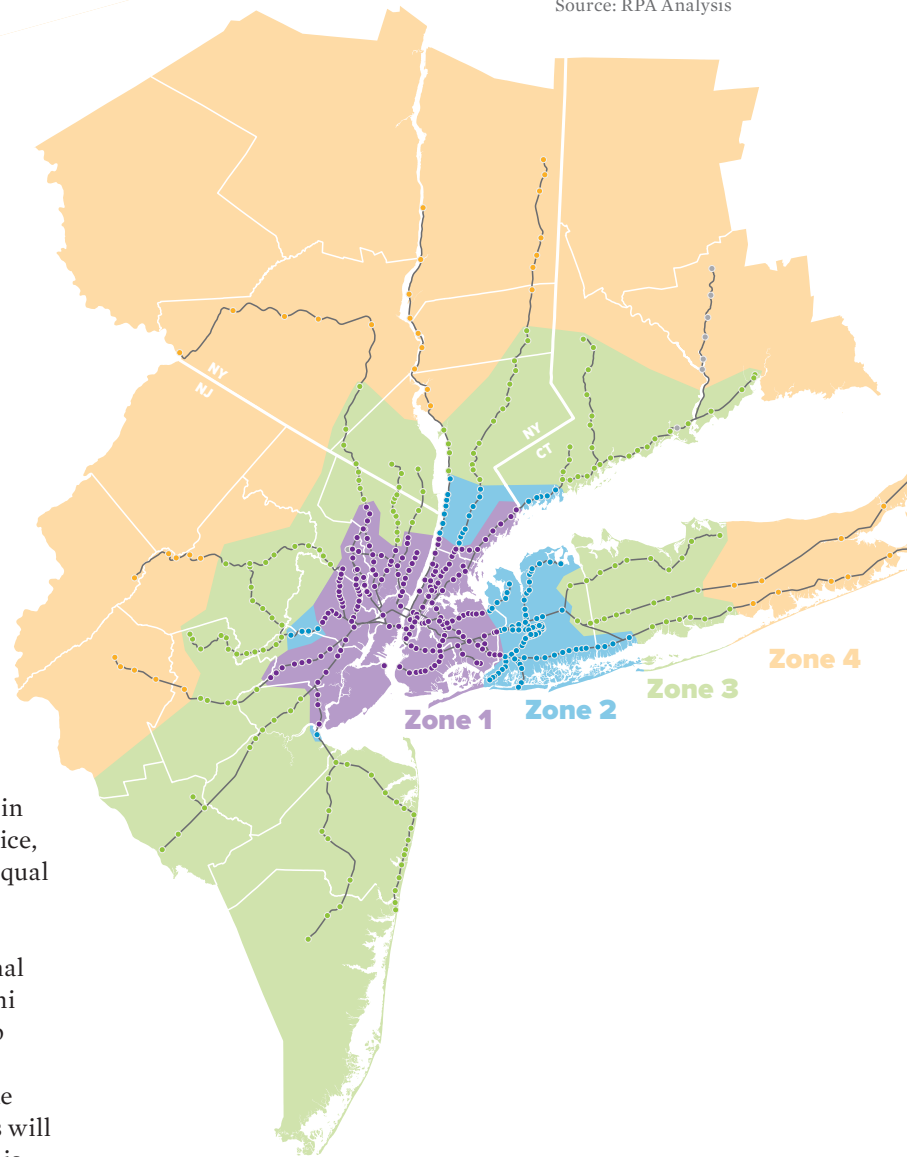
³⁰ Calculated to the proper terminal (GCT or NYP) for each railroad.

Figure 14:
Preliminary
Service Zones
Source: RPA Analysis



The service zones were adjusted to account for RPA's 2040 Vision which concentrated more growth in "older" inner suburbs of NJ and southern Westchester county.

Figure 15: Adjusted
Service Zones
Source: RPA Analysis



Under the RPA Vision scenario, a large portion of the region's population and job growth will be concentrated in the region's inner urban core making it natural to target this area with an increased level of service. To support this, Zone 1 was expanded as shown in Figure 15 to encompass more of Northeastern New Jersey and Southern Westchester. These areas, especially Northeastern New Jersey (e.g. Hudson and Essex Counties), are already relatively dense urban environments and are capable of supporting additional growth. However, many parts have poor transit connections and service to major centers in the region which constrains their growth. By placing these areas in Zone 1 it will provide them with a new metro-like service, enabling an expansion of the urban core to an almost equal extent on both sides of the Hudson.

There are, of course, some outliers in the proposed zonal framework. Hub stations like Stamford and line termini like Poughkeepsie tend to see higher levels of ridership than one would expect from a typical station in their designated zones. For the purposes of this proposal, the provision of additional service to these special stations will not be addressed. However, as the regional rail system is adopted a more in-depth study of the appropriate service levels should be pursued. While the distinctions are not absolute, and there is much variety throughout the region, the above zonal system provides a useful framework within which to construct a proposed service plan.

Service Plan for T-REX

This service plan is at the very core of RPA's T-REX proposal. Before determining what physical infrastructure is required it is essential to define the how much and what kind of service is envisioned for the future. RPA developed its service schemes by considering inputs such as changing travel behavior (the future of work) and the output from RPA's regional demand model. Service in other major cities outside of the New York region was also assessed and used as a reference. Finally, new service frequency standards were set, with three tiers of service defined; new fare policies were discussed along with complementary technologies that would help support the three T-REX services.

How Peer Cities Set Their Headways and Orient Their Commuter Rail Infrastructure

Service frequencies for each zone were determined through an examination of the rail systems of New York's global peer cities to indicate what frequencies are feasible with regards to physical infrastructure as well as consideration to the demand induced from switching from an infrequent schedule or demand-based service to a more frequent headway-based one. Finally, the service frequencies were formulated around the zonal framework described in the previous section.

Demand based schedules are services which attempt to meet specific periods of demand with a scheduled train or set of trains. They result in service with lower frequencies where passengers look at the clock to time their arrival with a specific train. These services are generally perceived by riders to be the most inconvenient since they must budget additional wait time to ensure they don't miss their connection. Headway based schedules, an alternate way of thinking about service frequencies and scheduling, allow riders to show up at a station without consulting a schedule under the assumption that the next train will arrive relatively soon. Specifically, headways are the intervals of time between trains as they travel along their route. For example, a route which has six trains per hour would have 10

minute headways (assuming the trains were evenly spaced) with an average wait time of just five minutes (assuming riders arrive in a uniform manner). The exact headway length at which passengers tend to rely on schedules to plan their trips is not precisely known but generally appears to be between 10 and 15 minutes depending on other service qualities such as reliability and ease of access.³¹ For services with scheduled headways of 10 minutes or less, passengers tend to show up at their stop randomly under the expectation that a train will arrive shortly.³²

Many of New York's peer cities such as London, Madrid, and Paris have or are constructing transit systems which focus on providing frequent service throughout the day. The regional rail systems of each of these cities feature branching lines that funnel into and run through a shared corridor in the regional center to provide a metro-like service. Doing so allows for lower headways (more service) in the region's core while allowing operators to avoid having to store all of their trains near the core in anticipation of the evening commute. It also provides more direct access to a greater number of destinations within the city than a traditional terminal, in many cases eliminating the need for riders to transfer to a local transit service to complete the last leg of their journey.

Table 15 is used as guidance to identify reasonable core headways for the T-REX system. Specifically, a headway of at least ten minutes in the peak is robust enough to provide a relatively metro like service in the core³³ without requiring an exorbitant level of resources. This core headway was then extrapolated out using the zonal system as a way to categorize service levels by relating density and service.^{34,35,36}

³¹ "Transit Capacity and Quality of Service Manual, 3rd Edition." Transportation Research Board, pg. 4-28. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_165ch-04.pdf.

³² Ibid.

³³ When layered with other services this would result in core headways of 2-3 minutes during the peak

³⁴ PTALUP

³⁵ "Transit and Urban Form." Volume 1. Transportation Research Board, TCRP Report 16. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_16-1.pdf.

³⁶ "Transit-Supportive Densities and Land Uses: A PSRC Guidance Paper." Puget Sound Regional Council, February 2015. <https://www.psrc.org/sites/default/files/tsdluguidancepaper.pdf>

Table 15: Comparative Headway Analysis

City	Metro Density	CR Ridership	Current Stations CR	Route Miles	Regional Rail System/Line	Core Headways (min)	Through Running
London	635	124,600,000	84	86	Cross Rail (under construction)	2.5	1
Madrid	796	179,900,000	92	384	Cercanías C4	6	1
Paris	992	1,190,000,000	448	1,484	RER A	2	1
Tokyo	6,028	5,816,000,000	714	2,536	JR East, Keihin-Tohoku-Negishi Line	2-3	1
Vienna	574	108,100,000	50	91	Schnellbahn-S1	5	1
New York	667	261,114,703	399	1,758	MTA/NJT	Clock based	0

Source: RPA Analysis

Table 16: Proposed Headways by Service Zone and Time of Day

Service Type	Time Period	Headways by Zone			
		1	2	3	4
Peak, Traditional	7-10am Inbound, 4-7pm Outbound	10	12	20	30
Peak, Reverse	7-10am Outbound, 4-7pm Inbound	10	12	20	30
Midday/Evening/Early Morning	5am-7am, 10am-4pm, 7pm-11pm, Outbound/Inbound	15	15	30	45
Late Night	11pm-5am, Outbound/Inbound	15	15	30	45
Weekend Service	7am-11pm	15	15	30	45

Source: RPA Analysis

Setting Headways, New Standards for Regional Rail

In extrapolating the core headway to the entirety of the T-REX system, a few guiding principles were followed. First, non-traditional commutes (reverse direction) should have a comparable headway to the peak direction. Second, mid-day and off-peak service should only decrease slightly from peak service levels to encourage use of the system for discretionary trips. Third, the stations in zone one will have levels of service equivalent to the rest of the system (or even better) rather than being skipped over as they currently are.³⁷ Finally, weekend service should be comparable to that available midday during the week to allow for the system to accommodate the many discretionary trips that occur over this period.

These principles led to the development of the headways in Table 16. When organized by the zonal and temporal groupings, a simple and easy to remember matrix is created which lets a rider quickly determine what level of service they should expect based on time and location.

The proposed headways for T-REX are aggressive, in some cases they are more frequent than some subway routes in zone one (an issue that will be addressed in RPA's analysis of the subway system). This is intentional and meant to make the system more similar to a metro rather than the current system which is oriented around serving suburban

riders during the peak of the peak. Doing so allows riders to make use of T-REX throughout the day for work or discretionary travel without adjusting their schedule to match the train.

The Three New Services

To facilitate these new standardized headways three different services were developed that would run on the regional rail network.

Metro (M)

The Metro is a rapid transit-like service which reaches beyond the bounds of New York City into Hudson County and the inner suburbs of New Jersey and New York. The Metro supplements the subway and PATH within the urban core, introduces rail service to several of the “transit deserts” and under-served parts of the outer boroughs of New York City, provides more frequent and regular service to the inner suburbs, and provides improved reverse-commuting opportunities from the urban core to suburban employment centers. Within the Manhattan core and crossing the Hudson and East Rivers, Metro service would operate on three new dedicated trunk line tunnel routes, which form the system's supporting pillars. On the multi-track railroad main lines approaching the core, Metro service would take over the local tracks and serve a combination of existing and new local stations. Further afield, several existing commuter branch lines would be converted to Metro, filling out a network that would fully cover the most densely-populated areas of the region.

³⁷ The RPA Vision concentrates a large amount of residential and job growth in these areas. These populations and jobs will require a higher level of transit service which cannot be met by the current subway system.

The Metro would complement the existing rapid transit services in the region (NYCT, PATH, etc.) by functioning as a “super express” service in Manhattan while providing robust and frequent service to the surrounding areas, replacing the infrequent and expensive commuter rail services. This would be a dramatic upgrade in frequencies for many of these areas. Furthermore, the service could be provided to some areas that do not currently have rail service by reactivating old right-of-ways and co-mingling with freight lines, such as in Bergen and Passaic counties. Many places with poor, indirect or non-existent rail service would now end up “on the transit map” of the region, including:

- The three Metro trunk lines and the rail network feeding them are shown in Figure 16. They include:

- ### Figure 16: Metro Service Map

Source: Regional Plan Association



CONNECTICUT

- Jersey Loop

- Northern leg crossing Hudson River in tunnel from Union City/Weehawken to 57th Street
- Northern branches to Yonkers/Tarrytown, Mt. Vernon/White Plains and New Rochelle/Port Chester
- Southern leg crossing Hudson River in tunnel from Hoboken/Jersey City to Houston Street
- Southern branches to Plainfield, Montclair, Bergen County Line and Pascack Valley Line
- Parallel to East Midtown Spine along Third Avenue between 57th Street and Houston Street

Each Metro branch would have service at 15-minute intervals all-day long, with additional peak service as warranted by demand. The trunk lines through the core would be served by at least three branch lines on each end, resulting in all-day headways of five minutes or better. The trunk lines would support service at headways of 2.0 to 2.5 minutes during the peak periods.



Regional Express (RX)

The Regional Express (RX) would be a service which would replace today's commuter rail services, overlaid on top of the Metro service. On multi-track segments of the rail network, such as the Northeast Corridor in NJ, the LIRR Main Line, the New Haven Line, and on portions of the Hudson and Harlem Lines, the Regional Express service would run on the express tracks parallel to the Metro running on the local tracks. On the longer two-track branch lines, Metro and Regional Express trains would share the tracks and would be scheduled to avoid operating conflicts.

RX trains would serve the same geographical extent as the current commuter rail services but feature a slightly different zonal stopping pattern to help improve headways and expand the range of trips served. Rather than the current peak service, which features trains that serve suburban zones but then operate non-stop or with very limited stops to either Penn Station or Grand Central, all RX trains would stop at selected hub stations within the urban core and inner suburban zones (zones 1 and 2) so that riders

Figure 17: Regional Express (RX) Service Map

Source: Regional Plan Association





could take trips within zones easily or take trips between zones by simply riding to the correct hub station and transferring to the desired train.

The RX and Metro services would be overlaid in the region's core and the RX would only stop at major stations along these sections of track. This will provide the opportunity for passengers in farther out areas of the region to take a RX train and then make a simple in-system transfer to the Metro as they enter the region's core to reach their final destination. Such a transfer would avoid forcing customers to wait for the correct express train based on their destination, a situation which will be faced by LIRR riders once East Side Access opens.

All RX trains via Penn Station or using the Jersey Loop or Midtown Spine would run through the core. Selected trains, including those that run off-peak, would provide service on both side of the core. Other trains during peak periods would operate through the central core but would terminate or originate at storage yards on the far side of the core area, resulting in smooth operations and maximizing throughput capacity of the system.

All suburban commuter rail lines, with the exception of a few branches with very light demand, would have RX service, with service frequencies as good or better than current service. Long Island RX trains would operate via both Penn Station and the East Side Access connection to Grand Central. Metro-North RX trains would operate both to Grand Central via existing routes and via Penn Station, with selected peak trains also using the Manhattan Spine route. New Jersey RX trains would operate via Penn Station and would also operate via the Jersey Loop. Many places currently served by commuter rail would have more frequent and regular service, with both all-day Metro service and peak-focused RX service:

- ▶ Elizabeth, Rahway, Perth Amboy, New Brunswick, Westfield, Plainfield, South Orange and Montclair, NJ
- ▶ Hempstead, Valley Stream, Far Rockaway, Long Beach, Great Neck and Port Washington on Long Island
- ▶ Yonkers, Mt. Vernon, New Rochelle and Port Chester in Westchester County

Trans-Regional Limited (TRL)

A third class of rail service, the Trans-Regional Limited (TRL), will fill the gap that currently exists between today's Amtrak intercity services (i.e., the Northeast Regional and Acela Express) and commuter rail. It will operate across the entire region and, in most cases, extend beyond the commuting territory to adjoining regions — Philadelphia to the south, Albany to the north and New Haven and Hartford to the northeast. It will offer regular service and transit-like headways during peak periods (every 15 minutes on the main routes)

The TRL will have faster average speeds than commuter rail, and lower fares than Amtrak. The TRL would serve all major hub stations within the region — the same hub stations served by RX trains — providing simple and easy connections to both the RX and Metro. However, the TRL will not serve non-hub Metro or RX stations to increase average train speeds and provide an expeditious trip between regional hubs.

This service would functionally integrate the region's major cities and downtowns by creating a new service where, for all intents and purposes, one does not currently exist. For example, to travel between Newark and New Haven currently involves two rail trips and a transit trip in Manhattan, each with their own fare or an expensive ticket on the infrequent Amtrak intercity service. The TRL will

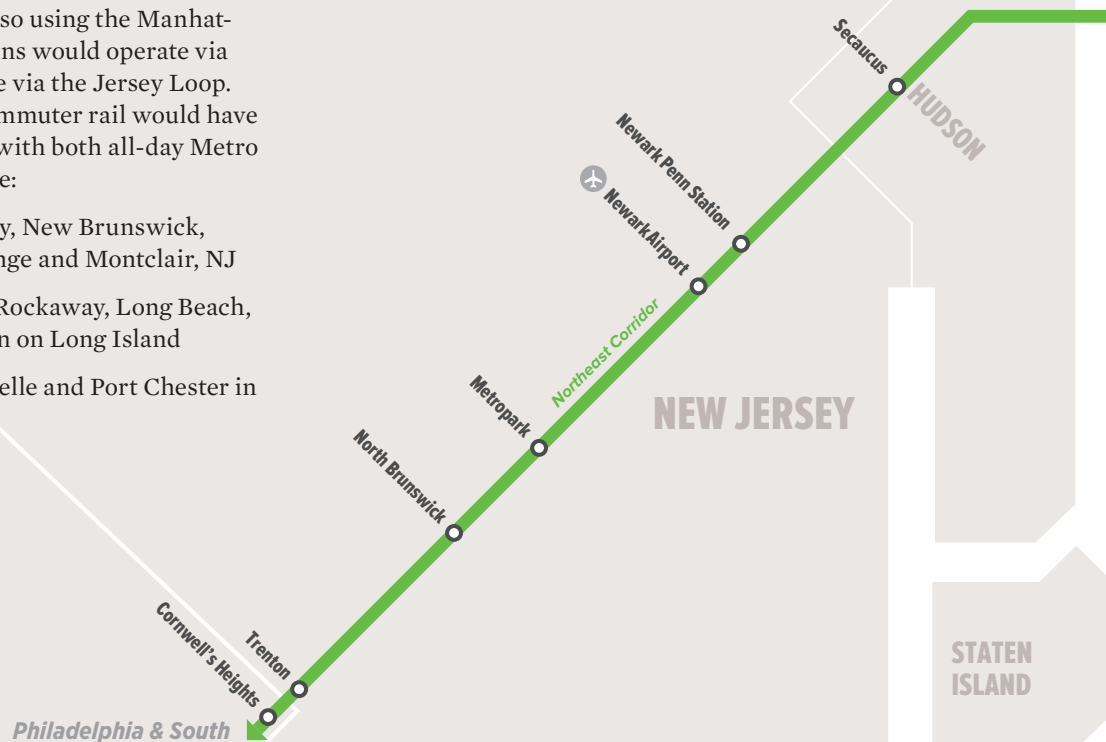
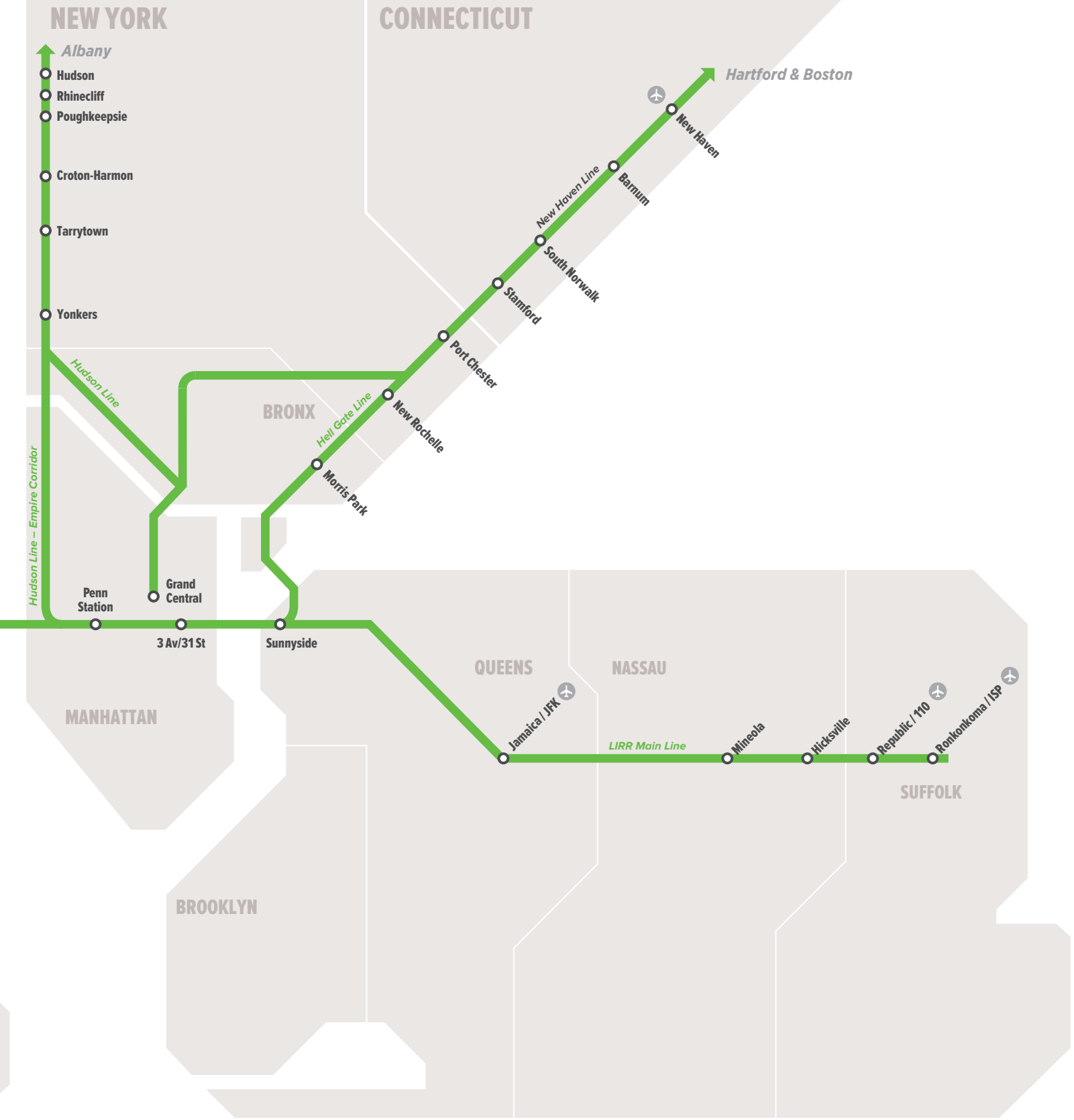


Figure 18: Trans-Regional Limited (TRL) Service Map

Source: Regional Plan Association



simplify these convoluted routings into one integrated system that will allow for single seat rides between these hubs facilitating work trips and encouraging personal trips.

TRL service would be provided on the following routes:

- ▶ Northeast Corridor (Philadelphia-Trenton-NYC-Stamford-New Haven-Hartford)
- ▶ Trenton, NJ to Ronkonkoma/Brookhaven, NY
- ▶ Albany, NY to Ronkonkoma/Brookhaven, NY
- ▶ Albany, NY to Grand Central Terminal
- ▶ Hartford/New Haven to Grand Central Terminal

Setting New Fare Policies, Structures and Technologies

As part of the new service, the current pricing scheme must be altered for commuter rail stations in the inner core counties (Bronx, Brooklyn, Queens, and Hudson). The expansion of the MTA’s current City Ticket program is recommended to allow for the purchase of a one way ticket to be used for intra-borough travel (with some transfer restrictions) during the weekends for \$4.25. Expanding this program to be in effect for the entire week, not restrict transfers, and allow for the purchase of monthly and weekly tickets would greatly increase the accessibility of the system for residents of these areas.

Table 17 demonstrates how adopting the City Ticket would drastically reduce the high per mile price paid by residents of the inner core counties. The new prices were calculated assuming that the current City Ticket fare would be 4% of the monthly ticket price, or \$106.25, which is about the average for the system as a whole is. Pricing the City Ticket program like this would bring the fares paid by borough residents more in line with the rest of the system.

Table 17: Current and Proposed Future Cost per Mile of Monthly Rail Pass

Miles From Terminal	Current		Future	
	Avg. Monthly*	\$/Mi*	Avg. Monthly	\$/Mi
0-10	\$190.00	\$0.65	\$107.41	\$0.38
10-20	\$219.86	\$0.35	\$194.77	\$0.31
20-30	\$275.64	\$0.28	\$274.87	\$0.28
30-40	\$347.67	\$0.25	\$347.67	\$0.25
40-50	\$397.75	\$0.22	\$397.75	\$0.22
50-80	\$437.91	\$0.18	\$437.91	\$0.18
80-120	\$477.50	\$0.13	\$477.50	\$0.13

*Assumes 40 trips per month. Current cost averaged for all railroads.
Source: RPA Analysis

Fare Payment Technology

As detailed later in this report, governance reforms will be required to coordinate the operations and long term planning of the three railroads. However, in the interim, a regional ticketing system should be developed. Integration of ticketing structures, policies and technologies would also need to occur if the vision of regional rail is to be fully realized.

Currently, tickets purchased for one of the region’s three commuter railroads (NJT) are not valid for use on the other two (MNR and LIRR) except during service disruptions and other special events. The advent of digital ticketing technology makes this an easy transition. The current practice discourages riders from making longer trips which traverse more than one system as they not only have to pay two fares but must navigate two different pricing and vending systems. Beyond rider convenience, adopting a region-wide ticketing system would create the opportunity to completely switch to an electronic ticketing regime that provided paper backups for those without a smart phone. Such a system would help speed the processing of tickets on board the trains or allow for fare validation off of the train while also reducing the amount spent on physical paper tickets. Finally, such a system would buttress a proof of concept for a through running train route at Penn Station by enabling passengers to purchase one ticket for a New Jersey-New York trip rather than two separate ones.³⁸

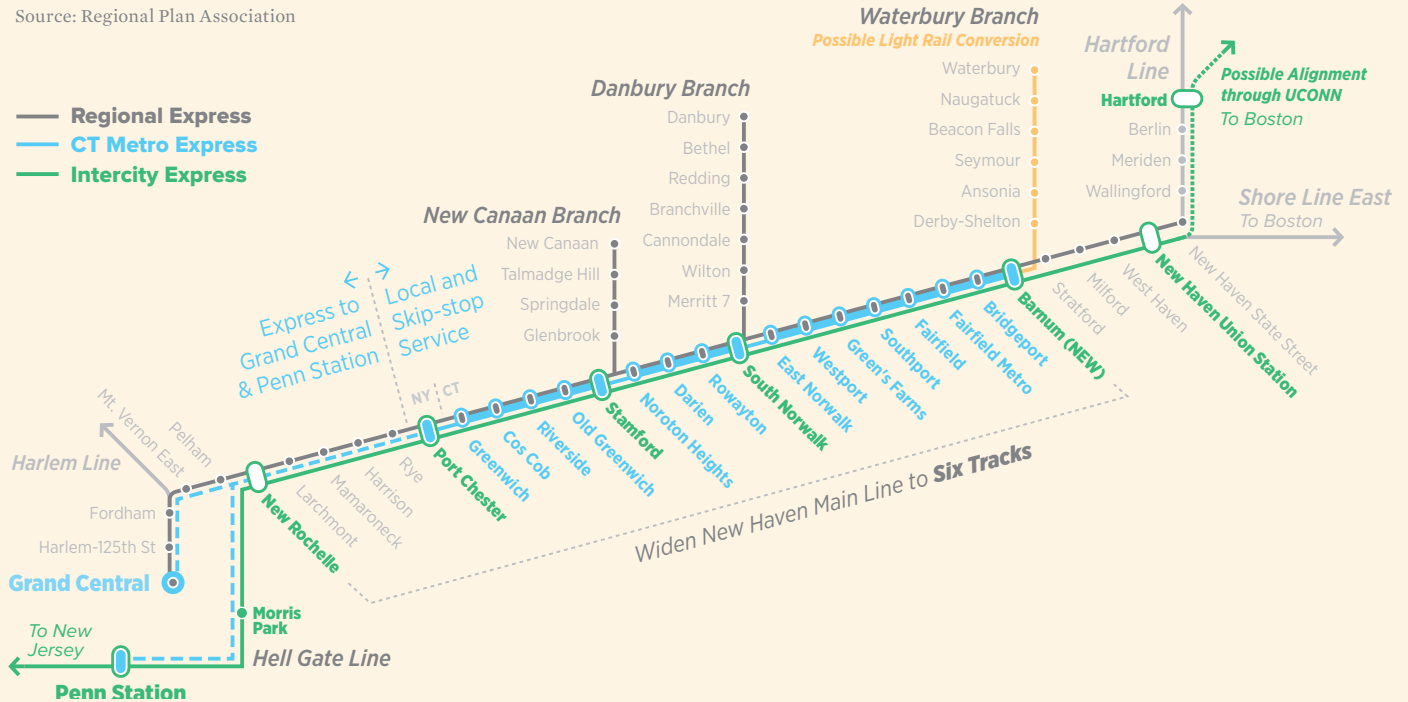
The MTA’s New Fare Payment System should serve as the foundation for a regional fare system and be adopted by all three railroads. It could initially use a standardized bar code for validation and eventually a proximity pass that could first use “active validation” methods relying on readers onboard trains or at stations, but over the longer-term shifting to “passive validation” using sensors in stations or on trains to identify users without any action having to be taken on their part.

³⁸ Such a route currently exists in the “Train to the Game” service run by MNR and NJT from Connecticut to New Jersey for football games at MetLife Stadium. However, the service is more of a novelty, there is only one train per game, rather than a true proof of concept route meant to gauge rider interest in intra-regional trips.

Connecticut Metro Express

Figure 19: CT Metro Express

Source: Regional Plan Association



Connecticut suffers from a serious congestion problem. The Interstate 95 corridor, which mostly parallels the New Haven Line (NHL), and the Merritt Parkway to the north experiences gridlock conditions throughout the day. The inability for Connecticut residents to swiftly traverse the Northeast Corridor is hampering economic growth in the state. Lost labor productivity and uncertainty around mobility caused by congestion and poor connectivity is negatively impacting Connecticut's ability to retain and attract companies and talent. According to 2010 data from Connecticut's Office of Policy and Management congestion results in 31.9 million hours of delay and costs Connecticut at least \$670 million every year.

As part of the T-REX (and NEC FUTURE), the widening the NHL to six tracks between New Rochelle, NY and the future Barnum station in Bridgeport, CT is recommended. This additional capacity would allow for more frequent local service for inter-city travel in Connecticut, improved express service between the state's regional centers and new express service along the corridor that would dramatically cut travel times from New Haven to New York City. Expanding the capacity of the New Haven Line is consistent with the vision for Northeast Corridor intercity and regional rail service developed by the Federal Railroad Administration and articulated in the programmatic environmental impact statement released in 2017.

This new service — called *CT Metro Express* — would run on the local tracks between Port Chester, NY and Barnum, CT, limiting crossovers along the route by exclusively using the existing local tracks which would result in a more reliable service. At Port Chester, these trains would cross over to the intermediate tracks (the express tracks in the new 6-track configuration) and continue on to GCT or PS as a *Regional Express* train, making limited stops at key stations. CT Metro Express could run as a local service, making all stops along the line, or in a skip-stop pattern to create a balance between local access and improved travel times for those making trips within the state.

This new system would deliver a substantial increase in service for CT residents including:

- ▶ 6-8 Higher-Speed Rail Intercity (Amtrak) trains per hour;
- ▶ Up to 8 Trans-Regional Limited (Metro North) trains per hour; and
- ▶ 32 Metro and Regional Express trains per hour in the peak direction.

This would be a substantial improvement from the 2 Amtrak and 21 Metro-North trains per hour that serve the corridor today. This 110% increase in service would go a long way to improving mobility in Connecticut while also taking pressure off I-95 and other congested highways that feed the corridor.

New Core Capacity and Additional Infrastructure Investments

The T-REX proposal builds upon recent investments such as East Side Access and leverages them along with other new investments to create an integrated, flexible, and more robust rail network to support the proposed service changes and allow for new service plans to meet the travel requirements of future generations. The capital investments would create new capacity and new access to parts of the region that are currently poorly served or unserved by rail. These proposed capital investments are needed to deliver the service plan for the Metro, Regional Express and Trans-Regional Limited services. The justification for these service patterns and levels is rooted in the desire to produce the following outcomes:

- ▶ **Capture growth:** RPA's demand model indicates that additional capacity (beyond existing plans, such as Gateway) will be required to offer the level of service outlined in this proposal and to serve anticipated demand.
- ▶ **Equitable mobility and transportation access:** New service is needed to improve access to jobs and commute times for underserved residents throughout the region.
- ▶ **Reliable service:** Planned capacity will be oversubscribed by 2040 leaving no operational buffer. This would mark a return to unreliable service and congestion.
- ▶ **Modal shift:** There are thousands of bus and auto users that could be diverted to rail if the capacity was provided to serve them and offers a substantial travel time savings. This would reduce the congestion on major roadways and in dense urban areas such as Manhattan.
- ▶ **Redundancy/Resiliency:** There are services to the west and north of the core that lack sufficient redundancy or rely on aging infrastructure. For example, the uptown PATH utilizes severely aged infrastructure while New Jersey Transit's Main/Bergen and Pascack Valley lines run through the Meadowlands and are threatened by sea level rise.

The proposal is centered on the creation of new rail capacity in the region's core which would create an urban transit like service in New York City and inner suburbs while also

allowing for an increase in service in outer suburban areas. New capacity would be provided by two new "spines" traversing the core on its longitudinal and latitudinal axes along with a "loop" which would introduce two new sets of trans-Hudson tunnels. These "spines" and "loop" will be supplemented by new tracks or expanded right of ways in the inner suburbs to increase the capacity of existing lines and provide service to new areas.

All trains running through the region's core would be equipped with modern train control technology which would support service frequencies of 30 trains per hour or higher.³⁹ In the longer term modern train control could be extended out along highest ridership lines and eventually to the entire T-REX system. This would allow for even greater capacities and service reliability. These investments would also set the stage for the full automation and driverless operation of T-REX.

This current proposal was inspired by earlier RPA regional plans and the four-year Transit Leadership Summit (TLS) research effort, which engaged 17 major metropolitan areas from around the globe on "best practices" in public transportation. The First Regional Plan in 1929 called for ambitious investments in the commuter rail system and greatly improved access to all points within the core. More recently, RPA's Third Plan released in 1996 proposed the Regional Express (Rx) which envisioned targeted integration of the commuter rail and subway networks and promoted through-running service. The survey of peer transit systems as part of the TLS effort indicated that most cities, even some much smaller than New York, had or were in the process of transforming and reorienting their conventional commuter rail networks to better serve their region and improve access to their central business districts. The solution, in most cases, included through-running commuter services that in the past terminated at the boundary of the CBD (most cities have several rail terminals that serve the east, west, north and south sectors of their major central business district), creating more direct access to jobs and eliminating the need to transfer to local transit for many

³⁹ See RPA's report on Communications Based Train Control. "Moving Forward." Regional Plan Association, May 2014. <http://library.rpa.org/pdf/RPA-Moving-Forward.pdf>.

commuters. These systems also served as express services for those within the cities and to more rapidly move through the CBD.

Yards

The implementation of a new and more robust rail service will require the construction of new rail yards and the expansion of some existing facilities to store, turn, and service the trains. An initial attempt was made to identify potential locations for new yards and candidates for expansion by looking for locations that provided sufficient land area and operational flexibility. However, the location, size, configuration, etc. of a yards is very dependent upon the requirements of the services it is associated with. As a result, these locations may change as the system is finalized and rolled out. The candidate locations are shown in Figure 21.

Electrification

As discussed earlier, running a frequent and reliable rail service generally requires the rail line to be electrified to improve train performance and reliability. Many of the region's inner rail lines are already electrified but there are some exceptions that will have to be upgraded to provide the level of service required of them by the T-REX system. All of these lines are in New Jersey and are currently served by diesel service. Specifically, the southern portions of the Bergen/Main Line and Pascack Valley lines and the eastern portion of the Raritan Valley line will have to be electrified in order to provide the level of service prescribed for Zone 1 stations.

Table 18: The Segments of T-REX

Lines	Route Miles	Track Miles
Crosstown	7.20	14.39
Jersey Loop	12.58	25.15
Manhattan Spine	11.74	28.74
Monmouth-Ocean-Middlesex Line	34.56	69.12
Susquehanna & Western Reactivation	9.32	18.64
West Shore Reactivation (w/short segment Northern Branch)	18.06	36.13
JFK Connector (+partial reactivation of RBB)	5.17	10.33
New Empire Connection Tunnel	0.23	0.46
Fifth Track — Harlem Line Terminal Area	6.69	6.69
Fifth Track — Mainline Terminal Area	8.66	8.66
Subtotal	114.19	218.31
Supporting Infrastructure — NEC Future Fifth & Sixth Tracks		
New Brunswick to Secaucus Fifth & Sixth	27.33	54.66
New Haven Line Super Express Tracks	38.88	77.76
Subtotal	66.21	132.42
Total	180.41	350.73

Source: RPA Analysis

Table 19: T-REX Station Summary vs. Existing System

Station Type	Stations
Existing — Total	390
Light Rail Conversion (Loss of CR Stations)	22
Planned/Underway	5
Revised Station Count (after adjustment above)	373
New Subterranean	17
New Above Ground	43
Net gain — # stations	60
Retrofitted Subterranean	2
Retrofitted Above Ground	14
Total	433
% increase from existing (today)	11%
% increase in new stations (over existing)	15%

Source: RPA Analysis

Figure 20: Required Infrastructure Investments



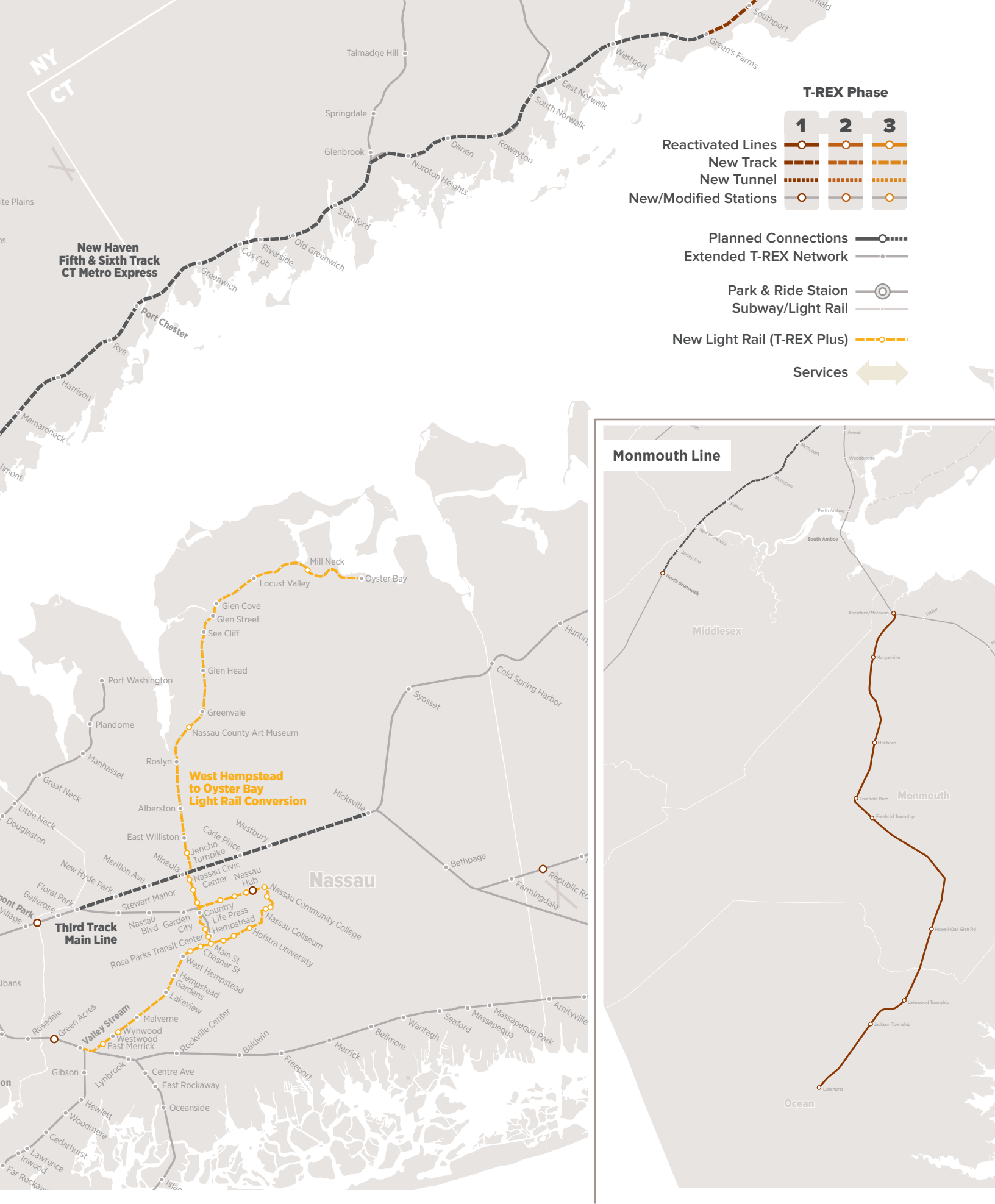


Figure 21: Map of Proposed Yard Locations





Crosstown Line

The Crosstown Line is built largely on the foundation of the Gateway project and others that are currently underway. It leverages these investments to support a new through running service between New Jersey and New York while also addressing the current trans-Hudson capacity issues faced by the North River tunnels. The Crosstown Line calls for the southern expansion of Penn Station to be designed as a through-running station from the start, with two tubes extending east to Sunnyside Queens and a new eastside station on 31st Street and 3rd Avenue. The major infrastructure investments required to support this service are listed below.

New Trans-Hudson Tunnels (3&4)

The Crosstown Line will require a pair new trans-Hudson tunnels as proposed in the current Gateway project. These tunnels are required to provide the capacity needed to operate the improved service patterns described in the service zones section above as well as allow for rehabilitation of the existing tunnels.

Penn Station Expansion

Penn Station's current configuration as a terminal is inefficient and cannot handle the train or passenger traffic it sees on a daily basis as the busiest transit station in the Western Hemisphere. The creation of the new Crosstown Line will require an expansion of the existing station to the South, while also providing the opportunity to streamline and integrate its concourses and wayfinding. The station expansion would be configured to allow for through running in both the eastbound and westbound direction and feature wider platform widths and sufficient vertical access points to prevent the extreme crowding currently observed at the Station. The station would also have sufficient clearances

to accommodate some larger freight cars. These improvements would increase capacity for trips from New Jersey and Long Island while also allowing for a service from the New Haven Line via Penn Access, benefitting Connecticut based commuters bound for the West Side of Manhattan or New Jersey.

Preservation of Second Penn Station Connection to Empire Connection

To provide a more robust service up the Empire Connection on Manhattan's West Side, a new connection should be constructed from Penn Station. Currently, the line has a single track connection into Penn Station which runs underneath the West Side Yard and is incapable of handling more than just a handful of trains per hour.

The construction of the Hudson Yards complex provides an opportune time to create a second link between Yard C at the northern part of Penn Station and the Empire Connection. This new track would exit Yard C headed west and then turn north just shy of Hudson Boulevard where it would join in with the existing Empire Connection. However, there are currently plans to build a skyscraper on this site as part of the Hudson Yards development.

The two projects are not incompatible with each other but efforts must be made now during the design and construction of the building to ensure that its foundation and basement are built to allow for the future connection. The solution would likely be similar to the one created to preserve the Gateway right of way through the development where a "box" was constructed around the right of way to protect it while the building was built on top.

New East River Tunnels (5&6)

The Crosstown Line would also include new East River tunnels (the fifth and sixth tubes) and the requisite connections to Penn Station to allow for through running. The addition of new East River tunnels will also allow Metro-North's new "Penn Access" (running off the New Haven Line) service to grow without constraining LIRR operations into Penn Station. A junction in Long Island City would enable freight trains to directly access the Lower Montauk line.

New Eastside Station, 31st Street and 3rd Avenue

A new station would be constructed on 31st Street and 3rd Avenue (centered on Lexington Avenue) that would allow connections to the Manhattan Spine and Jersey Loop. This station will serve as a future transfer point between all three proposed corridors while also providing direct access to Manhattan's East Side for New Jersey residents. This station would essentially become "Penn Station East" and help reduce the load on the existing Penn Station by providing a new option for those destined for the East Side. The station would also help reduce crowding at Grand Central (and free up additional capacity for more commuter or intercity services) for Connecticut and Long Island riders

by providing a second East Side station for them to access Manhattan. A connection between the Lexington Avenue subway line (#6) at Park Avenue at 32nd Street would also be possible.

Northeast Corridor Capacity in New Jersey

In order to accommodate growth in both regional and intercity rail passenger demand along the Washington, DC to New York corridor, the Federal Railway Administration (FRA)'s NEC FUTURE vision calls for expanding the Northeast Corridor to six tracks between North Brunswick and Secaucus, NJ. The T-REX plan would take full advantage of this infrastructure. Premium high-speed intercity trains and Trans-Regional Limited trains would share the new high-speed express tracks. Regional Express service to and from the outer suburbs would utilize the intermediate tracks (today's express tracks), and Metro would take over the local tracks. At Secaucus, the local tracks would feed the Gateway Tunnel, carrying Metro trains. An expanded junction at Secaucus would provide connections to a new passenger storage yard as well as a freight connection from the NJ freight lines to the Gateway Tunnel. The intermediate tracks would feed the existing North River Tunnel and also the north leg of the Jersey Loop via a new track connection, with most RX services running via the Jersey Loop except at rush hour. The new high-speed express tracks would feed existing Penn Station, which would be modernized and reconfigured to support higher volumes of through-running intercity and Trans-Regional Limited services.

Northeast Corridor Capacity in New York and Connecticut

Similar to the Northeast Corridor in New Jersey, the New Haven Line between New Rochelle, NY and Green's Farms, CT is proposed for expansion from four to six tracks to support the FRA's NEC FUTURE vision. The allocation of rail services among the three pairs of tracks also would be similar — premium high speed and Trans-Regional Limited trains on the new express tracks, RX trains on the intermediate tracks and Metro trains (including Connecticut-focused skip-stop services) on the local tracks.

The Hell Gate Line in the Bronx would be expanded from two to four main tracks as part of the Penn Access project. The new East River Tunnel for the Crosstown Line would have dedicated track connections to both the local tracks of Hell Gate Line and the local tracks of the LIRR Main Line, in order to support smooth Metro operations.

Fifth Mainline (LIRR) Track

To support additional service from between Long Island and the rest of the region as well as to provide for a local service within Queens, a fifth track would be constructed on the LIRR's Main Line in Queens between Winfield Junction and Jamaica Station. This new track would allow for express trains to pass local trains servicing the LIRR stations in Queens enabling a robust local service at sta-

Is it possible to use the existing East River Tunnels for through running of PSNY tracks 1-4?

Tracks 1-4 in the existing Penn Station dead-end at the station and do not connect to the tracks that funnel into the East River Tunnels.¹ They are currently used by NJT trains that return to New Jersey instead of going on to Sunnyside Yards. The original Penn Station planned for these tracks to be extended eastward and connect to a future 2-track tunnel under 31st Street that would cross under the East River to Queens. This extension and new tunnel was never built, but the basement and sub-basement of the office building at 11 Penn Plaza across Seventh Avenue was constructed to allow for these future tracks. However, connecting tracks 1-4 into the existing 32nd Street Tunnel (East River Tunnel Line 1) is not possible because it would entail the construction of a new tunnel that was never originally planned through the middle of the existing block between Seventh and Sixth Avenues and 31st and 32nd Streets and would likely require the taking and demolition of that entire block. Similarly, connecting tracks from Penn Station South to Line 1 would also require a new tunnel beneath existing developed city blocks, and potentially the Herald Square subway station — a monumental undertaking without any significant capacity benefit.

¹ O'Hara, Patrick. "Different Diagrams of Penn Station." *The Long Island Railroad Today*. January 2014. http://www.thelirrtoday.com/2014/01/different-diagrams-of-penn-station.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+TheLongIslandRailRoadToday+%28The+Long+Island+Rail+Road+Today+29.

tions throughout Queens and Western Nassau County. While there would have to be some bridge expansions, much of this section of the Main Line right-of-way appears to have space for the tracks.

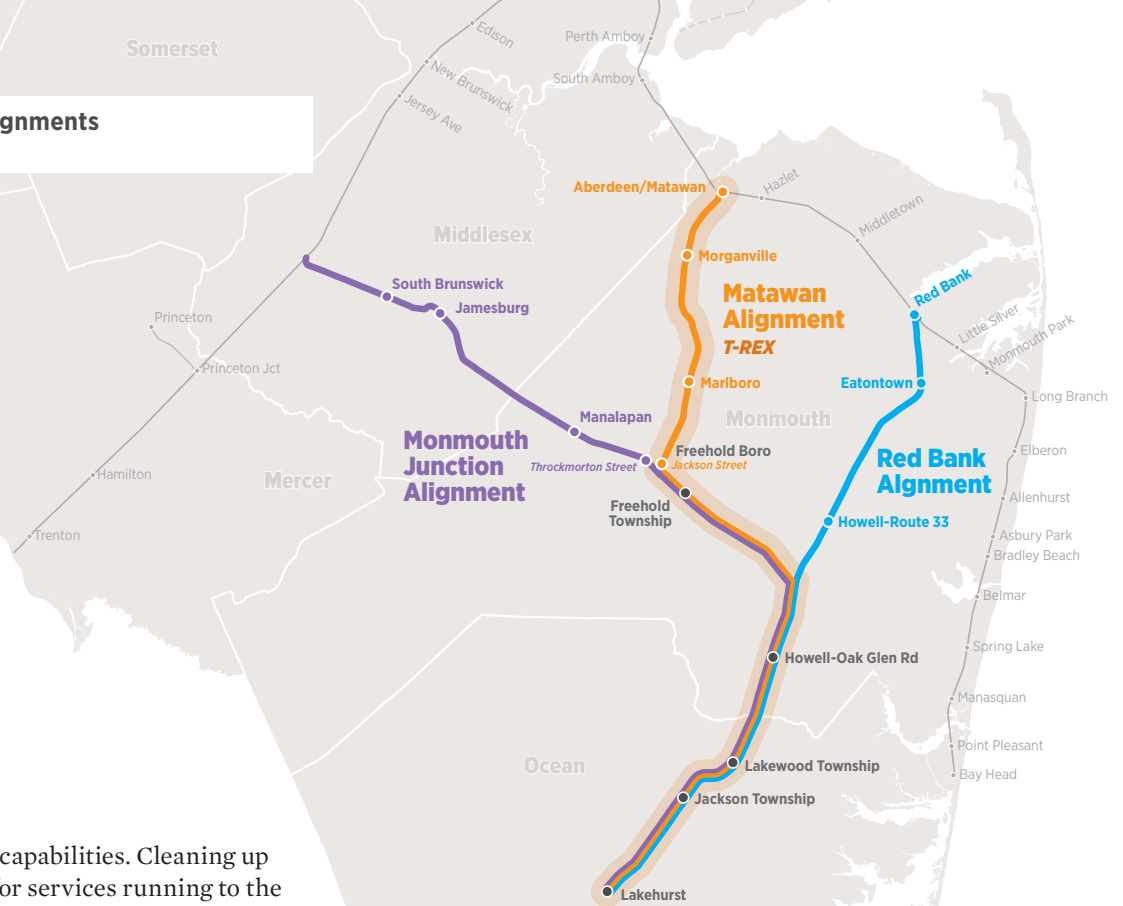
This section of the LIRR Main Line also parallels the crowded Queens Boulevard subway line (QBL). The additional track created on this section of the Main Line would allow for a more robust local service that would provide a more expeditious route for patrons of the QBL and lessen the crowding currently seen on that section of the subway.

Jamaica Station Configuration Changes

To prevent the "Jamaica Crawl", described earlier, from impacting service on the Crosstown Line, the station and its interlockings must be reconfigured. The platforms which are currently too short to handle 12-car trains should be expanded to do so while the Jay and Hall interlockings bookending the station should be reconfigured with a focus on speed and parallel movements rather than

Figure 22: Proposed MOM alignments

Source: Regional Plan Association



providing universal movement capabilities. Cleaning up the interlockings would allow for services running to the lower portion of the Manhattan Spine through Brooklyn to be paired with the Atlantic Branch while services on the Crosstown Line would be paired with the Main Line. Doing so would prevent conflicting movements and increase trains speeds approaching and passing through the station. Finally, an across the platform transfer would be provided between the services headed for the Manhattan Spine and those headed for the Crosstown Line to allow riders to transfer if necessary to reach their final destination.

Winfield Junction Station Complex

As part of the Crosstown Line, a multi-modal station complex would be constructed at Winfield Junction (the location where the Port Washington Line and LIRR Main Line split and where the Triboro line passes over both the commuter rail lines) with connections to local bus services as well as the Triboro line. The station would also allow for a convenient transfer between services running on the Port Washington Line and those on the LIRR Main Line. Several other stations could also be constructed along the main line, including at Sunnyside and Woodhaven Blvd/Queens Center.

Middlesex, Monmouth, and Ocean (MOM) Line

The NJ Transit North Jersey Coast and Northeast Corridor Lines currently provide rail service to the New Jersey counties of Middlesex, Monmouth, and Ocean (MOM) counties. These lines skirt the edges of all three counties and leave the inner portions of them, containing towns such as Marlboro and Freehold, without an easily accessible rail service option. As a result, almost 60% of work trips to the Manhattan Central Business District from areas in the MOM counties which currently do not have rail service

are made via bus.⁴⁰ This is almost twice the rate (34%) of the state as a whole and two to four times the rate as areas in the MOM counties which are served by the NJ Transit North Jersey Coast Line.

Over the years, various proposals have been floated which would reactivate or retrofit various freight lines to provide passenger service to the MOM region. NJ Transit has studied three possible alignments (depicted above). Each of these alignments would provide new service to hundreds of thousands of people. RPA's regional rail proposal includes the Matawan alignment to provide service to the MOM region. This alignment closely parallels U.S. Route 9, a corridor heavily reliant on buses for commutation, and would serve towns such as Marlboro, Freehold, and Lakewood. The Matawan option would join into the existing Coast Line at Aberdeen/Matawan. Adopting this alignment would require the junction where the NEC and Coast Lines converge, located in Rahway, to be reconfigured to allow for the additional service.

⁴⁰ RPA Analysis.



The Manhattan Spine

The Manhattan Spine is a new north-south trunk line that would run the length of island from the Bronx to the Battery and then to Brooklyn. It introduces a new express service to the east side of Manhattan and, in combination with Jersey Loop and Crosstown Line, provides easy transfers to riders destined for places on the west side, as well as the connections to the entire regional rail network. This new line below Third Avenue would allow commuter to walk to many of the major employers located within the Manhattan central business district and downtown Brooklyn, reducing the volume of riders transferring from commuter rail to local subway lines or buses.

The line consists of three parts, uptown, midtown and downtown segments, with a combined total of 8.5 new miles of track and 8 new stations. The Jersey Loop would run parallel to the Midtown Manhattan Spine beneath Third Avenue, adding another two tracks between Houston Street and 57th Street. Transfers among all three regional rail lines would be possible at 31st Street and 3rd Avenue. The Manhattan Spine could obviate or defer the need for phases 3 and 4 of the Second Avenue Subway.

Three corridors were evaluated for the Manhattan Spine — 5th Ave, 3rd Ave and 2nd Ave (repurposing Segments 3 and 4 of the Second Avenue Subway). It was determined that 3rd Ave was the best alternative because it would improve access to the East Side (especially the Uptown Spine) and still keep commuters within walking distance to region's largest CBD, Midtown East.

Uptown Manhattan Spine (57th to the Bronx)

The uptown portion of the East-Side Spine would run from 57th street to the Bronx underneath 3rd Avenue, following the route of the old Third Avenue “El” service which was torn down in 1955 in Manhattan and in 1973 in the Bronx. Upon entering the Bronx, the line would merge into the existing Metro-North system at Mott Haven Junction providing service to existing Metro North stations on the Harlem line and two new stations, Claremont Village and 149th Street. This portion of the spine would serve the northern suburbs of the region while also creating a second express transit line on the Upper East Side that is served by just one express line today, the Lexington Avenue Line (#4/5), and in part by the first phase of the more “local” Second Avenue subway. To support more frequent local service and regional service in the Bronx, Westchester and Connecticut additional tracks will be required on the Harlem and New Haven Lines.

Harlem Line Terminal Area Fifth Track

The four tracks of the Harlem line, south of the junction with the New Haven line at Wakefield, will be inadequate to serve both the increased local Metro service that is proposed here in the Bronx and the peak-period express services on the New Haven and Harlem Lines. An additional track (or two) will be needed from the junction of the Harlem and New Haven lines to the Mott Haven junction where service could either continue down the Park Avenue viaduct or the Manhattan Spine (3rd Avenue corridor). The existing right-of-way is in a cut and has insufficient space to add another track necessitating either a tunnel below the existing railway or an elevated structure above (an unlikely option due to the impact on the surrounding neighborhoods).

Barnum Station

Barnum station is a proposed station featuring two island platforms located on the New Haven Line in Bridgeport, Connecticut. For most of its length, the New Haven Line is comprised of four tracks with the inner tracks operation as express tracks and the outer tracks as local tracks. Currently, all of the stations on the line other than Stamford and New Haven feature side platforms on the outer tracks requiring any express trains servicing these stations to cross over from the inner to outer tracks, reducing the speed and capacity of the line. Metro-North currently mitigates this issue by running a zone express service where trains will service a group of local stations before entering the express tracks and continuing to New York to minimize the number of cross overs. Constructing a station with island platforms will help further minimize the number of cross overs required for Metro-North as well as eliminate the need for Amtrak trains to cross over from the express to local tracks to service the Bridgeport station improving the efficiency of the line. This station will make Barnum one of the major nodes on the New Haven Line and will position the area for dense commercial and residential development. Provisions should also be made to not preclude space for

What happens to phases 3 and 4 of Second Avenue Subway?

The Second Avenue Subway has been on the drawing boards since the 1920's and was planned to be the main trunk line in Manhattan — covering the last major unserved north-south corridor in Manhattan, the far eastside. After a series of fits and starts, the project finally started the construction of the first minimal operating segment (MOS) from 63rd Street to 96th Street in 2007. The Federal Transit Administration had required the MTA to break-up the 13 mile subway — 125th Street in Harlem to Hanover Square in Lower Manhattan — into four segments and phase them in a way where they might offer independent utility even if all four segments were not built. This sparked the debate over the “stubway” with many advocates believing just MOS 1 would ever get built because they would tie in with the existing Broadway Line via an unused set of track that were built as part of 63rd Street line complex in the 1960's.

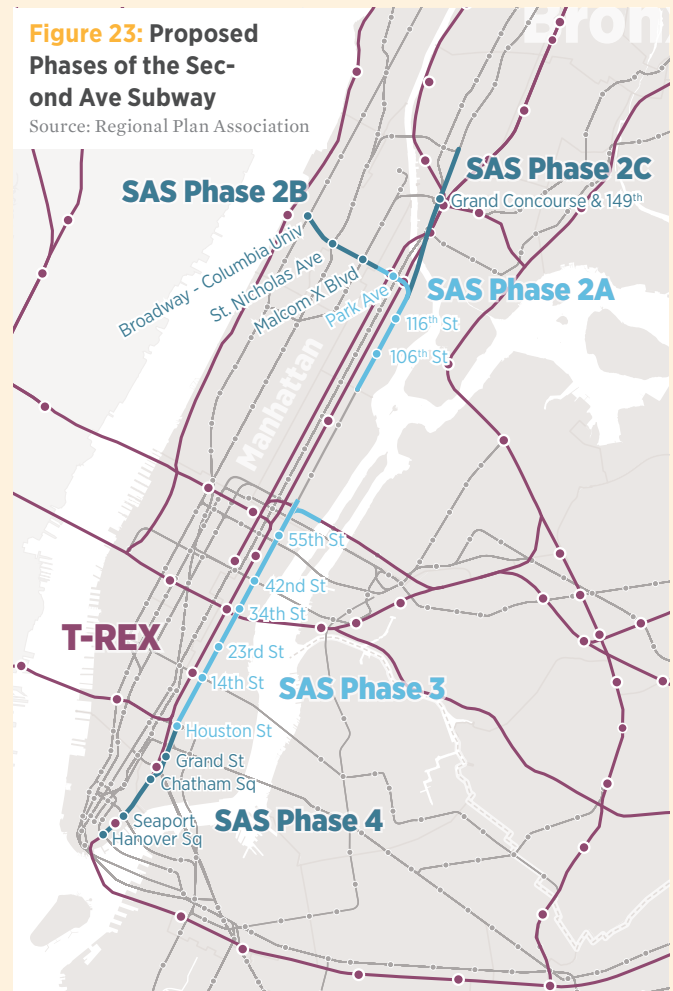
Leveraging this prior investment would allow the “Q” service in the BMT express track to use the new SAS to access the Upper East Side until the full-length subway was constructed and the “T” was introduced. The original design for MOS 1 called for an expanded 72nd Street station with three tracks and two island platform to eventually serve at the terminus for some or all of the Q service when the SAS was extended south in MOS 3. However, during the final design the MTA removed the extra track and platform in order to reduce the size and cost of the station along with concerns over geological conditions at the site. The MTA added an additional switch north of the station to facilitate some turnbacks, but this is a far cry from the original scheme. The agency also decided to tunnel bore just from 96th Street to 63rd Street and not head further south, stating insufficient funds and geotechnical complications (soil, not rock) south of Houston Street. While RPA is skeptical about the cost effectiveness of the two southern phases without additional capacity in Queens to support a more robust service on the lower half of the line (via 63rd Street tunnel), it strongly supports the northern extension (MOS2) of SAS to 125th Street and the Bronx.

So what does this mean for the southern phases of SAS?

The Q service is likely to stay because there will be no efficient means to turn the service at 72nd and no easy transfer (cross platform) between the Q and T services. UES residents will demand that the Q service remains because it provides excellent access to jobs (6th and 7th Avenue corridors), entertainment (Times Square) and major transporta-

tion hubs (Penn Station) even more so then the T service would. If the Q stays it means that the T can only run a limited service on the northern leg that would roughly match the frequency of the Q today — headways of 6-8 minutes. While the Q and T services combined would make for a frequent service north of 63rd Street, on the southern leg of the SAS the service would be half as frequent or to put it another way it would only use half the available capacity. To remedy this issue the MTA would need to construct new capacity in Queens to feed the southern leg of SAS via the 63rd Street tunnel.

Unless more capacity is created in Queens, the 3rd Avenue corridor might be a better option than the SAS to serve this lower part of Manhattan (and eventually Brooklyn), as long as it is designed and constructed in a manner to avoid the capacity pitfalls and construction impacts that have undermined the SAS. However, while T-REX is envisioned to use MOS4 for the segment south of 3rd Avenue, this segment could be designed to accommodate four tracks instead of two in order to preserve the right-of-way for a future extensions of the SAS to Lower Manhattan where it could act as the more local service for the east side (similar to earlier versions of the SAS that included 4-8 tracks).



tracks 5 and 6 along with land for staging yard capacity, as this station could serve as a future terminus for some regional services.

Midtown Manhattan Spine (57th Street to Houston Street)

The backbone of the T-REX network is the Midtown Manhattan Spine running below 3rd Avenue from Houston Street to 57th Street. This new rail corridor would connect multiple east-west corridors in Manhattan while also providing direct access between New Jersey and the East Side for the first time. In addition to connecting New Jersey to the East Side, this segment of the system will provide new transit service to the Midtown East portion of Manhattan. Currently, this area is served only by the overburdened Lexington Avenue Line, the busiest and most congested rapid transit line in the United States. The construction of a second mass transit line along this corridor would help reduce the severe crowding conditions seen along this portion of the Lexington Avenue line.

The Midtown portion of the spine would include three stations along with the major transfer node at 31st Street and 3rd Avenue. The 31st Street station would be constructed as a large facility meant to serve as a terminus for riders on the Crosstown Line destined for the East Side of Manhattan as well as a transfer point between the Manhattan Spine (North-South) and Crosstown (East-West) services.

Downtown Manhattan Spine (Houston Street to Atlantic Terminal in Brooklyn)

The downtown portion will run from Houston Street to Water Street along Bowery into St. James Place and down Pearl Street to Water Street. After the Water Street station the line will turn east under the East River and then continue below Atlantic Avenue, connecting to the existing LIRR system at the Atlantic Avenue Terminal. Below Houston this portion of the alignment follows the fourth phase of the Second Avenue Subway (see callout box on page 55 for further details). T-REX would extend over the existing Atlantic Branch of the LIRR, running frequent service to southeast Queens and a new service to JFK airport via the Rockaway Branch and a new spur to the airport's central terminal area. Infill stations would be added in Downtown Brooklyn, at Buffalo Avenue and in Woodhaven while the existing Atlantic Avenue Terminal at Flatbush Avenue would be reconfigured to support through-running.



Jersey Loop

The Jersey Loop would provide additional trans-Hudson capacity via two new two-track tunnels as well as part of the new North-South rail corridor along 3rd Avenue in Manhattan — the Midtown Manhattan Spine (see previous section). This new trans-Hudson capacity would help to relieve the current demand crunch at Penn Station and the Port Authority Bus Terminal. Convenient, frequent and rapid rail service would be provided directly to multiple points within the Manhattan central business district, from a network of routes combining existing rail lines and new routes using existing surface commuter rail rights-of-way — serving key locations in Hudson County, NJ, most of Bergen and Passaic Counties in northern NJ, and Rockland and Orange Counties in New York State. This dramatically improved rail service would offer a superior travel option for many west-of-Hudson communities where bus service currently is the most viable choice. This, in turn, would reduce the long-term need for massive new bus terminal capacity on the west side of Manhattan and enable trans-Hudson bus service to focus on those remaining routes and corridors not well-served by rail.

Upper Trans-Hudson Tunnels

The upper trans-Hudson tunnels for the Jersey Loop would run west from 57th street in Manhattan under the Hudson River to Union City with stations at Columbus Circle and Madison Avenue, connecting with multiple subway lines. The route would run underneath or adjacent to the Hudson Bergen Light Rail tunnel before joining an existing freight right-of-way. This alignment would introduce new trans-Hudson capacity to Bergen County while also providing for urban transit-like service to parts of northern New Jersey that are under-served by rail. Service would extend out along the southern segment of the Northern Branch until

it connects with the West Shore Line and Susquehanna and Western Railway to Paterson and up the Bergen/Main Line. T-REX would not conflict with the proposal to extend the HLRT on the Northern Branch; instead it would enhance it by offering transfers between the two services at two stations — North Bergen and Ridgefield Park.

Lower Trans-Hudson Tunnels

The lower trans-Hudson tunnels for the Loop would exit Manhattan at Houston Street and head west towards Hoboken and Jersey City, with a station either at Hoboken Terminal or Pavonia/Newport offering transfers to and from the Hudson-Bergen light rail line. Upon exiting the tunnel portal, the Jersey Loop route traverses the Bergen Arches, a pre-existing but abandoned right-of-way that provides a direct connection into New Jersey Transit's existing system. The lower portion of the Jersey Loop will help reduce demand on the PATH system while also providing a more direct trip to lower Manhattan for those in farther out places of New Jersey, a trip that currently requires multiple transfers. In the past, several subway extensions to New Jersey have also been considered, including the L, 7 and E trains. The T-REX concept offers comparable or superior capacity and would extend one-seat ride access across a much larger service territory in northern New Jersey.

Passaic-Bergen Rail Corridor (via New York, Susquehanna and Western Railway right-of-way)

The construction of the northern trans-Hudson portion of the Jersey Loop would provide direct rail service from Bergen and Passaic counties for the first time to both the west and east sides of Manhattan along with convenient access to Lower Manhattan, Brooklyn, JFK airport and the rest of geographic Long Island. The corridor would run along the right of way of the Susquehanna and Western Railway, from North Bergen to 18th Ave in Paterson. Track capacity would be increased to support frequent passenger service and maintain off-peak freight access. From 18th Ave, a short new section of right-of-way (1 mile long) would be constructed underneath 18th Ave and Market Street to the current NJT Main Line station. At this location, a new subterranean station would be constructed with connections to the current aboveground station. This new route would link the centers of Hackensack and Paterson, the county seats of Bergen and Passaic counties, respectively — providing each with excellent rail service to Manhattan and the entire regional rail network.

Three branches off of this route would provide connections to other rail corridors: to the Bergen County Line at Saddle Brook, to a new passenger route following the West Shore Line, and to the Northeast Corridor at North Bergen. This corridor would feature stations in North Bergen, Ridgefield Park, Hackensack, Maywood, Saddle Brook, and Paterson. It will also require the electrification of the Susquehanna route along with the portion of the Bergen County Line north of Saddle Brook.

West Shore Line Passenger Service (connection via Northern Branch)

Passenger service on the West Shore line would be restored, with two new tracks for passenger service, parallel and adjacent to the CSX freight line, from Ridgefield Park to West Nyack in Rockland County. The passenger tracks would be electrified and signaled to support service to at least 5 stations in Ridgefield, Bogota, Teaneck, Dumont, Haworth and Norwood, with service possibly extended as far north as West Nyack (Palisades Center, I-287). Today, the West Shore Line is exclusively used by CSX for freight rail, connecting the ports (and region) in New Jersey to major rail yards and facilities outside of Albany. In the past, the railroad served passengers all the way to Albany. In 1959 passenger service on the line was eliminated — an early causality of the of the post-WWII decline of the private railroads. Since then buses have filled this role and starting in the 1980's NJT began pursuing options to restore service to the line due to the surge of bus service demand along the corridor. However, this effort was abandoned over a decade ago due to the inability of NJT and CSX to reach a compromise on the service, lack of funding, and a lack of engagement from the local communities.

Restoration of the Bergen Arches and Hoboken Connection

The Lower Manhattan Trans-Hudson Tunnels would extend to Hoboken, with a station at the terminal — as part of the terminal rebuild to address sea level rise. The line would then turn southwest to enter the Bergen Arches, an unused rail-cut that runs through the Palisades. There would be an additional station in Jersey Heights before the line exits the Arches and connects to the commuter rail network. The station in Jersey Heights would be designed as an intermodal hub to facilitate transfers between local feeders and regional rail. A direct connection to the commuter railroad at Hoboken terminal could also be explored.

Newark Broad Street Third Track

While Newark's Broad Street Station has three tracks, the rail segments east and west of it, including the Newark Drawbridge, do not. This forces trains running on the Montclair-Boonton and Morris and Essex Lines to merge, creating a bottleneck. To enable more frequent and reliable service through Newark, just over a half a mile of the line, including the Drawbridge, would have to be triple tracked. The space to build the additional track exists along the entirety of the project area with the exception of the Newark Drawbridge which would have to be replaced. However, the bridge was constructed in 1903 and is currently slated for replacement that would allow for the addition of the third track.⁴¹

Addition by Subtraction

As the commuter rail system is expanded and reoriented, the limited one-seat service currently provided on three of the region's lightly-patronized branch lines should be considered for conversion to light rail service. The lines are the LIRR Oyster Bay and West Hempstead Branches and the MNR Waterbury Branch. These lines have relatively low ridership compared with other branches in the region, and the trains consume capacity on the main lines that could be more effectively utilized by other services. The Waterbury branch had only 458 boardings on an average weekday in 2015, less than 1% of MNR's total daily boarding, while the Oyster Bay and West Hempstead branch accounted for only 1.3% of LIRR's average weekday boardings in 2014. Due to this lack of demand and the relatively high operating costs of commuter rail, service frequencies on these branches are limited, making them less attractive alternatives for local residents to use.

Converting these branches to light rail will allow for simpler rail operations on the T-REX system by removing the existing complicated merging patterns from the operating plan, freeing up capacity on the trunk lines and allowing for a more reliable and speedy regional rail service. The conversion of these branches would result in a more frequent local service, using smaller and light rail vehicles that could also be automated would be less costly to operate. A convenient transfer to the regional rail service with timed transfers would be provided at the station where each branch previously merged into the system. The combination of this transfer and the more frequent light rail service would actually improve service into the core for users of these branches, albeit at the cost of a simple transfer.

⁴¹ "Newark Drawbridge Engineering Study Approved." NJT Press Release, accessed December 4, 2017. http://www.njtransit.com/tm/tm_servlet.srv?hdmPageAction=PressReleaseTo&PRESS_RELEASE_ID=1124.

The Three Phases of T-REX

Due to its size and complexity the T-REX system cannot be built all at once. The plan, in fact, lends itself to phased implementation over an extended time period. The pace of construction will depend upon travel demand (driven by the pace of population and employment growth), the need for redundant or parallel rail capacity to enable the existing subway system to be repaired and modernized, and the pace at which capital funding can be made available. However, T-REX is expected to be a steady and sustained investment program over a period spanning several decades. The following phasing priorities are suggested, based on needs, opportunities and priorities as currently envisioned.

Phase One (10 years)

The first phase of the T-REX proposal is the Crosstown Line that would build off of the Gateway project and enhance its value, increasing its capacity from an the current estimated additional 22-24 trains per hour per direction to 30-33 trains or a 38% increase in capacity over the current proposal. RPA's demand modelling indicates that the trans-Hudson market is expected to gain over 88,000 transit riders by 2040 under our unconstrained growth projections. There is currently no way for the existing trans-Hudson transportation facilities to handle this increase as they are all fully or almost fully subscribed. The completion of a new pair of trans-Hudson rail tunnels and expansion of Penn Station will relieve the overcrowding currently seen at these facilities while also providing the additional capacity for the existing North River rail tunnels to be fully rehabilitated from the damage they experienced during Hurricane Sandy.

The Phase One service along the Northeast Corridor includes Metro service on the local tracks between North Brunswick, NJ and Port Chester, NY, and Regional Express and Trans-Regional Limited service from Trenton and New Haven on the express tracks and intermediate tracks where available. This service, coupled with plans for increased intercity service in the Washington-New York-Boston corridor, requires investment in additional main line capacity.

In order to deliver this service, Phase One of RPA's regional rail proposal incorporates the Gateway program, as well as the rail system capacity investments that are part of the recommended vision for the Northeast Corridor developed

by the Federal Railroad Administration, as documented in the NEC FUTURE programmatic environmental impact statement. The Northeast Corridor plan would construct two additional tracks paralleling the Northeast Corridor main line from North Brunswick, NJ through Green's Farms, CT, providing capacity for improved intercity rail service as well as the three T-REX services — Metro, Regional Express and Trans-Regional Limited.

Within the core area, a new set of tunnels would be built traversing Manhattan and the East River from Penn Station into Queens as well as a new rail hub station located at 31st St. and 3rd Ave and one located in Sunnyside in Queens. These tunnels will provide the additional capacity required to implement a more frequent through running service as recommended in the regional rail proposal. The construction of the station at 31st St. and 3rd Ave. would provide regional rail service to the East Side from New Jersey, a routing that is currently impossible, helping to relieve the crowding levels seen at Penn Station. The station would be constructed to integrate with Phase Two of the proposal to allow for an easy transfer to a north-south oriented rail line and could also include a connection to the Lexington Avenue subway line at Park Avenue.

The construction of a new set of trans-Hudson and East River tunnels will also provide the capacity to reactivate direct rail service for Monmouth, Ocean, and Middlesex (MOM) counties in New Jersey. As discussed in the new infrastructure portion of the proposal, these counties have a dearth of rail service and are heavily reliant on express buses to the Port Authority Bus Terminal. Once completed, the new service would have direct access to New York and would help relieve the congestion currently seen at the Port Authority Bus Terminal.

Phase Two

Following the completion of the Crosstown Line, the next phase would be constructing the northern section of the "Jersey Loop" and the Midtown and Downtown segments of the "Manhattan Spine". The construction of this segment of the proposal provides further trans-Hudson capacity, allowing for the restoration of passenger service on the West Shore line, use of a portion Northern Branch, and reactivation of the New York, Susquehanna and Western lines for passenger service in Bergen and Passaic Coun-

ties. The areas served by these lines are almost exclusively served by express buses today. The completion of this portion of the system would likely enable the Port Authority Bus Terminal to be replaced in-kind or by a smaller facility by reducing the demand for express buses in these counties.

Beyond providing new rail service to areas in New Jersey currently without it, the second phase of the proposal would provide a new north-south transit service on the east side of Manhattan which currently is only served by the Lexington Avenue Subway. This service could obviate or defer the need to construct the lower portions of the Second Avenue Subway (SAS). The Manhattan Spine would be connected to the Crosstown Line via a new hub station located at 31st St and 3rd Ave station. This station would provide a seamless transfer between the Crosstown, Jersey Loop and Spine (North-South) services.

The Manhattan Spine's southern leg would run under the East River after stopping at Fulton and Water Street and into Downtown Brooklyn where it would connect into the current Long Island Rail Road system at Atlantic Terminal. This portion of the line would provide robust and speedy rail transit service to parts of outer Brooklyn and South-Eastern Queens which currently have limited transit options.

Phase Three

The recommended final phase of the regional rail system is the Uptown Manhattan Spine and the Lower Trans Hudson Tunnels of Jersey Loop. The uptown portion of the Spine will provide relief for Metro-North's Park Ave Tunnel which is currently run at capacity.

The completion of Penn Access, a plan to add tracks and station on the Hell Gate line so that MNR New Haven Line trains can directly access Penn Station, would likely buy some time for Metro North with respect to its capacity constraints. However, the project will not divert any riders bound for the East Side, only marginally improves access options from the northern suburbs to Lower Manhattan, and does little to improve transit options in the central, southern and western Bronx. Penn Access was never meant to be a full-scale supplement to Park Ave Tunnel and Grand Central. Thus, as the region continues to grow, a larger scale capacity project will be required. The Uptown portion of the Spine would do just that, paralleling the Park Ave Tunnel along 3rd Ave, providing a new express track through the Bronx from Mott Haven to Woodlawn, and seamlessly connecting the Hudson Valley, central Westchester and the Bronx into the new regional rail system. The full Manhattan Spine will offer one-seat ride service to the Lower Manhattan business district from the Metro-North service territory, for the first time.

The lower leg of the Jersey Loop will provide a third new set of trans-Hudson tunnels (7 and 8), lessening the congestion on the existing tunnels, improving access to Hudson

County, creating opportunities for more direct travel within the region, continuing the modal shift in trans-Hudson commuting from bus to rail, freeing up bus terminal capacity for improved service to remaining areas not served by rail, and providing additional redundancy. The construction of this new tunnel could also serve as a long-term replacement for the uptown PATH which has tunnels over a century old, small stations, an inefficient junction, and a terminal at Hoboken that limits capacity and performance (and also is vulnerable to sea level rise and storm surge) and is costly to maintain.

On the New Jersey side of the Hudson River, the tunnels will lead to a station at Hoboken/Newport and connect into the existing NJ Transit system via the Bergen Arches, an abandoned right of way passing through Jersey City. A new station on the Arches will be constructed, providing regional rail service to an area that is currently only served by buses and PATH, neither of which are oriented towards intra-regional travel.

Impact of T-REX on Travel Demand Estimates

This section describes the impact on regional work trip demand if the T-REX proposal was constructed. It builds on the output described earlier of the demand estimates projected for the Current Trends and RPA Vision scenarios. In Table 20 the number of trips and those by transit and auto in each of the six stratified markets are summarized. The data shows the impact after the full set of rail proposals is in place. This includes T-REX, as well as light rail projects that supplement the heavy rail network, referred to as T-REX Plus. These projects are the Triboro rail proposal and the light rail proposals in New Jersey and Long Island that are described in the *Fourth Regional Plan*. Not included are the changes in the urban and suburban bus network to speed service, nor the expansion recommendations for the NYC subway system. Significant findings include:

- ▶ The regional transit share of the 11.45 million work trips would grow to from 27.1% in 2015 to 32.4% with the T-REX Plus proposals, compared to 28.5% in 2040 prior to the any of the new transit proposals being put in place.
- ▶ The gain in transit share would be uneven, with the largest jump in shares for the Suburban to Manhattan CBD market, growing from 75.7% in 2015 to close to 90% with the T-REX Plus proposals, compared to 78.4% without them. However, all the markets would increase transit shares, most notably the Suburbs to NYC and the reverse NYC to Suburbs markets.
- ▶ Transit volumes in 2040 would climb by 37.5%, growing from 2.7 million to 3.7 million. The biggest absolute jump would be in the Suburb to CBD market, which would add 420,000 over the 2015 base and the NYC to NYC (borough to borough) market, which would add 330,000 trips over 2015. Among the suburban sectors to Manhattan by far the largest increases in trips with T-REX would be from New Jersey and Long Island, suggesting that earlier phases of T-REX be first priority.
- ▶ The incremental gains in transit trips resulting from the T-REX Plus proposal when compared to 2040 trips without them would be 440,000 trips, mostly in the Suburb to CBD market, and NYC to Suburbs market (100,000), but with 40,000 or more in three other markets: NYC to NYC , Suburb to NYC , and Suburb to Suburb.
- ▶ With no added rail projects in 2040 there will be 800,000 more auto trips to work each day compared to 2015 base with more than half of that number within the suburbs. Only the NYC to CBD market would lose a modest number of auto trips.
- ▶ However, with the T-REX Plus proposal in place, auto trip growth would shrink by almost half, growing from 6,310,000 to 6,758,300, or 7.1%, rather than by 12.6% without T-REX.
- ▶ Auto work trips into the CBD from NYC and the suburbs combined are projected to grow by 18,000 between 2015 and 2040 without T-REX, but if T-REX were to be in place by 2040, the 2040 auto trip levels would decline by 26,000, a drop of 29%.

As can be seen in Table 20, each of the six markets behaves differently with regard to the impact of T-REX Plus. In the following tables those markets most impacted by T-REX are shown in more detail, including the impact of phasing described earlier.

Table 21 arrays the changing demand for transit and auto trips for the base 2015 and 2040, and each of the phases for travel to the CBD from each of the suburban sectors. In each phase, from no new transit, to Phase 1, to Phase 2 to the T-REX Plus proposal, the share of transit use goes up, as would be expected. The largest jump occurs with Phase 2 in place with the transit share climbing from 81% to 87.3%, or 150,000 trips a day, and auto trips dropping by 30,000. The impact of Phase 2 is seen in all the sectors, but Hudson Valley East, would see its transit share grow most when the T-REX Plus proposal is in place because of the northern extension of the Manhattan Spine (3rd Avenue) to Bronx, which would connect T-REX to all east of Hudson lines — the Hudson, Harlem and New Haven lines.

In Table 22 the New York City to the CBD results are arrayed. Transit shares inch up with Phase 2 and with the T-REX Plus proposal reach beyond 90% in the Bronx, Brooklyn and Queens. Because of the high incidence of

walk and bike trips for trips originating in the CBD, and to a lesser extent in Upper Manhattan, transit shares stay lower. With Phase 2 and T-REX Plus in place, auto trips decline by 32,000. The declines in trips in this market as each of the phases is implemented is because the growth in jobs in the NYC boroughs would entice more of its residents to stay in their own borough, and the vast improvements made to the Suburb to CBD market by T-REX would reduce the number of city residents working in the CBD. In addition, the transit improvements in the boroughs recommended by RPA and referenced earlier would further encourage borough residents to work within the boroughs, but were not tested by the demand model because of limitations in the model.

In Table 24, the model results for trips within the New York City boroughs are presented. Because the phases of T-REX has modest impacts in these trips, rather than showing the impacts of each phase the results are arrayed to show each borough to borough sub-markets. The markets are ranked by size of market in 2015.

The total number of work trips grows by 200,000 in the 2015 to 2040 period, with 147,000 of those trips on transit. Without T-REX, transit shares grow by only two percentage points, a result of the impact of higher residential and job densities. With T-REX in place the shares reach just under 50%, up from 43.8% now. Transit ridership for work trips would be 230,000 more per day than it is now. Auto trips without the transit improvements would grow by 8.8% and with it would dip by 2.2%.

The internal trips in the boroughs — Brooklyn to Brooklyn, Queens to Queens, etc. are the largest markets. The effect of the Triboro project is reflected in greater increases in transit shares for the markets connecting the three boroughs of the Bronx, Brooklyn and Queens.

Since the improvements in bus service and subway expansion were not tested in the model, as noted above, the impacts on transit and auto use (shown in Table 24) are more muted than they are likely to be.

In Tables 23 and 25 the impacts on work trip of T-REX are arrayed for the trips from Suburb to New York City and the reverse, from New York City to Suburb. Both markets gain transit riders in a similar fashion from T-REX Plus, climbing from 22% and 28%, respectively, to 39% and 44%. The number of transit riders inbound toward NYC (excluding the Manhattan CBD) increase by 125,000 and 121,000, well more than double the number of today's transit riders. Auto trips for work are reduced for trips toward NYC. For the reverse commute the auto trips increase but the share by auto declines. All suburban markets in both directions see the impact of the T-Rex Plus program.

The last market, the Suburbs to Suburbs is detailed in Table 26. Not surprisingly, the impact of T-REX Plus is much more modest than the other markets, from 4.6% transit today, to 6.6% with T-REX in 2040. Still, transit commuting grows by 23,000 with T-REX in place, but the major transit growth even without T-REX, almost 124,000 over the 2015 base is a result of the placement of proportionately more jobs and workers in suburban regional centers. Over half of this gain is within New Jersey. Auto trips are kept to 7.3% over the 2015 base and drops by 4.2% from the 2040 level without T-REX. The trips across sectors are a very small part of the regional suburban to suburban total, only 3%.

T-REX would increase number of commuters using transit in the region by 440,000 trips per day by 2040 over RPA's earlier base projections without it. With T-REX there will be an additional one million daily transit commuters by 2040.

Table 20: All Regional Work Trips with RPA Vision and T-REX

	Total	Transit	Auto	%Transit
2015				
SUB to CBD	510,775	386,570	123,708	75.7
NYC to CBD	1,352,454	1,062,592	138,634	78.6
NYC to NYC	1,956,166	855,946	743,286	43.8
SUB to NYC	330,226	71,883	257,879	21.8
NYC to SUB	272,189	76,684	194,409	26.3
SUB to SUB	5,573,414	255,432	4,860,142	4.6
Total	9,995,224	2,709,107	6,318,060	27.1
RPA Vision — No System Expansion				
SUB to CBD	683,417	535,933	146,959	78.4
NYC to CBD	1,435,045	1,134,831	133,858	79.1
NYC to NYC	2,197,055	1,003,470	808,695	45.5
SUB to NYC	482,331	122,364	359,340	25.4
NYC to SUB	309,376	93,615	214,820	28.0
SUB to SUB	6,346,773	379,029	5,444,265	6.0
Total	11,453,998	3,269,241	7,107,937	28.5
RPA Vision — T-REX Plus				
SUB to CBD	904,828	806,920	97,566	89.2
NYC to CBD	1,248,509	1,020,105	102,149	81.7
NYC to NYC	2,247,286	1,086,020	792,346	48.1
SUB to NYC	502,580	197,213	304,821	39.2
NYC to SUB	447,081	197,083	248,256	40.1
SUB to SUB	6,105,115	402,942	5,213,154	6.6
Total	11,455,399	3,710,282	6,758,292	32.4
% Change — T-REX Over No T-REX				
SUB to CBD	32.4	50.6	(33.6)	
NYC to CBD	(13.0)	(10.1)	(23.7)	
NYC to NYC	2.3	8.2	(2.0)	
SUB to NYC	4.2	61.2	(15.2)	
NYC to SUB	45	111	16	
SUB to SUB	(3.8)	6.3	(4.2)	
Total	0.0	13.5	(4.9)	
% Change — T-REX Over 2015				
SUB to CBD	77.1	108.7	(21.1)	
NYC to CBD	(7.7)	(4.0)	(26.3)	
NYC to NYC	14.9	26.9	6.6	
SUB to NYC	52.2	174.4	18.2	
NYC to SUB	64	157	28	
SUB to SUB	9.5	57.7	7.3	
Total	14.6	37.0	7.0	

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.
Source: RPA Analysis

T-REX will attract of over 270,000 more transit commuters from the suburbs to the Manhattan CBD, or 400,000 more than use transit today.

Table 21: Suburb to Manhattan CBD Work Trips with RPA Vision and T-REX by Project Phase and Suburban Sector

Sector	Total	Transit	Auto	%Transit
2015				
Long Island	120,435	89,354	31,058	74.2
Connecticut	28,587	22,240	6,340	77.8
Hudson Valley East	76,853	55,318	21,508	72.0
Hudson Valley West	22,383	14,426	7,952	64.5
New Jersey	262,517	205,232	56,851	78.2
Total	510,775	386,570	123,708	75.7
RPA Vision 2040 — No New Transit				
Long Island	179,400	141,561	37,813	78.9
Connecticut	39,312	31,279	8,025	79.6
Hudson Valley East	94,400	69,838	24,533	74.0
Hudson Valley West	25,806	17,335	8,466	67.2
New Jersey	344,500	275,919	68,122	80.1
Total	683,417	535,933	146,959	78.4
RPA Vision 2040 — Phase 1				
Long Island	203,203	168,269	34,910	82.8
Connecticut	50,815	42,935	7,871	84.5
Hudson Valley East	89,743	66,114	23,601	73.7
Hudson Valley West	24,298	16,241	8,053	66.8
New Jersey	369,856	304,508	64,911	82.3
Total	737,914	598,066	139,346	81.0
RPA Vision 2040 — Phase 2				
Long Island	228,467	202,578	25,869	88.7
Connecticut	64,594	57,380	7,206	88.8
Hudson Valley East	65,399	47,919	17,458	73.3
Hudson Valley West	49,785	42,543	7,236	85.5
New Jersey	450,472	399,649	50,456	88.7
Total	858,717	750,070	108,225	87.3
RPA Vision 2040 — T-REX Plus				
Long Island	217,872	194,373	23,480	89.2
Connecticut	71,472	64,708	6,757	90.5
Hudson Valley East	107,583	91,639	15,926	85.2
Hudson Valley West	46,456	39,896	6,556	85.9
New Jersey	461,445	416,304	44,848	90.2
Total	904,828	806,920	97,566	89.2
% Change T-REX Over 2015	77.1	108.7	-21.1	
% Change T-REX Over 2040	32.4	50.6	-33.6	

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

T-REX reduces the number of people commuting by auto to the Manhattan CBD from within NYC by 45,000.

Table 22: NYC Boroughs to Manhattan CBD Works Trips with RPA Vision and T-REX by Project Phase and by Each Borough

2015	Total	Transit	Auto	%Transit
Manhattan CBD	276,066	128,801	19,218	46.7
Upper Manhattan	249,238	209,246	21,368	84.0
Bronx	137,100	122,865	13,802	89.6
Brooklyn	338,257	302,252	33,686	89.4
Queens	304,727	266,535	36,542	87.5
Staten Island	47,066	32,893	14,018	69.9
Total	1,352,454	1,062,592	138,634	78.6

RPA Vision 2040 — No New Transit

Manhattan CBD	301,682	142,683	18,794	47.3
Upper Manhattan	278,563	236,160	20,917	84.8
Bronx	138,945	126,532	11,980	91.1
Brooklyn	325,802	293,723	29,848	90.2
Queens	330,325	292,637	35,881	88.6
Staten Island	59,728	43,096	16,438	72.2
Total	1,435,045	1,134,831	133,858	79.1

RPA Vision 2040 — Phase 1

Manhattan CBD	295,211	139,560	18,553	47.3
Upper Manhattan	270,856	229,378	20,486	84.7
Bronx	131,991	120,065	11,516	91.0
Brooklyn	308,607	278,210	28,237	90.2
Queens	322,282	286,852	33,681	89.0
Staten Island	60,314	44,251	15,867	73.4
Total	1,389,261	1,098,315	128,341	79.1

RPA Vision 2040 — Phase 2

Manhattan CBD	274,402	139,627	16,240	50.9
Upper Manhattan	234,578	199,186	17,723	84.9
Bronx	109,314	99,595	9,381	91.1
Brooklyn	293,849	267,697	24,121	91.1
Queens	320,532	289,717	29,185	90.4
Staten Island	54,574	40,769	13,635	74.7
Total	1,287,249	1,036,590	110,284	80.5

RPA Vision 2040 — T-REX Plus

Manhattan CBD	253,611	133,147	14,714	52.5
Upper Manhattan	242,686	209,410	16,717	86.3
Bronx	129,215	119,365	9,462	92.4
Brooklyn	270,623	246,880	21,882	91.2
Queens	300,921	272,664	26,722	90.6
Staten Island	51,427	38,636	12,631	75.1
Total	1,248,484	1,020,100	102,128	81.7
% Change T-REX Over 2015	-7.7	(4.0)	(26.3)	
% Change T-REX Over 2040	-13.0	-10.1	-23.7	

Source: RPA Analysis

T-REX increases transit shares for the region's fastest growing suburb to outer borough market, from 22% to 39%.

Table 23: Suburb to NYC Boroughs Works Trips with RPA Vision and T-REX and by Suburban Sector

2015	Total	Transit	Auto	% Transit
Long Island	154,935	25,032	129,717	16.2
Connecticut	7,369	2,403	4,963	32.6
Hudson Valley East	58,657	12,449	46,043	21.2
Hudson Valley West	22,205	4,131	18,067	18.6
New Jersey	87,060	27,868	59,090	32.0
Total	330,226	71,883	257,879	21.8

RPA Vision 2040 — No New Transit

Long Island	207,815	41,964	165,656	20.2
Connecticut	12,275	4,403	7,868	35.9
Hudson Valley East	90,542	20,663	69,588	22.8
Hudson Valley West	28,464	5,820	22,638	20.4
New Jersey	143,234	49,515	93,589	34.6
Total	482,331	122,364	359,340	25.4

RPA Vision 2040 — T-REX Plus

Long Island	204,671	63,865	140,626	31.2
Connecticut	17,329	9,691	7,634	55.9
Hudson Valley East	83,307	25,804	57,268	31.0
Hudson Valley West	32,533	12,156	20,369	37.4
New Jersey	164,740	85,697	78,924	52.0
Total	502,580	197,213	304,821	39.2
% Change T-REX Over 2015	52.2	174.4	18.2	
% Change T-REX Over 2040	4.2	61.2	-15.2	

Note: Transit plus auto entries do not add to "Total" since "Total" includes walk, bike and work at home trips.

Source: RPA Analysis

T-REX would attract more transit users for all borough-to-borough markets than exists today.

Table 24: NYC Borough Work Trips with RPA Vision and T-REX for Each Borough to Borough Pair

Home	Work	2015				RPA Vision 2040 — No New Transit				RPA Vision 2040 — T-REX Plus			
		Total	Transit	Auto	% Transit	Total	Transit	Auto	% Transit	Total	Transit	Auto	% Transit
Brooklyn	Brooklyn	527,520	223,947	178,212	42.5	595,346	265,749	189,395	44.6	594,843	271,724	188,171	45.7
Queens	Queens	425,016	148,329	198,192	34.9	481,308	183,875	210,785	38.2	476,206	196,478	197,700	41.3
Bronx	Bronx	225,177	83,818	84,827	37.2	235,031	94,478	84,052	40.2	227,319	95,511	79,862	42.0
Upper Manhattan	Upper Manhattan	142,688	51,306	16,638	36.0	143,030	54,813	16,040	38.3	134,834	52,722	15,151	39.1
Staten Island	Staten Island	94,967	14,378	71,022	15.1	98,221	16,729	71,011	17.0	102,027	17,262	72,633	16.9
Queens	Brooklyn	84,033	39,259	42,358	46.7	85,624	43,249	40,003	50.5	83,548	45,203	35,928	54.1
Brooklyn	Queens	68,592	32,747	33,506	47.7	71,706	36,151	32,894	50.4	88,522	48,343	37,032	54.6
Queens	Upper Manhattan	63,343	45,632	17,148	72.0	80,512	60,213	19,538	74.8	83,080	65,132	17,223	78.4
Bronx	Upper Manhattan	53,076	41,231	11,273	77.7	51,650	41,697	9,403	80.7	46,353	37,838	8,041	81.6
Brooklyn	Upper Manhattan	50,546	39,744	10,532	78.6	57,708	46,344	11,056	80.3	60,364	49,573	10,470	82.1
Staten Island	Brooklyn	29,682	11,002	18,575	37.1	36,154	9,223	26,280	25.5	33,175	8,813	23,738	26.6
CBD	Upper Manhattan	23,443	14,598	4,767	62.3	33,826	21,745	6,551	64.3	36,646	24,573	6,489	67.1
Upper Manhattan	Bronx	23,142	18,398	4,316	79.5	26,497	21,427	4,589	80.9	34,429	28,142	5,691	81.7
Bronx	Queens	21,572	11,986	9,379	55.6	32,034	12,114	18,216	37.8	35,127	15,186	17,812	43.2
Queens	Bronx	20,791	10,399	10,200	50.0	24,715	8,750	14,601	35.4	27,245	11,295	14,231	41.5
Bronx	Brooklyn	19,801	13,997	5,728	70.7	33,117	18,160	14,430	54.8	38,526	22,612	15,273	58.7
Brooklyn	Bronx	13,284	8,880	4,348	66.8	20,677	10,758	9,568	52.0	27,830	15,467	11,879	55.6
Upper Manhattan	Queens	12,621	9,519	2,913	75.4	14,545	11,155	3,176	76.7	19,627	15,542	3,814	79.2
Upper Manhattan	Brooklyn	12,054	10,118	1,852	83.9	15,023	12,851	2,069	85.5	19,695	17,073	2,480	86.7
CBD	Brooklyn	11,334	8,924	2,067	78.7	14,947	12,072	2,445	80.8	18,764	15,325	2,919	81.7
CBD	Queens	6,738	5,141	1,462	76.3	8,229	6,439	1,621	78.2	13,381	10,766	2,358	80.5
Brooklyn	Staten Island	6,488	2,994	3,411	46.2	5,165	1,590	3,215	30.8	5,449	1,691	3,371	31.0
Staten Island	Queens	5,596	1,856	3,731	33.2	7,115	1,632	5,431	22.9	7,872	2,042	5,769	25.9
Staten Island	Upper Manhattan	5,347	2,437	2,898	45.6	9,570	4,660	4,888	48.7	10,318	5,388	4,905	52.2
CBD	Bronx	3,750	2,933	774	78.2	5,653	4,588	1,000	81.2	9,204	7,627	1,473	82.9
Queens	Staten Island	2,064	803	1,253	38.9	2,785	741	1,985	26.6	3,000	872	2,059	29.1
Staten Island	Bronx	1,584	518	1,064	32.7	2,732	577	2,135	21.1	2,921	693	2,206	23.7
Upper Manhattan	Staten Island	685	412	267	60.1	1,033	621	403	60.1	1,450	898	540	61.9
CBD	Staten Island	633	391	224	61.8	756	480	255	63.5	1,234	803	395	65.1
Bronx	Staten Island	599	248	347	41.4	2,345	587	1,663	25.0	2,715	745	1,854	27.4
Total		1,956,166	855,946	743,286	43.8	2,197,055	1,003,470	808,695	45.7	2,245,700	1,085,338	791,467	48.3
% Change T-REX Over 2015										14.9	26.9	6.6	
% Change T-REX Over 2040										2.3	8.2	-2.0	

Note: Transit plus auto entries do not add to “Total” since “Total” includes walk, bike and work at home trips.

Source: RPA Analysis

T-REX increases transit shares for the NYC boroughs to suburb market from 28% to 44%.

Table 25: Reverse Work Trips from NYC Boroughs to Suburbs with RPA Vision and T-REX and by Suburban Sector

2015	Total	Transit	Auto	%Transit
Long Island	112,588	21,647	90,308	19.2
Connecticut	11,467	4,362	7,105	38.0
Hudson Valley East	60,008	18,597	41,136	31.0
Hudson Valley West	5,178	1,198	3,980	23.1
New Jersey	82,948	30,889	51,877	37.2
Total	272,189	76,693	194,406	28.2
RPA Vision 2040 — No New Transit				
Long Island	127,367	29,755	97,065	23.4
Connecticut	9,568	3,338	6,228	34.9
Hudson Valley East	58,706	15,740	42,753	26.8
Hudson Valley West	8,887	1,348	7,535	15.2
New Jersey	80,681	29,602	50,951	36.7
Total	309,376	93,615	214,820	30.3
RPA Vision 2040 — T-REX Plus				
Long Island	166,570	60,076	105,557	36.1
Connecticut	16,414	8,679	7,723	52.9
Hudson Valley East	69,433	24,589	44,536	35.4
Hudson Valley West	14,403	4,532	9,847	31.5
New Jersey	123,841	58,799	64,680	47.5
Total	447,081	197,083	248,256	44.1
% Change T-REX Over 2015	64.3	157.0	27.7	
% Change T-REX Over 2040	44.5	110.5	15.6	

Note: Transit plus auto entries do not add to “Total” since “Total” includes walk, bike and work at home trips.

Source: RPA Analysis

T-REX increases intra-suburban transit travel from 1 in 21 trips to 1 in 15 trips.

Table 26: Suburban Only Work Trips with RPA Vision and T-REX and by Suburban Sector

2015	Total	Transit	Auto	%Transit
Long Island	1,036,180	26,858	938,272	2.6
Connecticut	805,304	28,419	709,350	3.5
Hudson Valley East	429,616	17,837	363,922	4.2
Hudson Valley West	303,335	2,538	268,295	0.8
New Jersey	2,806,303	170,256	2,397,444	6.1
Inter-sector	192,676	9,524	182,859	4.9
Total	5,573,414	255,432	4,860,142	4.6
RPA Vision 2040 — No New Transit				
Long Island	1,132,503	36,070	1,018,869	3.2
Connecticut	921,800	42,133	801,376	4.6
Hudson Valley East	491,546	29,146	408,986	5.9
Hudson Valley West	328,376	3,442	289,154	1.0
New Jersey	3,244,205	254,441	2,711,660	7.8
Inter-sector	228,344	13,798	214,220	6.0
Total	6,346,773	379,029	5,444,265	6.0
RPA Vision 2040 — T-REX Plus				
Long Island	1,095,196	39,877	979,815	3.6
Connecticut	886,032	42,334	770,464	4.8
Hudson Valley East	483,149	31,033	402,219	6.4
Hudson Valley West	312,353	3,290	276,232	1.1
New Jersey	3,102,085	265,960	2,578,880	8.6
Inter-sector	226,300	20,448	205,544	9.0
Total	6,105,115	402,942	5,213,154	6.6
% Change T-REX Over 2015	9.5	57.7	7.3	
% Change T-REX Over 2040	-3.8	6.3	-4.2	

Note: Transit plus auto entries do not add to “Total” since “Total” includes walk, bike and work at home trips.

Source: RPA Analysis

Economic, Operational, Equity and Health Benefits

The T-REX is a huge project that will require a substantial investment and long-term commitment. Yet, it would transform the way we get to work, school and other destinations — connecting parts of the region that are poorly served by transit, dramatically increasing public transit capacity and enabling for the first time true regional travel. It would change where people live and where they work. Trips that are unthinkable today would become commonplace.

Economic Benefits

The dramatic improvement in regional accessibility and ease of travel that would result from the development of regional rail would lead to a large array of economic benefits. For example, decreasing travel times and increasing service areas would help address the high price of housing through the region and expand labor markets.

Expanded Labor Markets

Improving the reach and efficiency of the region's rail network would expand the region's labor sheds, effectively making more jobs available to existing residents without requiring them to move. This also improves productivity for employers, giving them a much larger labor market from which to match available workers with job openings. This expansion in job access would be brought about by two main mechanisms. One, T-REX will provide a robust and reliable transit service to those who don't currently have it. Residents of areas without decent transit options, such as Bergen County, will be provided with a service which is reliable and frequent. Furthermore, this service would provide access to multiple destinations allowing for residents to access jobs throughout the region instead of just Manhattan. The opening up of under-served areas would help employers find more qualified employees and give resident's access to more job opportunities. .

Secondly, the system expands job access by decreasing travel times and providing new destinations to those already well served by transit. Inner core suburbs are well covered by their respective commuter rail systems but generally only for trips ending or originating in New York City. Persons looking to travel to other suburban communities generally have to travel by car, deal with poor non-peak

direction rail service, or transfer between the region's multiple rail systems and pay multiple fares. RPA's proposal eliminates the need for many of these transfers, standardizes the fares paid for such trips, and decreases travel times by providing a regional express service.

As shown in the Paterson case study (see callout on next page), the number of jobs and workers reachable by transit would increase exponentially for many parts of the region.

Time Savings

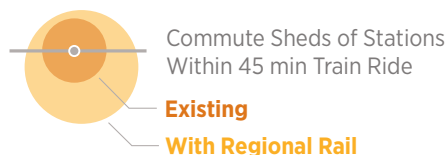
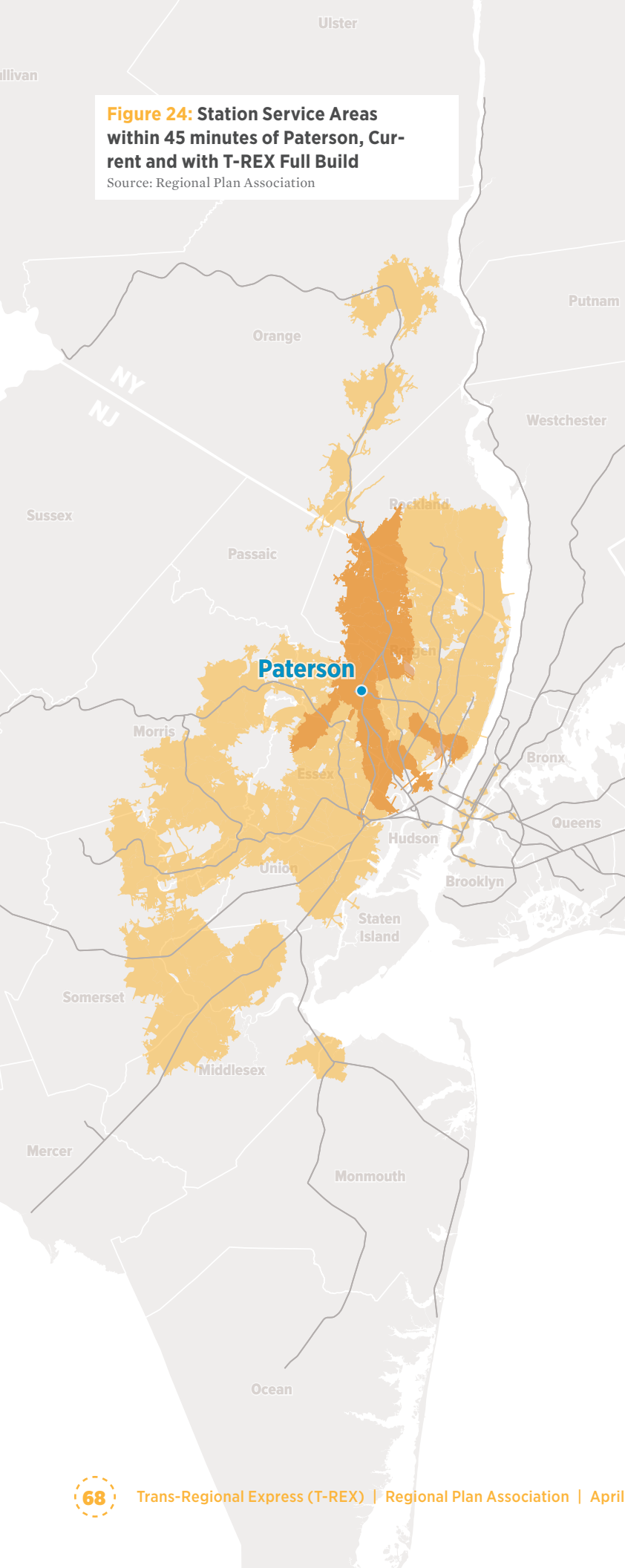
Reducing travel times throughout the region doesn't just open up new housing and job markets by making currently unthinkable trips practical, it also reduces the travel times experienced by many of the region's commuters. Reducing commute times provides flexibility for travelers to use that time for other productive activities such as spending more time with their families, pursuing additional education, or any number of other activities that can be pushed aside by long commutes.

To evaluate the impact of these time savings, the transit travel time reductions experienced by commuters were calculated assuming the proposed T-REX system was in place today based on 2010 census data.⁴² In addition, the monetary value of that time was estimated. To determine the time savings resulting from the full build out of the T-REX system, RPA computed the travel time between each of the system's stations on the new regional rail network. Access times from each of the zones used in the demand model to the closest station were added to these travel times along with penalties for having to make in-system transfers between lines. These times were then summed up and compared to current transit travel times between each of demand model zones. Those zonal pairs that had a shorter estimated travel time for the T-REX system were deemed to benefit from the system and the difference between the time on the T-REX system and current system was calculated. Pairs with a shorter time currently were kept the same under the assumption that the rest of the transit system remained unchanged and riders would choose to maintain their current commute if it was faster than the one provided by the T-REX system.

⁴² This is the latest available year of data from the U.S. Census Bureau's Census Transportation Planning Package.

Figure 24: Station Service Areas within 45 minutes of Paterson, Current and with T-REX Full Build

Source: Regional Plan Association



Case Study — Paterson

Despite its geographic proximity to New York City and legacy of well-paying industrial jobs, Paterson has underperformed economically for decades. One reason for this is the city's poor transit connections. Despite being only about 15 miles from Manhattan as the crow flies, it is almost an hour train ride from Paterson to New York Penn Station. This poor level of service effectively disconnects Paterson from large swaths of the region and discourages people and companies from locating there. This paucity of access is shown as the darker color in Figure 24, which maps the commute shed for all the commuter rail stations currently within a 45 minute transit ride of Paterson. The lighter color in the same figure dramatically demonstrates how T-REX would affect a place like Paterson. Implementing the T-REX Plus service would bring Paterson within a 45 minute commute of a large portion of northern New Jersey and New York City. This larger service area would result in a six-fold increase in the number of jobs within a 45 minute train ride of Paterson, from 96,000 to 675,000. Similarly, the number of people within a 45-minute train commute would increase from 151,000 to 1.1 million. Such an increase in access for a city like Paterson would be nothing short of revolutionary, making it a far more-attractive location for residents and business.

Table 27: Increase in Population and Jobs within 45 minutes of Paterson with and without T-REX

	Population	Jobs
Current	150,900	95,642
Future	1,061,203	674,523
% Increase	603%	605%

Source: RPA Analysis

Table 28: Travel Time Savings Examples

Origin	Destination	Existing	Future	Difference
Albany	Mineola	228	150	-78
Beacon	NY Penn Station	110	60	-50
Bergen Arches	Grand Central	48	23	-25
Bergen Arches	Houston St	39	6	-32
Columbus Circle	Grand Central	13	3	-10
Columbus Circle	Water Street	24	10	-14
Co-Op City	Grand Central	63	35	-28
Co-Op City	NY Penn Station	81	28	-53
Hackensack	Grand Central	61	24	-37
Hicksville	Newark Broad Street	82	55	-27
Houston St	Grand Central	15	6	-9
Lakewood	Grand Central	120	64	-56
Locust Manor	Grand Central	82	32	-50
Locust Manor	NY Penn Station	76	27	-49
Metropark	Mineola	94	67	-27
Metropark	NY Penn Station	45	25	-20
Morris Park	Stamford	82	51	-31
Morristown	Jamaica (JFK)	94	43	-50
New Haven Union Station	Grand Central	112	77	-35
New Haven Union Station	NY Penn Station	134	73	-60
Newark Broad Street	Union Square	41	21	-20
Newark Penn Station	Melville, L.I. (Route 110)	141	43	-97
North Bergen	Columbus Circle	50	9	-41
North Bergen	Grand Central	50	11	-39
NY Penn Station	Sunnyside	24	6	-18
Paterson	Columbus Circle	72	34	-37
Paterson	Grand Central	73	53	-20
Paterson	Hackensack	40	14	-26
Perth Amboy	Jamaica	93	77	-15
Plainfield	Grand Central	85	56	-29
Poughkeepsie	NY Penn Station	123	74	-49
Ronkonkoma	Grand Central	100	50	-50
South Norwalk	Newark Airport (EWR)	145	55	-90
Stamford	Grand Central	57	49	-8
Stamford	NY Penn Station	73	51	-22
Stamford	JFK	125	69	-56
Tarrytown	Willels Point (LGA)	86	43	-42
Teaneck	Grand Central	50	24	-25
Tremont	Water Street	58	23	-35
Trenton	Mineola	126	117	-9
Water Street	Grand Central	22	8	-14
White Plains	Jamaica (JFK)	82	44	-38
Williams Bridge	Grand Central	57	36	-21
Williams Bridge	NY Penn Station	56	23	-33
Yonkers	Water Street	65	36	-28

Source: RPA Analysis

The analysis showed that the T-REX system would reduce travel times by 39 minutes, on average, for all zonal pairs throughout the region. However, this average is not weighted by the actual number of people taking transit between each of the zonal pairs so pairs with very few transit trips are given the same weight as those with many. Weighting the average by the number of transit trips produces a number more representative of the time savings experienced by commuters throughout the region. Based on the very conservative assumption that any travel time reductions would not induce commuters to switch from other modes to transit, which of course would not be the case, it was determined that 54% of existing transit riders would see an average trip time reduction of 10 minutes (one-way) or 20 minutes a day (two-way) if the full build T-REX system was in place.

To estimate the monetary value of these time savings, it was assumed that time saved in transit was equal to half of the region's average hourly wage. A value of \$16.26 (hourly wage of \$32.51) was arrived at using data for the New York Metropolitan Statistical Area from the Bureau of Economic Analysis for 2010.⁴³ Under the same conservative assumption that the reduction in travel times from the T-REX system wouldn't induce any modal shifts, it was determined that, on average and after accounting for inflation, transit riders would save \$3.55 each way on their commute (in 2017 dollars). While a seemingly small number, these savings amount to \$12.3 million across all transit riders in the region each day, or \$3.4 billion annually.

Increasing Housing Choice

The reduction in travel times afforded by T-REX will shrink the temporal "distance" between places and allow people to travel farther for work geographically without increasing their commute time. As a result, regional residents would be in a better position to choose a place to live that suits their personal needs rather than one which optimizes their specific commute. This increase in choice will increase the competitiveness of areas within the region that currently have poor connectivity as well as increase the competitiveness of the region as a whole with other areas of the country that may not have the same level of housing choice.

⁴³ The average hourly wage was calculated by dividing total wages and salaries into the total number of wage and salary jobs in the region to arrive at an annual number. This number was then converted to an hourly figure assuming 50 work weeks in a year and 40 hours in a work week.

Capacity Increases

Many parts of our current commuter rail systems are run at maximum capacity during peak periods. This places physical stress on the infrastructure supporting these portions of the system as well as operational stress on the system's ability to handle unforeseen incidents (e.g. a broken down train or storm event) gracefully. T-REX aims to alleviate many of these issues by building out additional capacity at critical parts of the system to reduce physical wear and tear, eliminate bottlenecks and single points of failure, and increase operational flexibility. A few of these benefits are briefly discussed below to demonstrate how increases in system capacity at specific places will make the system as a whole function more efficiently and reliably.

Separation of Local and Express Services

Physically separating local and express service reduces train movement conflict between services with different operating characteristics. There would be fewer merges and diverges of different train types on the network resulting in a more reliable service. This would also allow for closer headways, since trains tend to have more similar average speeds and performance.

Elimination of Choke Points

Choke points include at-grade junctions, locations where trains are required to change or cross tracks to reach stations, points where the number of main tracks is reduced, and locations where trains change direction on the main line. Location-specific projects to systematically eliminate choke points would have a significant positive effect on both throughput capacity and service reliability. It will also greatly simplify the dispatching of trains. Critical for achieving regularized service patterns. The regional rail plan eliminates all significant choke points within the regional rail service territory.

System Redundancy

As recent derailments at Penn Station have shown, our region's commuter rail network has many single points of failure that are vulnerable to catastrophic events.⁴⁴ When there is a failure at a critical piece of infrastructure, such as a tunnel or critical interlocking, the entire system is crippled and unable to provide anything resembling a normal level of service. RPA's proposal is designed to eliminate many of these failure points by adding redundancy to the system through additional rail capacity. For example, one of the most critical of these failure points is the pair of Hudson River Tunnels which carry NJT and Amtrak trains between New Jersey and New York. A failure in either of these tunnels reduces trans-Hudson capacity by 75%. T-REX would eliminate this failure point by supplementing the current Hudson River Tunnels, which lead into Penn

Station, with an additional two tubes leading into Penn Station in the first phase of the system buildout. The full buildout of the system would also include four additional trans-Hudson tunnels (two at 57th Street and two at Houston Street) that would connect to the Manhattan Spine running along 3rd Ave providing a total of six new tunnels under the Hudson River. Furthermore, the 57th Street and Houston Street tunnels would not run through Penn Station allowing them to provide redundancy should any issue arise at the Station.

Building the T-REX Plus proposal would eliminate many of these failure points and create a rail system capable of handling catastrophic events such as future hurricanes or more mundane ones such as regularly scheduled tunnel maintenance.

Subway and Rail System Maintenance

One significant benefit of creating parallel capacity in the broader rail network, and building capacity in excess of what is required for anticipated peak needs, is the ability to minimize the negative impacts associated with closing a portion of an existing line (rail or subway) for maintenance, renewal or repair.

The T-REX regional rail network, in essence, builds capacity that parallels much of the subway/PATH system and even presents parallel routing opportunities for regional rail trains. This parallel capacity will be useful for system operations in the event of an unexpected outage on a portion of the system, giving travelers better choices of alternative routes or modes than currently exist. When fully built-out, it should be possible to close portions of existing lines for extended periods to perform capital work with high productivity and at reasonable cost (similar to the current 'L' train subway tunnel reconstruction plan, except with better alternative service options).

Flexibility for Service Reliability Future Growth

Beyond providing redundancy for significant and prolonged incidents such as a storm or derailment by allowing trains to bypass compromised pieces of infrastructure, increasing capacity throughout the system provides the ability for it to recover from smaller and more routine incidents while also providing the flexibility to offer new services. Smaller incidents such as a power outage or sick customer currently can wreak havoc on regional rail schedules causing delays for all of the trains on the affected line.⁴⁵ These small incidents can quickly ripple throughout the system because there is no "spare" operating capacity. Specifically, on many lines trains are run as close to each other as possible to maximize the line haul capacity of a piece of infrastructure. However, this also means there is no cushion between trains to allow for schedule recovery in the event of a delay, no matter how small.

⁴⁴ Fitzsimmons, Emma G. "Track Flaws Are Focus of Penn Station Derailment Inquiry, Official Says." *The New York Times*, April 5, 2017. <https://www.nytimes.com/2017/04/05/nyregion/train-tracks-amtrak-penn-station-derailment.html>.

⁴⁵ Rosenberg, Eli. "Delays Cascade on L.I.R.R. After Power Problem in Tunnel." *The New York Times*, May 30, 2017. <https://www.nytimes.com/2017/05/30/nyregion/lirr-train-delays.html>.

T-REX helps eliminate these packed schedules in two ways. First, it will spread trains more evenly throughout the region on new pieces of infrastructure. Doing so helps reduce the demand placed on any one line by providing people multiple alternative routes to reach their destination. For example, the creation of two new major crossings under the Hudson River (the 57th and Houston Street Tunnels) will help distribute trans-Hudson rail passengers across three crossings instead of funneling them all through one crossing, as is currently the case. This spreading of demand will allow each crossing to operate at less than 100% capacity while still meeting the aggregate demand of the trans-Hudson market.

Secondly, T-REX reduces the operating pressure currently placed on the rail system by adding additional track capacity to existing critical corridors.

Building this additional capacity into the region's rail system will allow for demand to be spread more evenly and reduce the pressure placed on any one piece of infrastructure, thereby increasing reliability and efficiency.

Relieving Pressure on Existing Roads and Rail Transit Service

Much of the region's rail, subway, and road systems are utilized at or near their maximum capacities. T-REX is designed to reduce the loads placed on these pieces of infrastructure. For example, the proposed system parallels the #7 and Queens Boulevard (E, F, M, R) subway lines in Queens. These lines are currently over congested with riders who use them to reach jobs located in Long Island City or Manhattan. The T-REX would provide a parallel express route to these services which would draw riders off of them by offering reduced travel times and comparable fares. The system would perform a similar function in mid and southern Manhattan by providing a relief valve for the Lexington Avenue line, the country's busiest mass transit line. The southern leg of the Jersey Loop would relieve the extreme congestion during rush hours on the Uptown PATH line.

Reducing the over-usage of our transportation infrastructure leads to myriad benefits such as reducing physical wear and tear on our aging infrastructure. It also creates more opportunities to enter portions of the system, as noted earlier, and perform maintenance and upgrades. Finally, reducing transit congestion levels makes the system both more pleasant to use for all riders and easier to use for those with disabilities.

Encouraging a Modal Shift

Tangentially related to relieving pressure on existing transportation infrastructure, T-REX will encourage a modal shift from personal automobiles and slower bus services to rail by providing a real rapid transit alternative in places with poor or nonexistent service. Currently, many areas of the region, such as Northern New Jersey, are not well served by transit. As a result, these areas are highly dependent on automobiles and can experience high levels of vehicular congestion. Providing a reliable and robust rail system would allow many of these trips to be completed by transit. In fact, RPA's demand modelling work estimates that the full build of the T-REX system, as noted earlier, would shift about 400,000 daily work trips, more than the Long Island Rail Road's daily (work and non-work) ridership, to transit from other modes when compared with the base (no build) aspirational development case. While RPA's demand model doesn't discriminate between transit modes, it is safe to assume that the vast majority of these trips would occur on the T-REX system since no other changes to the region's transit system were made when arriving at these numbers. Such a large modal shift would benefit the entire region by reducing roadway congestion and as well as the pollution and greenhouse gases emitted by automobiles.

With the RPA plan in place by 2027 the share of trips by rail will grow from 38% today to almost 50%, while bus shares would decline from 33% to 25%, as shown in Table 29. The absolute volume of bus trips would decline by 13% going from 100,000 work trips to Manhattan (south of Harlem) to 88,000. Meanwhile rail trips increase by 49%, which can be accommodated by the added Gateway tunnel. The total trips would grow by 14%, spurred a combination of population expansion assumed for the west of Hudson communities and by the improved transit which encourages travel to Manhattan.

Future phases of the RPA plan for regional rail improvements will further impact trans-Hudson. As described in the section above, the addition of two more tunnels and related rail line and services will eventually be needed to handle the growth anticipated for west of the Hudson River communities in New Jersey and New York.

Table 30 presents the impacts of the land use changes envisioned in the RPA plan on total travel to work and on the mode shares of that travel. The results demonstrate how transformative the new transit service would be. The number of people traveling to work from east of the Hudson to Manhattan will grow by almost 1/4 million, up 79%. Rail use almost triples, going from only 38% of all trips now to over 60% in 2040, while bus uses remains essentially constant, dropping to a 21% share. With the demand management measures suggested by the Port Authority to shift

Table 29: Work Trips Across the Hudson River by Mode — 2015 and 2027 — RPA Plan Initial Phase

	Year	Description	Total	Rail	Bus	Ferry	Auto
Daily Work Trips	2015	Existing	301,869	115,487	100,801	8,667	76,914
	2027	Nothing Gets Built	335,791	124,351	97,704	9,641	104,095
	2027	RPA Plan Initial Phase	345,476	170,082	87,618	10,862	76,914
Modal Shares (%)	2015	Existing	100.0	38.3	33.4	2.9	25.5
	2027	Nothing Gets Built	100.0	37.0	29.1	2.9	31.0
	2027	RPA Plan Initial Phase	100.0	49.2	25.4	3.1	22.3
Growth from 2015 to 2027 (%)	2027	Nothing Gets Built	11.2	7.7	(3.1)	11.2	35.3
	2027	RPA Plan Initial Phase	14.4	47.3	(13.1)	25.3	0.0

Source: RPA Analysis

trips by bus from the PABT, the volumes of bus passengers destined for the Manhattan bus terminal or to its replacement would likely further decline.

The estimates of the impact of the first two phases of T-REX on bus use (based on the mode choice model) understate the shift from bus to rail for a number of reasons. First, the level of bus service is likely to decline as riders shift from bus to rail. This is not accounted for in the model. Second, the model does not attempt to account for the reconfiguration of bus services that would feed key rail intermodal facilities in Secaucus, at the Newark Airport station on the Northeast Corridor, in North Bergen and in numerous other stations in northern New Jersey. Nor is the model sensitive to the increased rail frequency proposed in this report. Finally, although somewhat speculative, the model does not account for a shift in housing patterns brought on by the conversion to housing at surface parking lots at many stations brought about by new first mile / last mile on demand services likely to be put in place over the next generation. Taken together, these limitations undoubtedly resulted in the model underestimating the bus to rail ridership shift of the rail proposals recommended in this report and overstates bus demand and the capacity needed in Manhattan. One implication of this is that a smaller investment would be needed in a new bus terminal, allowing the shifting of some of those funds to support rail service improvements.

Promoting a More Equitable Region

T-REX would transform the commuter rail system from one used predominately by higher-income commuters to one that is accessible and affordable to people with a broad range of incomes. Because the system would serve far more locations with frequent service throughout the day, it would become more like a rapid transit service taking people to low and middle-wage jobs outside of the Manhattan office district. Higher ridership along with policy

changes would make fares more affordable. Many low-income communities of color in New York City's boroughs, smaller cities and the region's inner suburbs would have greatly improved service. The economies of poorer cities like Bridgeport or Paterson would receive a boost.

As with any generational infrastructure investment, care must be taken with T-REX to ensure that it promotes equitable outcomes which do not create or reinforce inequitable land use patterns and power structures. The level of investment proposed in T-REX is akin to the original development of subway system, which drastically reduced travel times between vast swaths of New York City — eliminating the need for expensive personal means of transportation that had previously limited the mobility range of lower income citizens. Furthermore, the system has been designed with a focus on connecting lower income communities within the city and the inner urban core, such as Paterson and East New York, with the rest of the region to reduce travel times and encourage economic growth.

T-REX would also increase real estate values throughout the region, making it less likely to have disproportionate local effects on housing costs. The broad scope of T-REX, and its ability spread the benefits of construction dollars over a wider swath of the region, will tend to dilute the localized effects of changing mobility. Improving mobility across the entire region can be expected to have the effect of increasing value in parallel with economic opportunity in a more measured way, over a larger area.

Care must still be taken as it is built to ensure that the land uses and development patterns around the system do not lock in any existing inequities or create new ones. A full strategy for doing so is beyond the scope of this document, but RPA intends to produce analyses and promote implementation strategies that avoid or mitigate inequitable land use, economic or environmental outcomes.

Table 30: The Impacts of T-REX on Trans-Hudson Travel to Work

	Year	Description	Total	Rail	Bus	Ferry	Auto
Daily Work Trips	2015	Existing	301,869	115,487	100,801	8,667	76,914
	2027	Nothing Gets Built	335,791	124,351	97,704	9,641	104,095
	2027	RPA Plan Initial Phase	345,476	170,082	87,618	10,862	76,914
	2040	Nothing Gets Built	373,526	139,360	110,178	10,724	113,264
	2040	RPA Plan Initial Phase	395,383	202,924	104,193	11,352	76,914
	2040	T-REX Phase II	505,902	306,610	107,853	14,525	76,914
	2040	T-REX Phase III	542,432	337,225	112,719	15,574	76,914
Modal Shares (%)	2015	Existing	100.0	38.3	33.4	2.9	25.5
	2040	Nothing Gets Built	100.0	37.3	29.5	2.9	30.3
	2040	RPA Plan Initial Phase	100.0	51.3	26.4	2.9	19.5
	2040	T-REX Phase II	100.0	60.6	21.3	2.9	15.2
	2040	T-REX Phase III	100.0	62.2	20.8	2.9	14.2
Growth from 2015 to 2040 (%)	2040	Nothing Gets Built	23.7	20.7	9.3	23.7	47.3
	2040	RPA Plan Initial Phase	31.0	75.7	3.4	31.0	0.0
	2040	T-REX Phase II	67.6	165.5	7.0	67.6	0.0
	2040	T-REX Phase III	79.7	192.0	11.8	79.7	0.0

Source: RPA Analysis

Sea Level Rise

If current climate change trends continue, sea levels could rise by up to 3 feet within the next fifty years and up to 6 feet by 2100. Large, coastal cities are particularly vulnerable to the impact of sea level rise (SLR) that can seriously disrupt the infrastructure systems they depend on to function. Of these various systems, coastal railroads are especially at risk since any disruption in one section inherently disrupts the entire system. The regional rail lines along the Hudson River and Long Island Sound and in Lower Manhattan, Sunnyside/Queens and Hoboken will all need to be protected from SLR. Perhaps nowhere is this more evident though than at Secaucus Junction, located in the Meadowlands marshlands in New Jersey.

The Meadowlands is host to a confluence of NJ Transit rail lines that all run through Secaucus before travelling to New York Penn Station or Hoboken Terminal. All but two NJ Transit lines run through this low-lying station which serves as a connection between the lines that have no direct connection to New York City and terminate in Hoboken and those headed into New York's Penn Station. Over 26,000 riders use this station each day to board a NJ Transit train or transfer to one bound for New York, making Secaucus the third busiest rail station in the NJ Transit system.

The importance of Secaucus as a major transfer point in the NJ Transit system is threatened by its location. Over 17% of the total land area around the station is vulnerable to inundation at three feet of sea level rise and over 43% is vulnerable at six feet. The station structure itself and the upper level tracks are likely safe with up to three feet of sea level rise but the lower platforms and track are vulnerable

at levels below that. The lower level of the station serves the Pascack Valley and Main/ Bergen lines, whose riders can transfer for New York-bound trains on the upper level. There is insufficient space between these tracks and the NEC running above to raise the track-bed six feet. Complicating matters further, the sections of the Pascack Valley and Main/ Bergen, lines leading into the station from the north run through marshland that is vulnerable to inundation before three feet of SLR and will likely need to be reconstructed and/or fortified if service is to be sustained with SLR.

Currently, resiliency policies for the Meadowlands are mostly focused on managing storm events and quickly recovering afterwards. While necessary in the short term, these policies should not preclude plans to handle water levels that prevent acceptable level for rail service. Some strategies such as the fortification and raising of Secaucus Junction and vulnerable lines should be explored and might be possible. However, these interventions must be considered within the context of the surrounding communities — some actions taken to protect the station might worsen conditions for adjacent residents or commercial tenants. RPA's regional rail proposal assumes that critical infrastructure at Secaucus could be fortified with minimal community impacts. If this isn't possible, the proposal has been designed to be flexible with respect to train routings. In the long-term future, if the low-lying portions of the Main, Bergen and Pascack Valley Lines through the Meadowlands become impassable due to sea-level rise or threat of storm surge, it would be possible to re-route the Pascack Valley and Main/Bergen lines through the Upper Trans Hudson Tunnel of the Jersey Loop — bypassing the Meadowlands entirely and demapping the remainder of the lines through Hoboken. This would be a long-range contingency and far less desirable than the proposed T-REX network,

since it would decrease network redundancy and result in the elimination of 12 stations south of the Susquehanna line, including the link to Hoboken and Gold Coast waterfront. However, it demonstrates the flexibility of the new tunnel and other rail infrastructure recommendations with respect to future climate uncertainty.

Goods Movement

The infrastructure improvements proposed for T-REX do not only benefit passenger rail services. In fact, some infrastructure projects, such as the construction of the Crosstown Line, provide the opportunity to allow for off-peak freight rail service which was never possible before. Running such a service could help alleviate the burden placed on the region's roads by the thousands of trucks that traverse them daily to deliver goods. To be clear, trucks or other last mile delivery solutions would still be necessary to make the final goods delivery but a properly planned freight rail service could eliminate those trucks carrying goods to and from distribution centers and long-haul through truck trips.

While intermingling passenger and freight operations has the potential for substantial benefits and capital cost savings, there are major challenges to doing so that must be addressed in the rail system's initial planning phases. Traditional freight train cars can be longer, wider, and taller than passenger cars, and any infrastructure constructed as part of a regional rail system must be created with these dimensions in mind — or future rail freight operations through New York City designed and customized in tandem with the regional rail infrastructure. Furthermore, freight trains are typically powered by diesel locomotives that cannot be used on underground sections of track because of the fumes they emit. As a result, any freight trains making use of the regional rail system must use electricity as their means of motive power. While uncommon, there are examples of electrified freight railroads throughout the world and in the United States and locomotives capable of hauling freight via electric power are already in production. However, the wayside infrastructure providing the electricity would have to be developed with a freight use case in mind to ensure power and clearance requirements were met.

Integrating freight and passenger services also requires careful operational planning and coordination. Since freight trains are much heavier than passenger trains they are typically unable to match the performance characteristics of passenger trains with respect to acceleration, deceleration, and top speed. As a result, they require more time to traverse the same section of track as a passenger train and can be an impediment to frequent and reliable passenger operations. Freight trains also present an operational issue from a maintenance perspective. The heavier

weight of the trains causes the rails on which the trains run to wear down and deform at a much quicker rate than passenger services. This wear and tear can limit the speed of passenger trains and result in a bouncy and uncomfortable ride. However, examples such as the North London Line on the London Overground and on many of Metra commuter lines in Chicago indicate that such an operation is entirely feasible and addressing both of these issues is just a matter of proper operational planning and maintenance. As a result of these concerns, night-time or off-peak rail freight on the regional rail network is more likely to be supportable with a rail freight operation customized for the unique physical and operating conditions within the New York metropolitan area than with the types of freight trains typically operated by the Class I freight railroads for long-haul service across the nation. Features customized for the operating environment in New York City, on Long Island and across southern New England would likely include electric traction power, rail cars and locomotives designed to be compatible with station and tunnel clearances, and train lengths and weights designed for operational compatibility and optimal infrastructure maintainability.

Despite the challenges to integrating a robust passenger service with freight service, it is a worthwhile endeavor given the efficiencies of freight rail when compared to long-haul trucking and the ever-increasing impact of truck traffic on the region's highways. The reduction of trucks resulting from a regional freight rail service would reduce regional emissions and congestion. The service would also allow for the opportunity to relocate freight distribution centers in a more geographically balanced way, reducing logistical issues for shippers.

Public Health and Physical Access

Reconfiguring the region's fractured commuter rail system to be a holistic regional rail system provides the opportunity to ensure that it is accessible to many more of the region's residents. As required by law, all of the new infrastructure proposed here would be fully compliant with the Americans with Disabilities Act (ADA). ADA compliance incorporates accessibility for mobility, visual, and hearing impairments. As demonstrated in Table 31, many stations in the system are wheelchair accessible, but they do not include provisions for hearing and visual impairment such as tactile warning strips, tactile signage, and variable signage that can adjust to visually display all audible information. Transit agencies also have the option of installing infrared transmitters next to print signs that transmit signage information audibly. With this technology, passengers could scan a platform and hear the signs instead of having to read Braille.⁴⁶

⁴⁶ Americans with Disabilities Act — 2010 Standards, 810 Transportation

Figure 25: Stations without Wheelchair Access in the Existing Commuter Rail Network

Source: Regional Plan Association

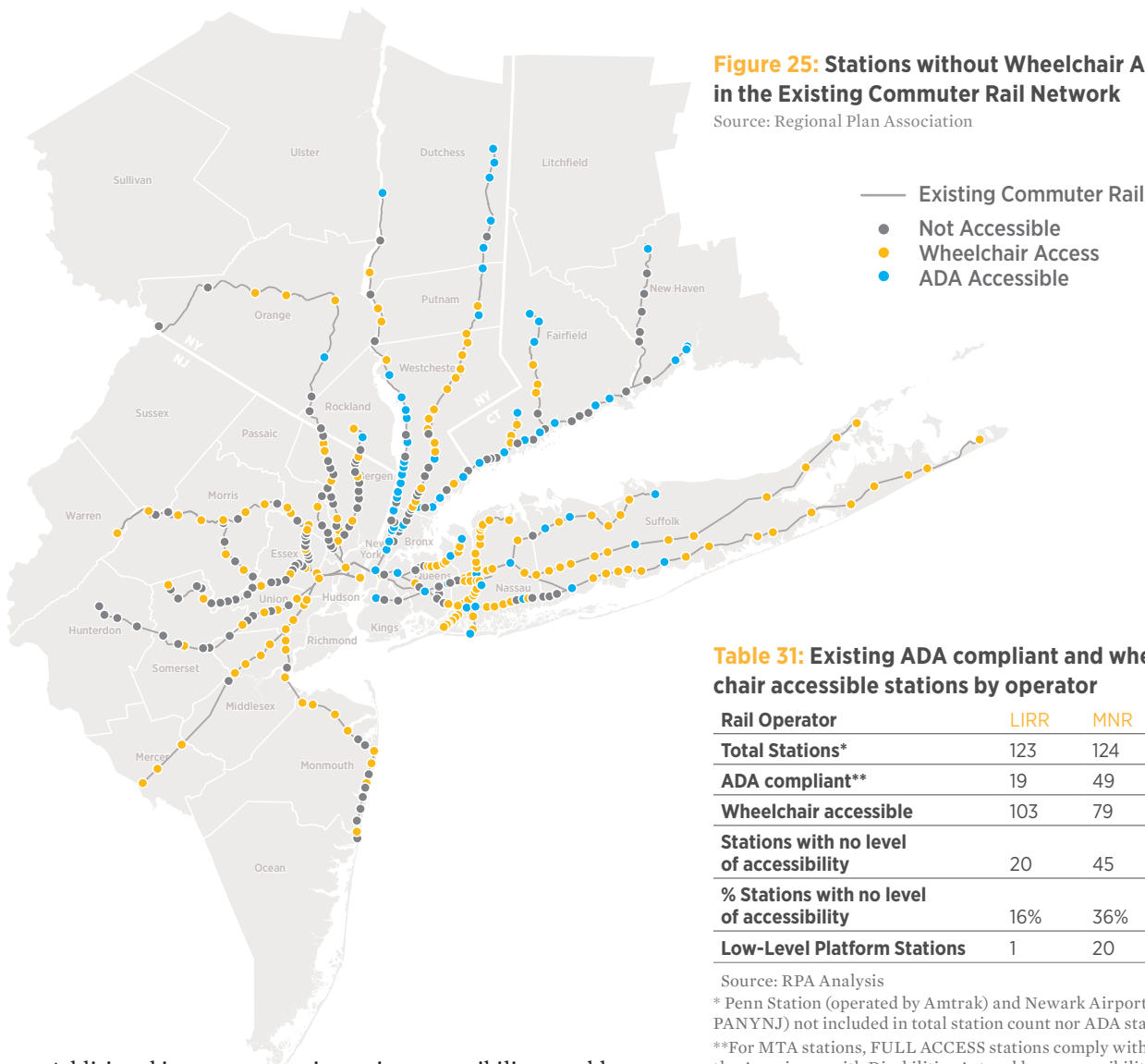


Table 31: Existing ADA compliant and wheelchair accessible stations by operator

Rail Operator	LIRR	MNR	NJT
Total Stations*	123	124	142
ADA compliant**	19	49	***
Wheelchair accessible	103	79	61
Stations with no level of accessibility	20	45	81
% Stations with no level of accessibility	16%	36%	57%
Low-Level Platform Stations	1	20	97

Source: RPA Analysis

* Penn Station (operated by Amtrak) and Newark Airport Station (operated by PANYNJ) not included in total station count nor ADA station counts

**For MTA stations, FULL ACCESS stations comply with all requirements of the Americans with Disabilities Act and have accessibility features for persons with mobility, visual and hearing impairments. Accessibility at other stations is limited to the features listed on their online station page.

*** NJT does not provide the same level of ADA detail, therefore the stations listed as “accessible” are not assumed to provide accessibility features for persons with visual and hearing impairments as well.

Additional improvements in station accessibility would come from retrofitting all existing low level platform commuter rail stations to be compatible with trains designed for high level platforms. These upgraded stations would allow for those who are unable to or have difficulty walking to exit the train onto a high level platform that would be serviced by a ramp or elevator to provide access to the surrounding street network. Some stations with low-level platforms have been made wheelchair accessible through placement of ramp-accessible high platform segments, but uniform high-level platforms would better serve disabled customers. It would also speed service by reducing the passenger time to board and alight. As shown in Table 31 below, New Jersey would see the bulk of the improvements as many of the Region’s existing low level platform stations are located there.

T-REX would have an even greater impact on overall public health than just fixing inaccessible stations. It will improve air quality by shifting trips from cars and buses to rail. It would reduce the stress of commuting through increased

Facilities § Chapter 8: Special Rooms, Spaces, and Elements — United States Access Board (2010). <https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/ada-standards/chapter-8-special-rooms,-spaces,-and-elements#810%20Transportation%20Facilities>.

service frequency, and a more reliable service that will substantially reduce delays and allow the system to recover from incidents. Finally, by supporting a dense, walkable urban form, it will encourage walking and biking and reduce health inequities by putting resources from medical facilities to educational institutions within reach of low-income residents.

Cost Estimates

Any infrastructure project on the scale of T-REX is bound to cost in the billions of dollars. With existing processes and costs for building new rail transit, RPA estimates that the full-build of the T-REX would be \$71.4 billion or an annual regional investment of \$2.4 billion over a 30 year period. This would be in addition to the \$39 billion NEC Future program which includes the Gateway project and additional tracks five and six between North Brunswick, NJ and Green's Farms, CT.⁴⁷

This section contains a high-level cost estimates for the components of the system based on existing cost structures. The unit construction costs of local rail projects were used to cost out the different elements of the system. The elements of the cost include civil construction works (70%) along with administration, indirect, design and engineering and project management costs (25%). The only adjustment made over today's capital costs was the use of a lower contingency of 5%, per RPA's work on construction costs in which a lower contingency was recommended.

These costs could be further reduced with the recommendations for delivering projects faster for less as outlined RPA's *Building Rail Transit Projects Better for Less*. Also, these estimates are likely conservative because they do not account for the efficiencies that would be realized (e.g. sharing project management resources) from approaching the construction of the various lines as one singular project rather than a group of separate ones. T-REX could also preclude the need for other large infrastructure projects throughout the region such as a much larger Port Authority Bus Terminal and possibly the third and fourth phases of the Second Avenue Subway.

Tunneling

The most expensive portion of the T-REX system is the new core capacity lines — the Crosstown, Manhattan Spine and Jersey Loop⁴⁸ — in the region's core which must be constructed underground using tunnel boring machines (TBMs) and other mining techniques. These techniques are invariably complex and expensive. To estimate the cost

⁴⁷ The T-REX cost estimates do include the costs of extending the Gateway further east to geographic Long Island, even though this project is also part of NEC FUTURE.
⁴⁸ This also includes a small tunneled segment in the 3rd Avenue corridor in the Bronx and a new double-tracked tunnel connecting Penn Station and the west side railroad.

Table 32: Costs stratified by system elements and total

Stations	Number	Cost
Underground*	17	\$13,445,263,363
Surface	43	\$4,914,285,714
Upgraded Surface	14	\$820,000,000
Upgraded Underground	2	\$462,000,000
Subtotal		\$19,641,549,078
Tracks	Track Miles	Cost
Tunnel	71	\$23,718,356,846
Surface**	147	\$20,892,594,752
Subtotal***		\$44,610,951,598
Interlockings/Bottlenecks	Number	Cost
Junction/Choke Point Relief	18	\$1,800,000,000
Pocket Track	11	\$385,000,000
Subtotal		\$2,185,000,000
Yards	Number	Cost
New-large	12	\$3,000,000,000
New-small	8	\$800,000,000
Existing Expand	12	\$1,200,000,000
Subtotal		\$5,000,000,000
Total		\$71,437,500,676

Costs include civil construction + admin, indirect, D&E, and PM costs +5%
*includes new terminal station
**retrofitted surface, reactivated surface, and new surface categories were merged into one surface category
***NHL removed
Source: RPA Analysis

of the underground portions of the T-REX, the per station and per mile tunneling costs were extrapolated based on the costs of prior heavy rail projects (SAS, 7 Line), thereby accounting for the high cost of construction in the New York. The 71 track miles of tunnel are estimated to cost \$24 billion with 19 underground stations estimated at \$14 billion — for a total of \$37 billion.

Reactivation/Adaptation Surface Rail Components

The majority of the infrastructure required for T-REX is comprised of reactivated or retrofitted aboveground rail lines. The costs associated with these projects are much less since very little, if any, right of way needs to be acquired and no tunneling is necessary. The majority of the work for these corridors would involve laying/upgrading track, installing modern signaling systems, and constructing new

rail stations. There would be 147 miles of new, retrofitted and reactivated lines surface railroad, with 57 stations. The estimated costs for these track segments and stations would be \$27 billion.

Junction Upgrades and Correcting Major Bottlenecks

To ensure sufficient throughput and service reliability major bottlenecks at interlocking/junctions and other major chokepoints must be eliminated. In the majority of the cases this will require grade separating major junctions (Shell Interlocking at New Rochelle) to eliminate train crossing conflicts. The installation of pocket tracks will also allow for bi-directional service and/or train staging. There are 18 choke point/junction relief projects at the estimated cost of \$1.8 billion and 11 pocket track projects that would cost \$385 million.

New and Expanded Yards

T-REX will substantially increase service which will result in a demand for more storage and maintenance facilities. While the cost estimate does not include the amount or the cost of the additional rolling stock that will be required, RPA did complete a survey of potential yard facilities. Twelve new large yards and eight new smaller facilities were identified, with an estimated cost of \$4 billion. Another \$1.2 billion was also reserved to expand 12 existing facilities.

Implementation

Funding

Building out the infrastructure required to support the T-REX system will require a sea change in the way the region pursues large infrastructure proposals. Currently, almost all infrastructure projects are treated as one-off endeavors and all of the resources used over the course of the project are retired at the conclusion while any funding sources are also discontinued. Construction of the T-REX system will require a different approach. The system should be viewed as a whole and not as a series of separate projects. To that end, a dedicated funding stream, estimated at \$2.4 billion each year, should be secured to ensure continual and consistent work on the entire system rather than a series of “stop and go” projects. A combination of revenue streams such as those that are recommended in the Fourth Regional Plan, which include land-value capture, greenhouse gas pricing and VMT fees, would need to be leveraged to cover this need.

Governance

T-REX will require a change in how commuter rail service is provisioned and a more regional approach to planning capital investments. Institutional changes will be needed to deliver the envisioned integrated service plan and through-running. The three railroads, NJT, MNR and LIRR, all use different equipment and are in various states of modernization. Greater compatibility between all three networks will be needed to ensure uniform and reliable service. For instance, most of the NJT (57%) network does not have high-platform stations — impacting the performance of their service due to increased dwell time at stations to allow additional time for passengers climb stairs to board or alight the vehicle. The railroads also have different unions and labor agreements along with various operating policies (including fares) that do not align.

There are many ways to address these variations and move towards a more integrated regional network. Institutional reform can take many shapes, from the more extreme vertical integration of the three railroads into one new entity to creating a new regional coordinating body while main-

taining the agencies we have today. While there are many variations between these two, it's illustrative to examine both ends of the spectrum.

Combining the three railroads into one new authority would allow a single entity to plan capital investments and set service standards and policies. This approach would create a very large new public agency that would require powers to operate in all three states and be given control of the infrastructure that is currently owned in operated by the states and even possibly Amtrak. Similar to when the Port Authority of New York and New Jersey was created, this would likely require an Act of Congress to ordain the agency with tristate powers. This regional rail authority would use these powers to modernize and expand the network in all three states. An example of a vertically integrated agency is Transport for London.

Another approach would be the creation of a regional body or broadening the powers of an existing entity, such as TRANSCOM.⁴⁹ This new regional entity could coordinate capital investments, operating policies and service planning across all three railroads. To accomplish this all three states would have to agree to give this organization “real” oversight and powers to coordinate the operations and policies of their commuter rail agencies. Each agency would be given representation on the board of this new entity and its mandate would be to deliver regional through running, seamless operations, uniform fare policies and the prerequisite capital program. This new coordinating body could be given federal and/or state funding streams to incentivize coordination along with possibly taking on the role as the regional fare collector. An example of a regional transportation coordinating body is Madrid's Regional Transportation Consortium (CRTM).

⁴⁹ TRANSCOM coordinates the region's roadway and tolling operations. More information on TRANSCOM can be found at <https://www.xcm.org/XCMWeb-Site/Index.aspx>

Appendix: Components of Regional Rail

Crosstown Line Core (North Brunswick to Belmont Park/New Rochelle)

Crosstown Line Core encompasses projects on the NEC that collectively benefit intercity, suburban regional express and regional transit service — generally included within FRA’s NEC FUTURE preferred alternative (ROD will be released shortly).

West (New Jersey) Leg

West Leg extends all the way to North Brunswick to take advantage of the Mid-Line Loop turnback capability and to include the City of New Brunswick in the territory served by regional transit.

- ▶ Hub/terminal station at North Brunswick (expansion of scope of planned new NJT station)
- ▶ Mid-Line Loop and County Yard expansion
- ▶ NEC 5th and 6th main tracks, North Brunswick-to-Edison (Phase 3, includes difficult route through New Brunswick and across/under the Raritan River)
- ▶ NEC 5th and 6th main tracks, Edison to Colonia (Phase 1)
- ▶ NEC 5th and 6th main tracks, Elmora to Newark Airport (Phase 1)
- ▶ NEC 5th and 6th main tracks, Newark Airport to Secaucus (Phase 2, mostly likely on a separate alignment from the NEC for improved speed and to separate intercity traffic from the dense commuter traffic and multiple junctions)
- ▶ Improved track configuration and interlockings at County, Edison, Union (NJCL junction), Elmora, Newark Airport for operational reliability and flexibility
- ▶ Hunter Junction — flyover for grade separation of east-bound Raritan Valley Line moves
- ▶ Westbound Waterfront Connection (Hudson Junction) — grade separation for westbound moves from Hoboken and the future Jersey Loop to the southbound local track of the NEC

- ▶ Yard and grade-separated track connections at Linden (far-side yard for mid-day storage associated with service originating on Long Island or the New Haven Line)
- ▶ Improved hub station at Metropark
- ▶ Improvements at Newark Airport station/hub (scope and cost depends upon plans for the airport and PATH and/or transit extension)
- ▶ Newark Penn Station capacity improvements (Phase 1)
- ▶ Newark Penn Station expansion (Phase 2, in concert with additional main tracks — scope TBD)

Central Portion of the Route

- ▶ Gateway Base Program
 - Additional tracks (creating 4-track mainline) between Newark and Secaucus
 - Sawtooth bridge replacement
 - Portal Bridge replacement and expansion
 - Secaucus Station expansion
 - New Hudson River tunnels (designated as Lines 5 & 6 in support of through-running)
 - Track connections at west end of New York Penn Station
- ▶ Bergen Loop Track Connections at Secaucus — clover-leaf ramps between NEC and Gateway routes on upper level and NJT Main-Bergen-Pascack Valley Line on lower level
 - Provides for direct revenue service from Main, Bergen and Pascack Valley Line to both the existing North River tunnels and planned Gateway tunnels to Manhattan
 - Provides access from Penn Station to new far-side yard in Secaucus vicinity for mid-day storage of regional transit trains (using the Gateway tunnels) and suburban regional express trains (using the North River tunnels) from Long Island or the New Haven Line

- Provides access for off-peak freight trains between the Gateway tunnels and the west-of-Hudson rail freight network, via Croxton Yard, Oak Island line and West Shore line. Alternatively, a new direct track connection to the Oak Island line could be considered at Kearny, in the vicinity of Swift Interlocking, or a separate grade-separated junction for freight could be constructed near the western portals of the Gateway tunnels.
- ▶ New York Penn Station comprehensive redevelopment
 - Moynihan Station improvements
 - Reconfiguration of existing tracks and platforms and existing concourses for improved safety, passenger convenience and throughput capacity
 - Penn Station South Expansion
 - Scope of improvements at and above street level TBD based on comprehensive District Master Plan and Economic Development Plan
- ▶ New tunnel (2 tracks) from Penn Station South to western Queens via 31st Street and beneath the East River (designated as Lines 5 & 6 in support of through-running)
- ▶ Grade-separated track connection in tunnel at Hunter's Point
 - Access to far-side yard along Lower Montauk Branch for service originating in NJ
 - Freight access to Lower Montauk Branch and Fresh Pond Jct.
- ▶ New 2-track alignment from new East River Tunnel to Hell Gate Junction (on new alignment between Sunnyside and Woodside, in vicinity of east end of Sunnyside Yard), with grade-separated junction not conflicting with existing/planned train movements at Harold Interlocking
- ▶ Central portion between Secaucus and Hell Gate Jct. equipped with dual electrification (AC overhead catenary and LIRR-compatible DC third rail)
- ▶ New hub/transfer station at Midtown East (Third Ave, 31st St), future hub/transfer station
- ▶ New hub/transfer at Sunnyside
- ▶ Potential new below-grade station at LIC/Hunter's Point, which would serve development along the waterfront and redevelopment of the LIC Yard, as well as provide connections with East River ferry services
- ▶ Track and interlocking reconfiguration at Jamaica to provide conflict-free route for regional transit trains (connecting the Main Line local tracks on the west and east sides of Jamaica and providing for convenient transfers to other regional transit services and LIRR suburban trains)
- ▶ Additional main track and track reconfiguration, Jamaica to Belmont Park, generally utilizing available space within the existing LIRR right-of-way
- ▶ New intermediate terminal station at Belmont Park, oriented as a line station along the Main Line. The existing Belmont Park station infrastructure is not useful and would be demolished, including wye junction, track-work and the set of existing short stub tracks, platforms and pedestrian connections — these facilities could be replaced by either TOD development or parking.
- ▶ New stations at Queens Center (Woodhaven Boulevard) and York College (Union Hall Street)
- ▶ Station modifications and improvements at Woodside, Forest Hills, Kew Gardens, Hillside, Hollis, Queens Village
- ▶ Jamaica Station and interlocking expansion and reconfiguration to support Crosstown and Manhattan East Side Spine service, convenient transfers between these services, and transfers to and from LIRR suburban express services
- ▶ Yard at Belmont Park (incorporating structured parking for the new Belmont Park train station, racetrack and potential TOD uses)

North (Bronx) Leg

- ▶ 2-track connection from Hell Gate Jct. to existing Hell Gate Line embankment in Astoria, transitioning from tunnel to aerial alignment
- ▶ Utilizes existing right-of-way across Hell Gate Bridge (easterly two track slots, parallel to existing Amtrak tracks), shared with freight during off-peak periods
- ▶ Provides junctions and track connections for rail freight to NY Connecting Railroad at Gate Interlocking (on the Hell Gate embankment) and to the CSX Oak Point Yard in the South Bronx
- ▶ 4-tracking of Hell Gate Line through the Bronx
- ▶ Replacement of Pelham Bay movable bridge (given proximity to proposed Co-Op City station, the replacement bridge probably should carry 4 tracks, though this has been controversial in the discussions between MTA/MNR and Amtrak)
- ▶ Grade-separated junction and expanded hub station at New Rochelle (major choke point relief, and simultaneously supports T-REX regional rail in all three directions, plus expansion of intercity service)

East (Long Island) Leg

- ▶ New fifth main track on LIRR Main Line between Hell Gate Junction and Jamaica (mostly at grade, with portions at the west end likely to be in tunnel)

- ▶ New stations in the East Bronx (Hunt's Point, Parkchester, Morris Park, Co-Op City South)
- ▶ Morris Park as potential hub station with double island platform station (significant local Eds/Meds employment and TOD potential, BRT in Pelham Pkwy/Fordham Rd corridor providing cross-borough connectivity, Bronx access point to NEC intercity rail network)
- ▶ New passenger rail yard and track connections along the Hell Gate Line in the Bronx (far-side yard for mid-day storage associated with service originating in New Jersey — site to be determined; one candidate would be the NYC Transit bus depot site on East Tremont Avenue, which could be reconstructed on a deck above the a new rail yard.)

Crosstown Line Connections

Northeast Corridor West of North Brunswick

- ▶ Trenton capacity and choke point relief project
 - Grade-separated track connections on south side of Delaware River to provide conflict-free access to NJT Morrisville Yard from the southbound and northbound local tracks
 - Turnaround yard and overnight storage yard for SEPTA Trenton Line
 - Conflict-free and Grade-separated flyover or duck-under on north side of Trenton Station to permit conflict-free movements of SEPTA trains to and from the turnaround yard

North Jersey Coast Line

- ▶ Additional main track between Union Junction and Perth Amboy, with associated interlocking and station modifications, to support simultaneous peak express and local service, as needed
- ▶ Intermediate terminal station at South Amboy
- ▶ Expanded yard facilities at South Amboy (or locations TBD)

Raritan Valley Line

- ▶ Completion of Hunter flyover project is a prerequisite
- ▶ Additional main track and/or sidings as needed to support simultaneous peak zone express and local service and bi-directional regional transit operations (probably not required, or only required at discrete locations, given service volume on this line — but service patterns have not yet been analyzed in detail, so I'd retain this as a placeholder)
- ▶ Line electrification to Raritan (initial phase could electrify to Plainfield)

- ▶ Intermediate terminal station at Plainfield
- ▶ Terminal station at Raritan
- ▶ Expanded yard facilities (locations TBD)

Morris and Essex Lines and Montclair Branch

- ▶ Additional main track and track/interlocking reconfiguration between Harrison and South Orange, as needed to support simultaneous peak zone express and local service and bi-directional regional transit operations, including additional capacity across the Passaic River and between Newark Broad Street and the Montclair Branch junction. (Extensive 3-track sections in this territory will support zone express service in peak direction; concerns are likely to be the at-grade junction with the Montclair Branch and the ability to interleave express and local services in the reverse-peak direction — service patterns have not yet been analyzed in detail, so this is a placeholder for additional capacity investment)
- ▶ Intermediate terminal stations at South Orange, Summit, Montclair State Univ.
- ▶ Station modifications and improvements as required
- ▶ Expanded yard facilities (locations TBD)

NJT Main Line

- ▶ Completion of Bergen Loop project is a prerequisite, with track connections into existing North River Tunnels and also into the new Gateway tunnels
- ▶ Double-tracking or extended passing sidings as required to support frequent bi-directional operations
- ▶ Line electrification between Secaucus and Paterson
- ▶ New intermediate terminal station at Paterson (or Hawthorne or Glen Rock, depending on demand and cost-effectiveness)
- ▶ Yard in Paterson area for overnight and mid-day train storage and servicing
- ▶ Also provides connection in interim initial phase for dual-mode trains from Bergen County and Pascack Valley Lines (these trains would operate via the Jersey Loop in later phases)

Monmouth-Ocean-Middlesex (MOM) Corridor — Long-range (following opening of full Jersey Loop)

- ▶ New route utilizing existing and former rail rights of way
- ▶ Route, alignment and station locations TBD — placeholder for planning purposes is connection to NJCL at South Amboy, but connection to NEC at North Brunswick also would be feasible
- ▶ New stations at multiple locations

- ▶ New/expanded yard facilities for fleet overnight storage and servicing

LIRR Main Line, Belmont Park to Hicksville

- ▶ Additional main track from Belmont Park through Bellerose and Floral Park (on north side of right-of-way, replacing unused side platform at Floral Park)
- ▶ LIRR Expansion Project, which provides third main line track from Floral Park to Hicksville, modifies stations and eliminates existing grade crossings
- ▶ Hub/transfer station at Mineola, with track shifts to accommodate platform on express track, plus conversion of Oyster Bay Branch to light rail with new station platforms and bridge or underpass crossing of LIRR Main Line
- ▶ Expanded hub/transfer station at Hicksville with a fourth track and platform edge to support Hicksville as an intermediate turnback location
- ▶ Grade separated junction of Port Jefferson Branch and Main Line at Divide Interlocking (Hicksville) to increase bi-directional capacity and improve service reliability

Hempstead Branch

- ▶ Grade-separated junction for Hempstead Branch west of Belmont Park — permits Hempstead to use the express tracks to/from Manhattan while minimizing crossing conflicts
- ▶ Potential grade-separation of Hempstead Branch through Garden City (most likely in trench), and elimination of multiple grade crossings

Jersey Loop North Leg Core (Paterson to Midtown East)

- ▶ New 2-track regional transit line on the existing NYS&W right-of-way between Paterson and North Bergen, NJ
- ▶ New 2-track line on new alignment within Paterson (most likely in tunnel) to connect NYS&W line with Paterson Station on NJT Main Line
- ▶ Track connections and sidings for freight service as required
- ▶ New 2-track tunnel from North Bergen to Midtown Manhattan in the 57th Street corridor, passing beneath the Palisades and the Hudson River
- ▶ New 4-track tunnel beneath Third Avenue between 57th Street and south of 31st Street
- ▶ Entire route electrified with 25kv AC 60hz overhead catenary

- ▶ New stations at multiple locations, including but not limited to downtown Paterson (transfer w/ NJT Main Line at existing station), Saddle Brook (transfer w/ NJT Bergen County Line at new station), Hackensack (transfer w/ NJT Pascack Valley Line at new station), North Bergen (transfer to HBLRT), Bergenline (transfer to HBLRT and new Palisades transit line), and multiple stations in Manhattan provide transfers to NYC subway lines
- ▶ Yard for train storage and servicing (location along the NYS&W right of way, to be determined)

Jersey Loop North Leg Connections

West Shore Line

- ▶ Junction at Bogota/Ridgefield Park
- ▶ New 2-track electrified rail line parallel and adjacent to the CSX West Shore Line
- ▶ Multiple stations
- ▶ Yard for train storage and servicing (location to be determined)

Northern Branch — if part of regional transit (T-REX) network

- ▶ Junction at North Bergen
- ▶ New 2-track electrified rail line within Northern Branch right-of-way (or single track with sidings)
- ▶ Multiple stations
- ▶ Yard for train storage and servicing (location to be determined)

Northern Branch — if developed as extension of Hudson-Bergen light rail (HBLRT)

- ▶ Hub station at North Bergen providing convenient transfers between T-REX and HBLRT

Bergen County Line Connection

- ▶ Junction at Saddle Brook between NYS&W right of way and NJT Bergen County Line
- ▶ Electrification Bergen County Line (to Waldwick or to Suffern)
- ▶ Yard expansion as required (Waldwick and/or Suffern) be determined)

Northeast Corridor Connection

- ▶ Grade-separated junction near the west portal of the Jersey Loop north leg tunnel through the Palisades from Manhattan

- ▶ New 2-track electrified rail line generally paralleling the CSX West Shore Line and NYS&W right of way and Tonnelle Avenue
- ▶ Grade-separated junction with NEC main line at Bergen Interlocking, just west of the North River Tunnel portals
 - To be built in tandem with the 5th & 6th track project between Newark and Secaucus
 - New 5th and 6th tracks would be the new high-speed line for intercity trains to Penn Station and would align with the existing North River tunnel tubes
 - The existing NEC tracks from Secaucus Station would align with this new 2-track route to the Jersey Loop north leg tunnel, providing a route for NEC and NJCL suburban zone express trains around the Jersey Loop clockwise.
 - Track connections would still exist between the existing NEC tracks from Secaucus to the North River Tunnels to Manhattan, which would be used by non-high-speed intercity trains and additional NJ commuter trains during peak periods.

Jersey Loop South Leg Core (West End Jct. to Midtown East)

- ▶ Grade-separated junction at West End Interlocking to both the M&E (in the direction of Newark) and the Main-Bergen Lines (in the direction of Secaucus)
- ▶ 2-track line through the Bergen Arches cut, ramping down to a tunnel approaching Hoboken or Jersey City
- ▶ 2-track tunnel beneath Hudson River to Manhattan at Houstonf Street, in deep tunnel across Manhattan and turning northward at Third Avenue, meeting up with the Manhattan East Side Spine route
- ▶ Electrification of the line with 25kv AC 60 hz catenary
- ▶ 4-track tunnel under Third Avenue from the East Village to E. 31st Street, joining with the north leg at the Midtown East hub station (4-track section has dual electrification — catenary and third rail)
- ▶ New station at Bergen Arches (transfer to new Palisades Line)
- ▶ New station in deep tunnel at Hoboken Terminal (transfer to NJT exurban diesel trains, PATH, HBLRT and buses)
- ▶ Multiple stations in Manhattan, with transfers to subway lines

Jersey Loop South Leg Connections

- ▶ M&E and Montclair-Boonton Line — uses existing M&E via Newark Broad Street

- ▶ Raritan Valley Line — uses M&E, then Westbound Waterfront Connection to southbound local track on NEC via Newark Penn Station, then to RVL at Hunter Junction
- ▶ NEC and NJCL — Westbound Waterfront Connection only accesses the NEC local tracks, so the south leg of the Jersey Loop would not conveniently connect to NEC and NJCL suburban zone express services (which is why these trains are routed via the north leg)
- ▶ Main-Bergen-Pascack Valley Lines and Meadowlands Sports Complex — uses existing Main-Bergen Line via lower level of Secaucus (requires either electrification of these lines or the use of dual-mode equipment)
- ▶ Access to existing NJT Meadows Maintenance Facility via M&E
- ▶ Access to new yard(s) in Secaucus vicinity via Main-Bergen connection

Manhattan East Side Spine East Leg Core (Midtown East to Green Acres)

- ▶ Shares 4-track dual-electrified route along Third Avenue
- ▶ New 2-track tunnel (third rail electrified) via Bowery and Water Street to Lower Manhattan, and then via tunnel under the East River to downtown Brooklyn and Atlantic Terminal
- ▶ New stations at E. 14th Street, Houston St., Seaport, Water Street, Downtown Brooklyn
- ▶ Reconfiguration of Atlantic Terminal to support through-running; includes track connections and junction to connect new tunnels into the LIRR Atlantic Branch as it heads east from Atlantic Terminal; Preserves track connections to Vanderbilt Yard for off-peak train storage
- ▶ Utilizes existing LIRR Atlantic Branch between Atlantic Terminal and Jamaica
- ▶ New station at Woodhaven
- ▶ Station upgrades at Nostrand Avenue, East New York
- ▶ Jamaica Station and interlocking expansion and reconfiguration to support Crosstown and Spine service; utilizes LIRR Jamaica Phase 1 improvements (including new island platform) and dovetails with Crosstown Line improvements to provide a hub station at Jamaica the offers convenient transfers between Manhattan East Side Spine and Crosstown Line regional transit (T-REX) trains, as well as convenient transfers between regional transit and suburban express (e.g., regular LIRR) trains, and improved transfers to the E,J subways, AirTrain and buses

- ▶ I envision the logical normal routings being Crosstown Line to Belmont Park and Hempstead/Nassau Hub, and Manhattan East Side Spine Line to Green Acres and Long Beach/Far Rockaway; However, it would be desirable to be able to switch T-REX trains between these two routes at Jamaica (one of the alternative Jamaica configurations enables this); this would be useful for contingency operations and would increase operational flexibility.
- ▶ New direct track connection on the east side of Jamaica (modification of Jamaica Phase 2 scope) to provide direct connection of Manhattan East Side Spine route onto the LIRR Atlantic Branch heading southeast
- ▶ New station on Atlantic Branch at South Jamaica
- ▶ Upgrade of existing stations at Locust Manor, Laurelton and Rosedale
- ▶ New intermediate terminal station at Green Acres; includes platforms on Babylon Branch tracks to enable transferring between Babylon Branch (suburban express) and Atlantic Branch (regional transit) trains
- ▶ Yard at Green Acres (incorporating structured parking for the new train station, reconfigured shopping center and potential TOD uses)
- ▶ Potential third track on Babylon/Montauk Branch between Green Acres (Valley Interlocking) and Jamaica — if required for capacity (needs more thorough ops analysis — the two-track line is close to capacity; included as placeholder)
- ▶ Elimination of existing St. Albans LIRR station (replaced by South Jamaica station on Atlantic Branch).

Manhattan East Side Spine East Leg Connections

JFK Branch

- ▶ Grade separated junction at Woodhaven with Manhattan East Side Spine line
- ▶ Restoration of 2-track rail line within former Rockaway Beach Branch right-of-way, with third rail electrification, between Woodhaven and Aqueduct Racetrack
- ▶ New 2-track alignment from Aqueduct Racetrack to JFK Airport Central Terminal Area (mostly in tunnel)
- ▶ New stations at multiple locations, with transfers to subways lines where possible, including two stations within the airport providing convenient walk access to most unit terminals, and links via a modified AirTrain system to the remaining unit terminals
- ▶ Yard for train storage and inspection at Aqueduct Racetrack

Long Beach and Far Rockaway Branches

- ▶ Extension of regional transit service (T-REX) from Green Acres follows existing LIRR alignments via Valley Stream station
- ▶ Grade-separated track connection (Flyover) — to permit Long Beach and Far Rockaway zone express trains to use the Babylon/Montauk Branch to/from Jamaica and Manhattan while minimizing crossing conflicts

West Hempstead Branch

- ▶ Convert to light rail as part of light rail network focused on Nassau Hub, Mineola and Hempstead
- ▶ Eliminate choke point junction of West Hempstead Branch at Valley Stream
- ▶ Continue light rail route to terminus at new Green Acres hub station, where convenient transfers would be available to Babylon Branch (suburban express) and Atlantic Branch (regional transit) trains in both directions

Manhattan East Side Spine North Leg Core (Midtown East to Mott Haven/Fordham)

- ▶ New 2-track tunnel, 53rd Street to Mott Haven, third rail electrified
- ▶ Junction and track connections to Hudson Line at Mott Haven
- ▶ New 2-track tunnel, Mott Haven to Fordham/Botanical Garden (portions could be at grade alongside Harlem Line ROW, or in tunnel beneath Third Avenue, depending on result of alignment study)
- ▶ Junction and track connections to Harlem Line at Mott Haven or Fordham/Botanical Garden
- ▶ New below-grade stations at multiple locations along tunnel alignments

Manhattan East Side Spine North Leg Connections

Harlem/New Haven Lines

- ▶ Harlem Line additional main track, Botanical Garden to Woodlawn Jct.
- ▶ Woodlawn Jct. reconfiguration (grade-separated connections)
- ▶ Intermediate terminal stations at New Rochelle and Mt. Vernon West, with provision for grade-separated train turnbacks to minimize crossing conflicts with through suburban express trains

- ▶ Yard storage and servicing facility (far side yard to support T-REX regional transit service from LI and JFK using Manhattan East Side Spine line — location TBD)
- ▶ Waterbury branch converted to light rail with a connection to regional rail system at Stratford

Hudson Line

- ▶ Track configuration to support both local (regional transit) and express (suburban zone express) service in right-of-way that varies in width between 3 and 4 tracks; also preserves access to High Bridge Yard for MNR trains at Grand Central (assumed to be required to support GCT operations)
- ▶ Intermediate terminal stations at Yankees and Yonkers, with provision for grade-separated train turnbacks to minimize crossing conflicts with through suburban express trains (as required)
- ▶ Additional yard storage and servicing facility (far side yard to support T-REX regional transit service from LI and JFK using Manhattan East Side Spine line — location TBD)

Systemwide Investments to Support Integrated Operations

- ▶ Traction power rationalization and upgrading
- ▶ Signal system rationalization and upgrading (implements and builds on PTC)
- ▶ High-density signaling on core segments of network — permitting practical headways of 2.0 to 2.5 minutes on the trunk line routes through the core area
- ▶ Station upgrades to meet consistent standards for integrated network (high level platforms, ADA compliance, minimum 8-car platform length and provision for 10-12 cars where applicable)

Rolling Stock

Regional transit service — open gangways, multiple doorways and vestibules

- ▶ EMU trainsets (catenary) for Crosstown Line service utilizing Hell Gate Line or from NJ and terminating in western Queens
- ▶ Dual-power EMU trainsets (third rail-catenary) for Crosstown Line service via LIRR Main Line, and for interim-phase service between Paterson and Jamaica
- ▶ EMU trainsets (third rail, compatible with both LIRR and MNR) for Manhattan East Side Spine Line service, and for Crosstown Line service that terminates at far-side yard in the Meadowlands/Secaucus area

- ▶ Consists planned at 8 cars during peak periods; stations and new yards planned with ability to extend to longer consists if and when warranted by demand (there will be significant constraints at certain existing yards and stations, which is one factor driving the 8-car standard; the other factor is the cost of fitting out all the underground stations, although the initial cavern excavations should enable or protect future expansion if possible).

Suburban regional express service — high seating capacity (e.g., bi-levels)

- ▶ EMU or locomotive+coach trainsets (third rail)
- ▶ EMU or locomotive+coach trainsets (catenary)
- ▶ Dual-power EMU or locomotive+coach trainsets (third rail-catenary)
- ▶ Dual-mode trainsets (dual mode locomotives plus coaches)
- ▶ Consists range from 8-12 cars during peak periods; 6-car minimum off-peak (equivalent to existing commuter rail standards, which fit within the limited confines of NY Penn Station)



Regional Plan Association

Regional Plan Association is an independent, not-for-profit civic organization that develops and promotes ideas to improve the economic health, environmental resiliency and quality of life of the New York metropolitan area. We conduct research on transportation, land use, housing, good governance and the environment. We advise cities, communities and public agencies. And we advocate for change that will contribute to the prosperity of all residents of the region. Since the 1920s, RPA has produced four landmark plans for the region, the most recent was released in November 2017. For more information, please visit www.rpa.org or fourthplan.org.

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