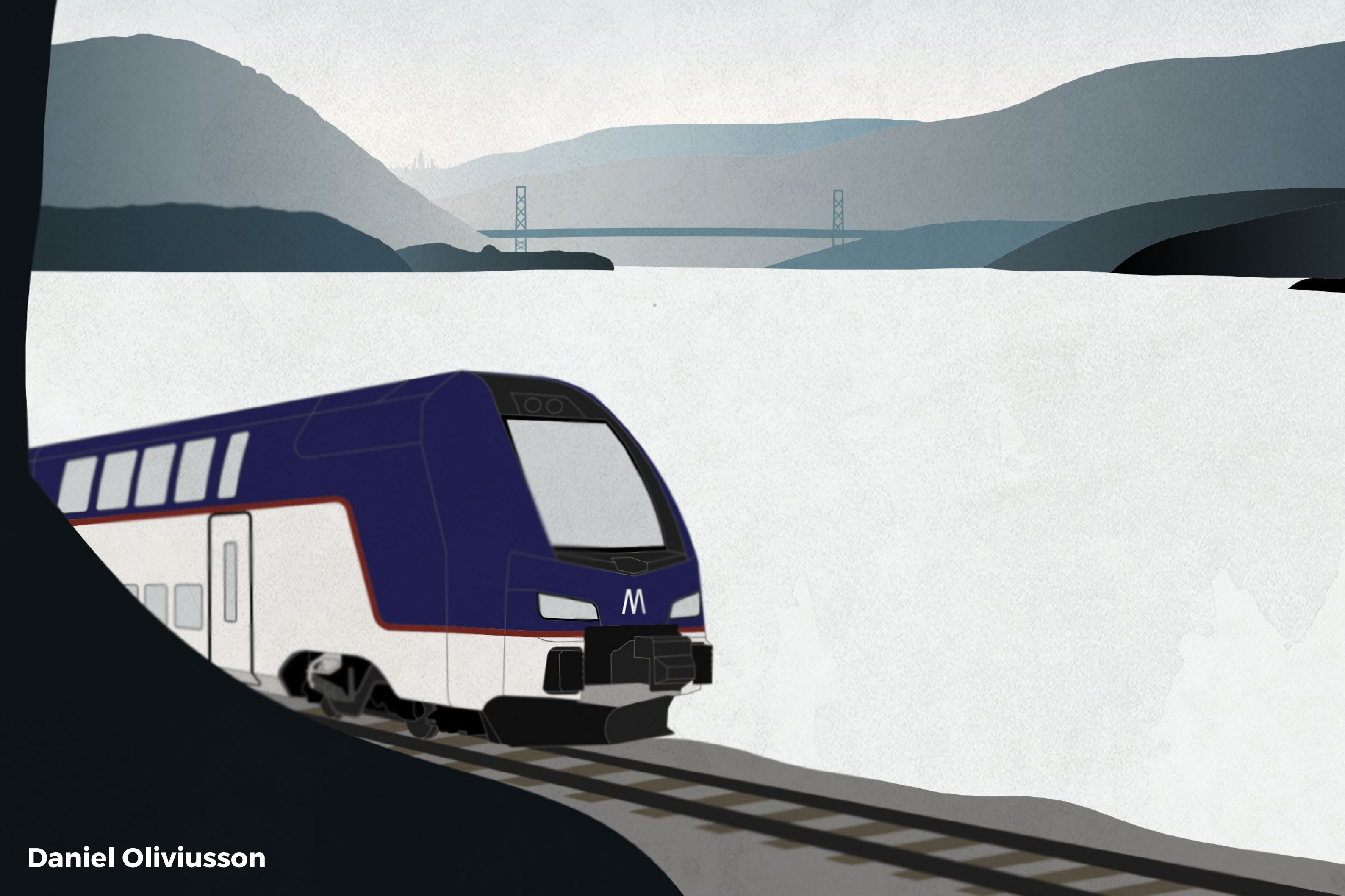
DORMANT TRANSIT

Sustainable Development through Reactivation of Disused Infrastructure



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SUDes
Sustainable Urban Design

Lund University

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Contents

THIS PROJECT

In all history movement has been the key component of human habitation. Nomadic tribes moved to where prey and resources were. When people began settling in villages and towns they were positioned so that the flow of resources and trade came through their communities. Towns and villages sprung up along routes often used for trade, road or waterway. Historically towns and villages were spaced at about a few hours so that one could walk there and back in a day.

This was the pattern until the industrial revolution when new transportation options became available, specifically the train. In Europe this didn't really change the urban fabric a lot, the villages and towns already existed and the rail lines only helped to make larger areas accessible, and for towns to merge into larger urban areas. In America the pre-industrial urban fabric was very small and limited to a few regions on the eastern seaboard. Thats why the transportation technologies of the time became much more influential in shaping the urban fabric of this new continent.

The dispersion and relatively long distances between towns in the U.S was first a product of transatlantic shipping and access to deep-water ports such as Boston, Philadelphia, Charleston and New York. The Second wave of cities was driven by the onset of steam power. The Mississippi river basin became navigable through river steamboat and the inland became accessible through steam trains.

This has given the U.S and specifically the American inland a dispersed and spread out geography that is more susceptible to the negative impacts of transportation dependency, such as car dependency. The need for transportation infrastructure and access to transportation can thus be considered greater than in regions were the walking man determined the urban fabric.

New York city has long been one of the world's great metropolises. It grew out of its ideal position on the Hudson River with a large natural harbor, its in-land connections and its access to coastal shipping. It quickly became the manufacturing center for the eastern seaboard of the United states and the main port for the transatlantic trade. The city also became the port of entry for the millions of imigrants that eventually became the majority if the population in This new country. During the 1800s the city grew to be one of the largest in the world. By 1925 the city overtook both London and Tokyo for the title of the largest city in the world. A title is has since lost and is now the 9th largest metropolitan area by population and 8th by size.[1]

The city has had a steady growth all through its existence with large number of emigrants arriving from Europe. From 1890 to 1950 the population increased with an average of 106 000 people per year taking the population from 1.5 million to 7.9 million people. The only real decrease in population occurred between 1970 and 1980. With the loss of large parts of the manufacturing industry. The city has since recuperated and has lately seen a second growth spurt with 1.5 million new New Yorkers since 1980.[2]

The same story has been playing out over the entire metropolitan region of New York. It has seen a steady growth with a large decline in population during the 70s and 80s. The only sub-region that hasn't followed the same trend is the old manufacturing centers of the Mid-Hudson area that is still seeing negative population numbers. The region as a whole had 20.3 million inhabitants in 2018 and the Mid-Hudson area had approximately 2.25 million inhabitants. New York saw most of its growth during a period when the train was the predominant mode of transport. Cars was only becoming available to the general public after the second world war, and at that point New York was already a world metropolis. The city and region are almost entirely design around the train and subway and is built to a density that only rail based infrastructure allowed for.

As a stark contrast we can see cities like Los Angeles and Phoenix that was constructed out of the logic of the car. They were constructed with much lower density and are much more sprawling. The New York region once had the largest urban transit system in the world however much of the regional transit system has been abandoned and lays dormant. Today the city faces a massive housing shortage and lacking transit infrastructure to support the growth that is needed. This thesis aims to research the possibility of reactivating parts of the old system to facilitate sustainable growth in the region.

1. Cox, Wendell, *Largest cities in the world 2016* [website], 2016, http://www.newgeography.com/content/005219-largest-cities-world-2016, (accessed 24 February 2019).
2. World Population Review, 2018, *New York City Population (2018-10-29)* [website], http://worldpopulationreview.com/us-cities/new-york-city-population/, (accessed 24 February 2019).

The reasons for choosing the City of Beacon and the wider Mid-Hudson region as the focus of this thesis are many and diverse but is all grounded in its vast potential and specific transit based challenges. Beacon sits about 100km north of New York City along the Hudson River. Its has a population of about 15 000 people and is located in the south of Dutchess county that has a population of about 300 000 people. A journey to NYC takes about one hour and fifteen minutes with the fastest train service and about and hour and twenty minutes by car in ideal conditions, often well over two hours.

The city lies in a zone that is too far away for reasonable commuting by car and and is essentially only accessible for commuters by train. The train services range from an hour and fifteen too and hour and twenty five minutes and are just barely acceptable as a daily commute. Many people opt to do this very long commute because of Beacons very attractive setting. It lays in the foothills of the Appalachian mountains and nature is very accessible and abundant. It has a quaint small town Main Street with nice shops, cafés and restaurants. Prices for housing is also significantly cheaper than in most New York burroughs.

The under-preforming nature of the existing rail system and the disused cross regional rail line that exists in Beacon put it in a position to become a regional hub for transit. Beacon has also seen an abandonment of a large part of its historical urban core, not unlike many other American cities.
These factors provide an excellent basis for sustainable urban growth in the city and in the region. Beacons geographical location far enough away from NYC not to be immediately accessible by car but within distance for a fast regional train makes any urban growth rail oriented by necessity. This need for rail oriented urban growth coincides with the prior abandonment of the station adjacent areas of the city and provide an ideal situation for urban growth that will compliment the city and create additional ridership for rail based transit, creating many positive synergies.

Most of Beacons available land for development lays within in a short walk of Beacon station and is located along the shore of the Hudson River. This land used to be urban neighbourhoods and industrial areas but were demolished in the 1960s and 70s and turned in to vast parking lots. By developing the rail system and the station adjacent areas in tandem a massive shift towards sustainable living patterns can be achieved with a relatively small interdiction. Reducing journey times on the existing rail line and reactivating the cross regional Beacon line would accelerate and spred this positive effect over the wider region.

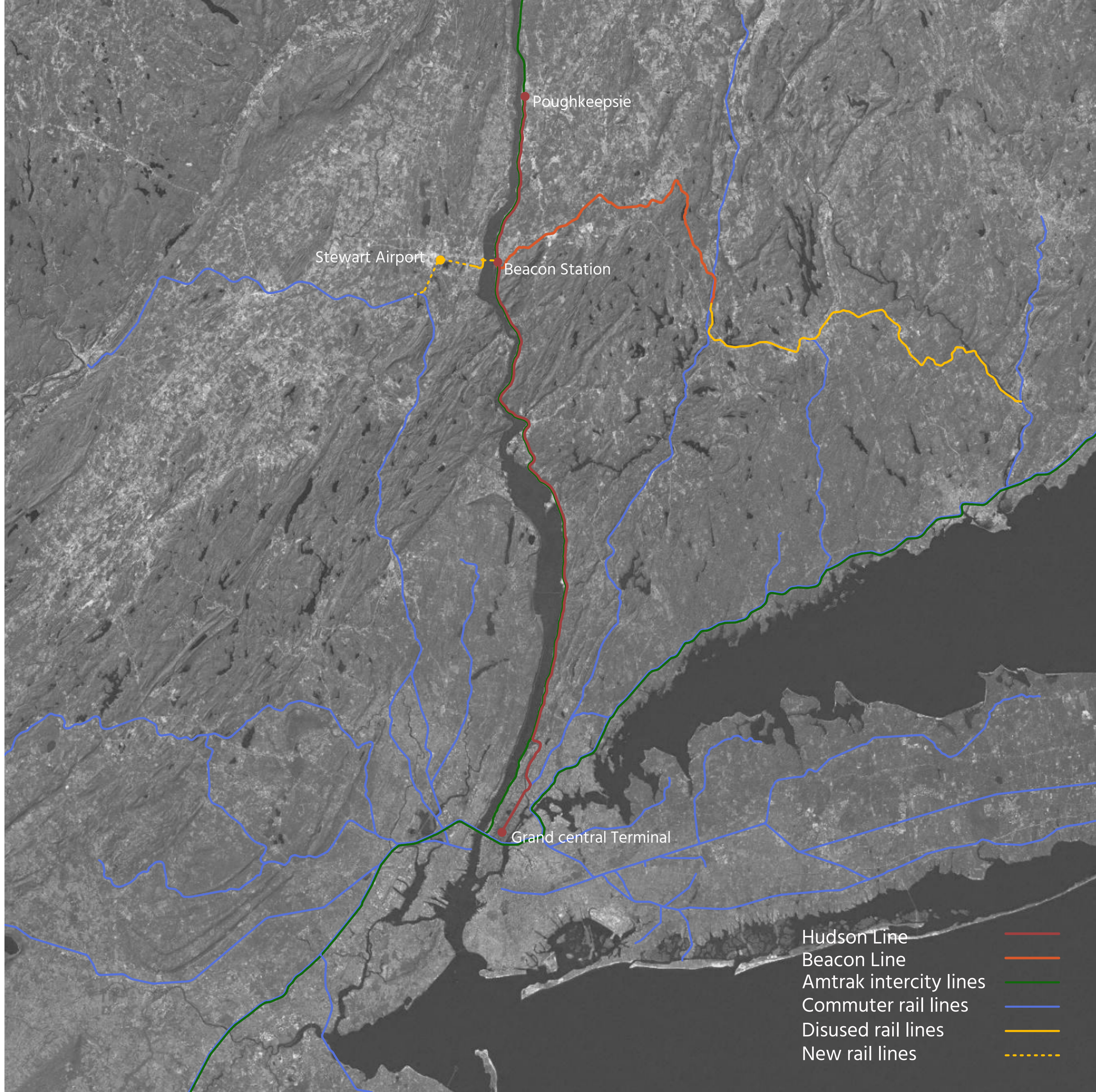
The key to achieving sustainable urban growth in this region is rail based transit, its speed and uninterrupted traffic pattern provides the means to shorten journey times enough to put cities and towns in the Mid-Hudson region within an hour of commuting from NYC. Doing so would unlock the potential of urban growth within these communities and regional growth in the region as a whole. It would also allow for a much more interconnected and accessible region that would help to create a less Manhattan centric urban network by creating regional hubs that acts as their own urban centers.

This thesis researches how journey times can be reduced and how old rail lines can be activated to bring the region closer together. The railways in question are the Hudson Line, an existing main line connecting Chicago with New York City via the Hudson River corridor. It is served with commuter trains as far as Poughkeepsie and by Amtrak long distance inter city trains beyond. This line is in a relatively bad state and is only electrified as far as Croton–Harmon. The line has the potential to be modernized in a way that could drastically increase capacity and reduce journey times by up to 40%.

The second line that this thesis focuses on is the Beacon line. It is a disused but still in place rail line that once connected to a cross regional network that spanned large parts of upstate New York and beyond. The line is the only still intact cross regional rail line and could also be connected other existing commuter rail lines to create a new cross regional axis that would allow for regional growth in the hinterlands of the Mid-hudson region. The Mid-hudson cross regional system once featured a ferry crossing for train cars at Beacon and a cross river bridge in Poughkeepsie, both are now abandoned and not in a state to be reinstated. Poughkeepsie once acted as the node for cross regional traffic and grew to become the regions largest city due to it. All of the cross regional infrastructure that once existed in Poughkeepsie has been demolished and is not viable to reinstate.

The existence of the Beacon Line provides the only remaining possibility for a cross regional railroad connection. A new river crossing at Beacon could also connect further commuter lines via the much faster Hudson line directly to New York City. It would also allow for Stewart Airport to get direct rail service from Manhattan making it the first New York airport to feature a direct rail link

This thesis researches how to achieve these transit improvements and what opportunities this brings for urban development in Beacon and the effected communities along the Beacon line.



PROJECT AIM & RESEARCH QUESTIONS

This thesis aims to answer three overall questions:

1. Regional connections
Is it possible to improve transportation connections the Mid-Hudson region using existing and disused rail infrastructure?

2. Socioeconomics
Is regional transportation a major factor in the social and economical sustainability and well being of the communities in the Mid-Hudson region?

3. Sustainable Urban development
Can improved transportation be a driver in transit oriented and sustainable urban development in the Mid-Hudson region?

To be able to answer these questions several areas of research will need to be examined. Spacial analysis and design proposals will be presented to illustrate the possibilities of Transit Oriented Development (TOD) as a concept and as a specific tool to develop the Mid-Hudson region.
Some of the areas of research are:

Examining regional growth in the context of transportation to determine how transportation technology has shaped the region. How changes in transportation accessibility has effected communities over time. If certain part of the region has seen a disproportionate effect and why that is.

Other areas of research will be concerning railway technology and understanding the specifics of how railways operate and effect the possibilities of urban development.

This thesis will contain one written part and several spacial analyses of sites along the Hudson Line and the Beacon line focusing on the portion within Dutchess County, New York. The thesis main design element will be a detailed urban design proposal on the area of Beacon Railroad Station within the city of Beacon.

Credit: Emily Moser, I ride the Harlem Line

1. INTRODUCTION

This chapter addresses historical backgrounds and the basics of the topics that this thesis will research.

Credit: Library of Congress, Geography and Map Division

TRANSPORTATION AND URBAN GROWTH

HISTORICAL GROWTH

This chapter explains how transportation has been the driving force behind urban development and how it technology has shaped our cities.

Humans have always had a need to be able to move around and transport its belongings. Hunter-Gatherer tribes moved to where there was prey and water, while at the same time bringing their shelter along with them. When they eventually started to settle down the collection of food and resources was done by farming, animal raising and trade.

Trade quickly became a way for certain parts of the population to specialize into different occupations such as blacksmithing or pottery. The transportation of resources between people and communities gave rise to a transportation network of roads, carrying oxcarts and people to market for trade [3]. Travel over longer distances and with heavier cargo was done with boats and ships on different waterways and over oceans [4]. This network created distinct nodes, often where inland trade routes intersected larger waterways. A great example of this is Sweden's capital Stockholm. Where lake Mälaren creates a barrier between the northern and southern part of the country. At its narrowest point the city was founded to utilize the trade on the north-south land routes and the east-west sea routes. At these types of natural converging nodes many great cities where founded. This system of trade was predominant from about 35 000 B.C. [5] to the onset of steam powered transportation in the 19th century [6].

The new steam power was the driving force that took the industrial revolution from being contained to places with running water to being able to set up production anywhere. This and the creation of the steam locomotive gave rise to a new urban form, the industrial city. The new industrial city could concentrate production in a way that was impossible while it was powered by water. This gave rise to manufacturing centers that for the first time could be placed right were the trade routes where instead of where there

3. David, Dollar and Aart, Kraay, *Trade, Growth, and Poverty*, 2004, The Economic Journal, Volume 114, Issue 493, 1 February 2004, Pages F22–F49, Oxford: Oxford University Press.
4. McGrail, Sean, *Boats of the World : From the Stone Age to Medieval Times*, 2001 ,Oxford: Oxford University Press.
5. National Maritime Historical Society. *Sea History*, 1979, Issues 13-25 published by National Maritime Historical Society, Peekskill, New York, Retrieved 2012-06-26
6. Jeremy Atack, Fred Bateman and Thomas Weiss, *The Regional Diffusion and Adoption of the Steam Engine in American Manufacturing*, 1980, The Journal of Economic History. Cambridge: Cambridge University Press

Credit: Edwin Lord Weeks, 1880, Open Market Morocco

Steam engines allowed production to be moved anywhere. People could for the first time live in very large cities when centralization of workplaces and the transportation of food became possible.

was a steady supply of running water. This in many cases meant that production could move back into the historical cities that was placed along trade routes to begin with.

Before industrialization cities tended to be rather small by todays standards but grew exponentially with the onset of manufacturing and the need for extensive urban workforces. Stockholm for example only had 92 000 inhabitants 1850 a number that had grown to 216 000 by 1885.[7] This can be see as typical for a mid-sized European city while in New York the population increase was even more staggering. 1840 the population of the five boroughs was 391,114 and by 1860 it had grown to 1,174,779, more then tripled the population in only 20 years.[8]

This rapid influx of people expanded the urban fabric to such an extent that walking quickly became an unsustainable way of getting around. The cities needed to come up with new ways of moving the masses around. By the 1810s horse-drawn trams had started appearing in Britain and by 1932 the first line was introduced in New York. Horse-drawn trams had a limited capacity and were slow. They also had a very high turnover of horses with a life expectancy of about two years. [9]

Intercity trains and steam hauled street level trains started appearing in the 1850s. As the city grew and became more congested railways had to be elevated or built in open cuts. One initial problem with introducing railway had been the cost of material. At first cast iron was used, but it was brittle and had a tendency to break and corrode. It wasn't until the 1860s when the rolling mill and the Bessemer process of producing wrought iron had become available that the railways really came in to their golden age. [10] With this mature technology railways and subways rapidly expanded to cover the region with one of the most extensive transit networks in the world.
By 1940 the system had grown to have 30 subway lines with over 470 stations as well as several different commuter rail systems serving the metropolis. By the mid 19th century urban regions had begun to form.

7. Stockholms stad, *Befolkningen i Stockholm 1252 - 2005* [website], 2005, http://statistik.stockholm.se/images/stories/pdf/Historisk_befolkning_web.pdf (accessed 19 march 2019)
8. Jane, Allen, *Population*, in Kenneth T. Jackson (ed.), *The Encyclopedia of New York City*, 1995, New York: New-York Historical Society & Yale University Press
9. William D. Middleton, *The Time of the Trolley*, 1967, Milwaukee: Kalmbach Publishing
10. Arnulf, Grübler, *The Rise and Fall of Infrastructures: Dynamics of Evolution and Technological*

Credit: Library of Congress, Geography and Map Division

SPRAWLING URBAN REGIONS

Cities could grow larger then a person could normally walk due to the invention of urban tram and rail lines. The dense urban metropolis was born.

Villages and towns adjacent to larger cities expanded and merged and through the expansion of rail lines and subway they became integrated into the urban fabric of the larger metropolitan areas. New York saw rapid expansion of commuter suburbs accessible by the rapidly expanded subways. It want uncommon for the subway lines to be extended first to open new land for development as it was an essential function when people lacked other modes of transport.

The expansion of the cities prompted a political process of incorporation of the formerly independent towns into the larger cities. In 1895 The Bronx was the first New York borough to be integrated into the city. Brooklyn, Queens and Staten Island followed in 1898. [11] The suburbs closes to the city were generally built with densely placed row houses or town houses. They typically housed the upper working class and the middle class. The newly developed areas were usually quite close to the factories and docks. The sanitary conditions were better then on Manhattan where slums and overcrowded neighborhoods had seen a deterioration due to the masses of migrants flocking to the city. Most migrants entering through Ellis island continued further west, but many stayed. The vast amount of temporary inhabitants and very poor newly arrived people helped to create slums. Often by so called slum lords that exploited the homeless.

The city's upper-classes began settling up-town with the mid-town business district as a buffer between them and the migrants of lower Manhattan. Many upper-class people also settled in the surrounding town that weren't connected to the Subway network. These towns were connected to Manhattan via the main lines that operated steam train services, these services were expensive and had a segregating effect. Lower class people generally couldn't afford the high ticket prices. Another aspect of this move to the suburbs was racism. From the late 1880s many of the immigrant arriving were of southern or eastern European origin many were either Jewish of Catholic. Earlier generations were generally protestant and many of them now left to form their own communities in the suburbs. [12]
This development continued until the Second World War.

Change in Transport, 1990, Heidelberg and New York: Physica-Verlag.
11. Kathryn Ford, Thorne and John H, Long (ed.), *New York Atlas of Historical County Boundaries*, 1993, New York: Simon & Schuster
12. Kenneth T. Jackson, *Crabgrass Frontier: The Suburbanization of the United States*, 1985, New

Credit: New York Transit Museum

The realignment of production means during the Second World War created the need for a car industry. This lead to a car oriented sprawling type of urban form.

The war created many new situations that especially American cities had to adapt to. The manufacturing industry had been expanded drastically to provide materials for the war effort. A large proportion of this new manufacturing was geared at producing vehicles of different types. When the war ended and the demand for military vehicles diminished millions of workers stood to lose their jobs.
The industry shifted to produce automobiles and many public investments were made to build highways and roads to bolster the new industry and to secure sales.

The car dramatically changed how land could be developed. Previously railways had to be built to access new land for development. This was an expensive investment in a high capacity system and the developments tended to be dense and compact because of the need for a high return to cover the large investment and the need for the neighborhood to be within walking distance of the train line. The car made it possible to develop large areas outside of the cities without the costly investment of rail lines. This in turn made it possible for the first time to sell single family houses with large yards in natural settings to working class families. The improvements in technology and manufacturing coincided with the return of millions of American soldiers that had served in the war. They had military salaries to invest in housing and many were looking to start a family. This created an almost explosive expansion of car-based suburbs.

The car had several perceived benefits over the older types of rail based transportation. It didn't need the expensive fixed infrastructure that the train did. Roads had historically been a public investment while rail lines typically were private. This meant that highways and roads were provided for free and new areas could be developed without having to build it own rail or subway line to access the city. At first this was a very viable and attractive proposition due to the relative lack of cars on the roads. But with the rapidly increasing numbers of cars the existing road and parking systems quickly became inadequate. In America and in many places in the world the private car was seen as a symbol for progress and a symbol of wealth. It was decided that the old cities would be adapted to the needs of the cars rather then revert to the existing logic of rail based transportation. This has lead to the urban sprawl that we see today. [13]

York: Oxford University Press
13. Kenneth T. Jackson, *Crabgrass Frontier: The Suburbanization of the United States*, 1985, New

Credit: Chicago Architecture Biennial

TRANSIT ORIENTED DEVELOPMENT

Planning a city out of the logic of rail travel gave rise to dense urban neighborhoods. The capacity of rail systems is the key to allowing very large dense cities.

Transit Oriented Development (TOD) is a type of development scheme that aims to maximize transit usage. This type of development is typically quite dense and has some kinds of mixed-use elements. In the industrial age when cities no longer were entirely accessible by foot development of new areas always needed to be combined with some kind of transportation system to accommodate for it inhabitants to be able to travel to the rest of the city. This could be done by either extending tram or subway lines or to build a railway.

Railway operators where early on aware that investments in rail lines and stations served to open new development opportunities. Ticket revenue was of course a good source of income and lines could be profitable outright but that generally only served to fund the railway operation but not to cover the vast investment needed to build the line. That would be covered by the sale of land that now could be developed for housing and by collecting rent by tenants. Urban development was thus the main driver of railway investments and the main part of the railways revenue came from real-estate. One prominent example of this kind of development was London Metropolitan Railways "Metro-Land" that became a template for railway development all over the world. [14]

In many western countries governments began strictly overseeing railway construction and urban expansion. In rapidly industrializing Japan growth was faster then in most other countries that had seen a gradual industrialization. This upheaval in manufacturing and Japans colonial expansion prompted extremely quick growth in the manufacturing sector causing Japanese cities to expand at extraordinary rate. This expansion caught a second wind after the defeat on Japan in the Second World War causing further urbanization with the increasingly export driven economy. This has caused Japan to have some of the largest and most expansive urban areas in the world. The capital Tokyo today has a metropolitan population of 37 million people. Making it the largest city in the world. [15]

This astonishing growth rate and lack of public control created a business environment with die hard competition

York: Oxford University Press
14. Alan Jackson, *London's Metropolitan Railway*, 1986, Exeter: David & Charles.
15. Tokyo Metropolitan Government, *History of Tokyo*, 2007, Tokyo

Credit: Hisui Sugiura 1927

Transit Oriented Development has evolved as a urban design concept out of the idea of creating mutually beneficial conditions between business owners and railway operators and by doing so help incentivize sustainable travel and reduce car-dependency.

and it quickly saw innovation of new business models to gain an upper hand over the competition. The first subway line in Tokyo, the Ginza Line connected the old town of Tokyo to the central business district. To increase the revenue it constructed a up-scale department store with the subway station in its basement with direct access. This proved to be an over night success In japans rainy and humid climate. Office buildings were also bought and eventually connected to the station via underground passages filled with stores and restaurants making it convenient for the commuters to shop and eat. This diversified business model helped to make the rail operators very profitable. [16]

Tokyo quickly out grew its traditional boundaries and started a westwards expansion. Previously all rail lines had operated along the coast of Tokyo bay but by 1885 a railway had connected the north and south of the city to the west of the Tokyo Imperial Palace. This line would eventually be fully connected into what is today Tokyos Yamanote Loop Line. The small towns to the west of the capital now became hubs for the new suburban networks of railways protruding like spokes out of the city. Each node served one of a few private rail operators that invested heavily in department stores, office complexes and entertainment venues. These railway nodes eventually grew to a scale rivaling Tokyo's existing downtown and gave rise to a multi-core region formed after the logic of the railway. [17]

These type of transit nodes has proved to be extremely popular and efficient ways of planning downtown areas. By maximizing the development around and even on top of the railway station a symbiotic relationship between businesses and the railway appears. The railway serves to attract people who need to travel and thus bring customers to the businesses. The businesses and offices in turn brings people from other part of the city to work and shop creating and influx of riders to the railway. In the case of many Japanese railways the railway operator is also the owner of the offices and shopping complexes creating a circular economy there they benefit in all instances.

Transit Oriented Development has evolved as an urban design concept out of the idea of creating these mutually beneficial conditions between business owners and railway operators. And by doing so help incentivize sustainable travel and reduce car-dependency. [18]

16. Tim Hornyak, *Heart of gold: The Ginza Line celebrates its 90th birthday*, 2017, Tokyo: Japan Times
17. Japan Rail East, *Tokyo Area Complete Railway Guide - Major JR Lines*, 2013, Tokyo, Futabasha.
18. Robert Cervero, *Transit Oriented Development in America: Experiences, Challenges, and Prospects.* 2004, Washington: Transit Cooperative Research Program, Report 102.

Credit: Nikken Sekkei

MASS TRANSPORT

This chapter cover the history of mass transit and its rise and fall in America .

Transportation has almost always been a concerted effort where people pool their resources to achieve transportation longer than a days walk. This includes ship building, horse breeding and taming, carriage making to name a few. The task of transporting yourself or items over long distances have always been a group effort.

It wasn't until the advent of the bicycle that transportation became entirely individual. Before industrialization transportation wasn't really a widely sought after service. Most people mainly participated in their local economies and communities . They went to their local church, sold their wares at the local market or in their local port and had usually never traveled outside their parishes. Regions with customs that encouraged pilgrimage saw more long range travel but in general people stayed where they were born.

Industrialization came in stages and the first stage were manufacturing that was centered around water power created the need for worker to move to the so called "company towns" that cropped up. These generally consisted of one or a few factories and mainly needed transportation of goods, but the need for passenger transportation was still limited. The second round of industrialization saw industry move to the larger population centers were labor was more readily available. This created expanding cities and the need for transportation for the masses.

Roads of the early 19th century were rough, either paved with paving stones or dirt. This made transporting anything larger then a regular carriage difficult.
To reduce the resistance and allow for heavier carriages cast iron rails was placed in the road surface. This allowed for heavy vehicles to transport up to 30 people at once using only one horse. The new tramway's were arranged in such a way that they provided a regular service that for the first time allowed people to travel without having to make arrangements ahead of time. This planning of services and scheduling became the benchmark for all forms of mass transit to come. [19]
More complex trade and the large volumes of people moving to the cities gave rise to the need for inter-city transportation. The first railway connecting two cities was the Liverpool and Manchester Railway, it began operation in 1830. [20]

19. Jay Young, *Infrastructure: Mass Transit in 19th- and 20th-Century Urban America*, 2015, Oxford: Oxford Research Encyclopedia of American History.
20. T. Taylor, *A history and description of the Liverpool and Manchester Railway, 1832*, London, British Library

Credit: A.B. Clayton 1830

During the early and mid 19th century many more cities were connected to the growing networks of railways in the UK. TheU.Srailways started out in the 1820s and was initially used to carry freight between different waterways and to carry passengers along the slow Erie canal but were transfered to ships on both ends of the canal. The first inter-city rail lines in America were the Boston & Providence Railroad and the Baltimore & Washington DC Railroad both opened in 1835. [21]
This became the starting point of a race to colonize the continent and the way to provide efficient and fast access to the American inland was to build railroads. Many private railroad firms competed to be the first to connect the eastern and western seaboards of the continent and to grab as much lands as possible in the process. The transcontinental railroad was finally finished by 1869. [22]

While rail networks grew quickly outside of the cities most of the inner city transportation was still carried out with horse drawn trams. This was an extremely harsh type of transportation and it saw life expectancy for horses go as low as less then a year. The huge turnover of horses and the massive accumulation of manure quickly overwhelmed the cities. [23] By 1850 it had become apparent that high capacity powered transportation was needed. Attempts at using cables to pull carriages along the rails proved insufficient in all but a few cases. Notably San Francisco's cable cars. Attempts at running steam locomotives on street level proved impractical and dangerous with many accidents. In London and New York parallel attempts at solving grade separated urban transportation were made in the 1850s resulting in London's Underground railroad and New Yorks elevated rail lines. Smoke from the steam locomotives became a major issue for the railroads. The ever increasing use of long tunnels created dangerous conditions with risk of carbon monoxide poisoning and an alternative solution was needed. Werner von Siemens presented the first electrically powered passenger locomotive in 1879 and the first revenue tram service started in 1883 outside of Berlin.

By 1902 a public ordinance in New York had outlawed the use of smoke generating locomotives in Manhattan, Queens and Brooklyn by 1908 and by 1905 both

21. James D. Dilts, *The Great Road: The Building of the Baltimore and Ohio, the Nation's First Railroad, 1828–1853*, 1996, Palo Alto, CA: Stanford University Press.
22. Stephen E. Ambrose, *Nothing Like It In The World; The men who built the Transcontinental Railroad 1863–1869*, 2000, New York: Simon & Schuster.
23. Eric Morris, *From Horse Power to Horsepower*, 2007, Berkeley, CA: University of California Transportation Center.

Pennsylvania railroad and New York Central Railroad had begun electrified service. [24] The electrification of rail and subway lines helped to clean up the previously smoky and polluted cities while at the same time helping to relieve the ever increasing road congestion.

Electrified rail and subway lines has since become the standard for urban transportation. The relatively short distance of the tracks in urban transits systems made electrification an economically viable solution and the efficient acceleration lent it self well to subways and commuter trains with short distance between stops.
For main line service steam stayed the main mode of traction for a long time and main line electrification came gradually. Countries like Sweden and Switzerland were early to electrify is main lines due to their topology and access to cheap hydro-electric power. America with its vast rail system and relatively sparsely populated inland never electrified its main lines outside if the populations centers on the East Coast and today rely heavily on diesel locomotives for traction.
The U.S also had over 500 cities with streetcar or tram systems. These cities gradually faced out street cars in an effort to conform to the new logic of the car. Many of the systems had also seen a lack of investment during the Great Depression and the Second World War and were in need of substantial rebuilds and upgrades. Most ended up being replaced by bus services or abandoned all together and replaced by people driving private cars. Today only about 40 cities in the U.S operate tram, streetcar or light rail systems. These systems are also much smaller then they were before the Second World War.
The period after the Second World War saw a substantial reduction in public transport in American and many places around the world when private cars became affordable to the masses. There were also a political push to plan for private cars and prioritize investments in to roads and highways. This period saw a systemic under-financing of public transit. This created a backlog of maintenance that gradually drove more and more cities to abandon their public transport systems or to downsize them. This period also saw a lot of its population growth and urban expansion being done in areas not served by rail lines creating a downward spiral for public transport accessibility. [25]

24. Michael C Duffy, *Electric railways, 1880-1990*, 2003, Stevenage, England: The Institution of Engineering and Technology
25. Joseph Stromberg, *The real reason American public transportation is such a disaster* [website], 2010, New York: Vox Media https://www.vox.com/2015/8/10/9118199/public-transportation-subway-buses (accessed 28 march 2019)

UNDERSTANDING TRAINS

This chapter intends to provide a basic understanding to why trains always should be the basic transportation framework in a city or an urban region.

One of the goals of this thesis is to show Architects, Urban Designers and Town planners what untapped potential train systems have and how reactivation of train systems can help to improve social and environmental sustainability for many communities. Architects and Urban Designers are traditionally well trained in how to accommodate cars in urban developments, accounting for parking, safety concerns, accessibility and many other questions. This thesis aims to give arguments to why understanding trains and rail bound transit are equally or even more important to cars in urban design and why training Architects, Urban Designers and Town planners in questions concerning mass transit and rail bound transit as crucial to achieving more sustainable communities.

Trains have always been and remain the most efficient way of moving people between two fixed points. The steel rails provide for a very heavy vehicle to travel at high speeds over long or short distances. The heavy vehicle and the smooth running surface gives it excellent characteristics to move many people in comfort. There has recently been attempts to achieve results similar to trams by running heavy buses on regular roads and it has seen some success but the fact remains that having a hardened running surface with very low resistance and friction gives the best possible conditions for running very heavy vehicles. To accommodate large amount of people on a single vehicle the vehicle need to have a frame sturdy enough to cope with the weight and stresses. It can be seen that trains last longer. A bus in high intensity city traffic needs to be replaced after about 5-7 years and a bus in regular low intensity service last about 10-12 years. Rail equipment typically last about 30-40 years and provide a better frame to refurbishment so they can provide a quality service even when they age.

So why isn't all mass transit driven by rail vehicles? Rail lines are substantial investments and need separate rights of way from other traffic. This is a costly investment that requires the purchase of land. Buses and car does not require this investment and are more economically efficient at a low to intermediate traffic density. The tipping point where that economic balance tips over in favor of a train is contested issue and is effected by many local factors. But there are limiting factors of how many people can be Transported using buses and how long distances people are willing to travel in

Metro-North Hudson line
Credit: Metropolitan Transportation Authority

Even very old infrastructure can be turned in to super-modern high capacity transportation systems. The relative youth and the scale of New Yorks system is a huge asset.

a certain comfort level. [26] The U.S has a vast untapped resource in its abandoned or under utilized rail system that makes it possible to create a modern and highly sustainable transit system using much less resources then otherwise would be possible. The rail systems created before the advent of the automobile was among the largest in the world. Pennsylvania railroads system alone was the worlds third largest after the UK and France. [27]

The abandonment of the railroads was a gradual shift. First from focusing on passenger transport to cargo and then slowly whining down operations and downsizing the networks. In contrast to the old streetcar networks much of is was left in place while streetcar rails often were torn up. The right of ways, IE. The embankments, track beds, bridges and tunnels were generally not demolished or torn down. This is a major asset in it self even it the tracks are in bad shape or removed altogether. The largest cost associated with railway construction has always been the procurement of land and the engineering works. The parts of the system in and around New York was extremely extensive and built for very high capacity. The engineering works are arguably amongst some of the finest in the world and was the pinnacle of technology for their period. They were also built to a very high standard with a lot of the construction of for example viaducts being done in stone that last for a very long time.

The fixed structures are younger than many comparable system in for example London and Paris. London Bridge station is a good example. It was opened in 1836 and recently renovated to increase its capacity to well over 50 million passengers per year. The basic structure is the same as in 1836 and still serves as a state of the art transportation node more than 180 years after its construction.[28] New Yorks Grand Central Terminal (1913) and much of New Yorks network is substantially younger and built for a larger capacity than London's current system. By reinvesting in the rail system and reactivating many of the old lines New York could be given a World class, state of the art transportation system much quicker and at a lower price then almost anywhere in the world.

26. Christopher MacKechnie, *How Long Do Buses and Other Transit Vehicles Last?* [website], 2019,New York: ThoughtCo, https://www.thoughtco.com/buses-and-other-transit-lifetime-2798844 (accessed 28 march 2019)
27. Albert J. Churella, *The Pennsylvania Railroad, Volume 1: Building an Empire, 1846-1917*, 2012, Philadelphia: The Pennsylvania Press
28. D.L Bradley, *The Locomotive History of the London Chatham and Dover Railway*, 1979, London: Railway Correspondence and Travel Society.


London bridge station
Credit: Dezeen

CAPACITY

No other mode of transportation type has the same capacity to move people efficiently and environmentally friendly. A double track rail line can have the same capacity as a 20-30 lane highway. While traveling at much heigher speed without any carbon emissions.

A rail line under optimal conditions can be the most efficient and high capacity transport system in the world. Using large vehicles on own dedicated tracks with no external interference makes for the best possible efficiency and can give a huge transportation capacity when the right conditions are achieved.

A line with two tracks can operate in either direction without having to wait for oncoming trains. If trains operate at different speeds a faster train will catch up to slower trains and cant pass until the train in front gets switched to another track. The other option is to allow enough head way so the train wont catch up, but that reduces the amount of trains that operate over the same track. The capacity on a single track line is dependent on the amount and distance between sidings to allow trains traveling in different directions. A double track line can have an extremely high capacity if all trains operate at a similar speed but mixed speeds will reduce the capacity greatly. A four track line can cope with both bi-directional travel and different speeds while still being very efficient. The difference between a streetcar and light or heavy rail is that streetcars run in a mixed traffic environment and has to account for variations in its operating pattern. Segregated rail systems doesn't and can thus be scheduled with much higher precision and run more reliably. The level of grade separation or segregation depends on the standard of the rail line. Slower lines often have road and pedestrian crossings while high speed lines always are completely separated from other hazards due to the risks associated with very high speed collisions. The capacity of the line depends on the amount of vehicles operating along the line and the capacity of the vehicles them selfs. Subways are completely segregated systems and runs relatively slowly so they can operate at short headways. The best preforming lines today can operate at one train every 90 seconds[29] in each direction. A subway train typically carry around 800-1200 people.[30] That mean that an optimally preforming subway line can transport 96 000 people per hour. A commuter rail line typically operates

29. Smart Rail World, *CBTC tackles Copenhagen's growth and aims for 25% headway reduction* [website], *2016*, *London:* Smart Rail World https://www.smartrailworld.com/cbtc-tackles-copenhagens-growth-and-aims-for-25-headway-reduction (accessed 28 march 2019)
30. The Swedish Tramway Society, *SL C20* [website], *2005*, Stockholm: The Swedish Tramway Society *https://www.sparvagssallskapet.se/vagnhallen/typ.php?typ_id=295&ling=en* (accessed 28 march 2019)

Credit: Tobias Snäll

at head ways of about 5-10 minutes and can carry around 2200 people giving it a capacity of 52 800 people per hour. There are commuter rail lines that operate at 2-3[31] minute headways but that usually accounts for the most central parts of the network were several line converge. The distance trains travel also determine how long the headways need to be. Long journeys increase the likelihood of delays. For example a 5 minute delay on a four hour journey is not unusual. External factors such as weather might slow a train down marginally and would only cause a delay of a few seconds in a commuter trail while a train traveling longer distances might be delayed by a few minutes by the same external factor. This creates a need to have slightly longer headways on long distance trains, usually around 7-10 minutes. This also creates a difficulty operating long distance trains and local trains on the same lines heading in to a main train station. Because a long distance train that has been delayed by 5 minutes have to slot in to a schedule were local trains might run every 3-4 minutes creating delays and service disruption. [32] So for operational stability and punctuality on a line a high degree of segregation and similarity in service patterns is preferred. A good example of that is the Japanese Shinkansen high speed lines. They operate trains traveling over 1000km at high speeds of up to 320km/h with headways as low as 3 minutes. That is only possible because the system is entirely segregated and only serviced by trains traveling at the same speed. The Tokaido Shinkansen is able to transport 452,000 passengers daily on a double track line. [33]

A single lane of highway, can at optimal performance transport 2200 cars per hour.[34] Giving it a theoretical capacity of 11 000 people per hour if 5 people travel in each car. U.S national statistics determines that the average ridership per car is 1,2 passengers. This gives a highway an ideal capacity of 2 640 people per hour. That means a subway can provide capacity equal to 36 highway lanes and a commuter rail line about 20 lanes.

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31. Modern Railways , *Thameslink aims for Olympic gold*, 2007, London: Modern Railways
32. News Öresund, *DSB vill begränsa trafiken med Öresundståg till skytteltrafik Lund-Malmö-Köpenhamn* [in swedish] [website], 2017, Malmö: News Öresund. https://www.newsoresund.se/motforslag-fran-dsb-nar-skanetrafiken-enats-med-transportministeriet-om-nytt-avtalsforslag-for-trafiken-med-oresundstag-till-danmark/
33. Central Japan Railway Company, *Central Japan Railway Company Annual Report 2011*, 2011, Tokyo: Central Japan Railway Company
34. C/CAG of San Mateo County, *APPENDIX B Traffic Level of Service Calculation Methods*, 2005, San Mateo: C/CAG of San Mateo County


Credit: Glenn Tanaka

TRACK

The main challenge and cost of building a rail line is to create a flat and relatively straight route through the landscape.

Railways consist of many components that act together to provide efficient, sustainable and safe travel. It is useful to have a basic understanding to be able to gauge what possibility the railway can bring. The track of the rail line is of course the most important component. It consist of the trackbed that is resting on either the ground or some type of engineering work. The most difficult and most expensive part of railway construction is to create a relatively flat route through a landscape that has features that need to be avoided or passed. To create this embankments, viaducts, bridges and tunnels are used. They are very expensive to build but have very long lifespans.

Geological conditions heavily effect how easy a railway can be built. Flat land is of course preferable but quite paradoxically some of the most mountainous countries in the world, Japan and Switzerland operate some of the most efficient and most utilized systems in the world. This is connected to the rail lines logic. Flat landscapes often have a dispersed urban structure while mountainous regions have dense cities that lay in valleys and along rivers that are easy to serve with a single rail line. The geometry of the track also plays a big part in how the line can be operated. Trains are heavy and travel very quickly so they need long curves to be able to travel at high speeds. The straighter the track the faster the train can travel. Straighter tracks means more tunnels and bridges to circumnavigate obstacles in the terrain making high speed lines substantially more expensive than regular lines that serve local and regional trains.

The rails them self are also a factor in how the service can be run. Tracks were originally built in portions and bolted together to create a continuous running surface. Today continuously welded rails are the standard and allow for completely smooth running except for when passing a point. The trains exerts pressure on the rail then it passes and creates a wave like movement through the rails. This movement increases at higher speeds. The railway ties that the running rails rest on determines how well the rails are fixed to the ground. Classic wooden ties are cheap but move and create a need for realigning the tracks more often. Concrete ties are heavier and reduce the motion but is prone to cracking. Continuously fixed concrete “slab tracks” fix most of these issues but are very expensive in comparison. The tracks are laid with a slight bank in the curves to help alleviate some of the centrifugal forces, this is called track elevation. Top heavy trains such as freight trains require less track elevation to not topple over.

SIGNALING SYSTEMS

Signaling systems are the backbone of modern rail travel. They determine capacity, safety and interoperability of the rail lines.

Signaling systems are the systems used to control the running of the railway. They control many aspects of the operation and are primarily the main safety tool.
Signaling systems exist to create a safe way of operating rail lines. In contrast to road traffic that is regulated by laws, railways have been able to determine by them selfs how to operate on their system. The operation has of course been monitored by the governments but usually not directly controlled. The great variety and difference in complexity of rail systems have created many different ways of handling questions concerning safety. Track side signals began being used and the telegraph could radio ahead to make sure no other train was on the track. This was a huge leap forward and dramatically increased the capacity of the lines. So called fixed block signaling divide the rail line in to segments and sensors were installed to detect if a train was in a certain block. A train was only given the green light if the block in front was unoccupied. But with increasing speeds and more trains the risk of misunderstanding and human error became more and more apparent. A need to safeguard against human error was developed. Digital signaling with communications in to the train cab where invented and is the standard of operating on modern railways. Systems that automatically follow safety instructions are becoming standard and stop trains that travel too fast or fail to stop at a stop signal. Even completely automated train operations is possible and is being used in several places around the world. The level of safety, automation and communication greatly effect the capacity of the rail line. Trains with a high degree of communication and automation can operate closer together. For example if the train in front emergency breaks the train behind it also emergency breaks automatically to make sure it doesn’t rear end the train in front.

Different systems were developed independently on a nation or even company level. This has created an interoperability challenge in for example Europe were trains might need to cross several national borders on it journey. Trains operating on such a route would need to have several signaling systems installed and certified. The European union has regulated that a new standard signaling system is to be installed on all main lines in an attempt to create a EU and de-facto a world standard for signaling. [35]

35. European Commission, Delivering an effective and interoperable European Rail Traffic, 2017, Brussels: European Commission

ROLLING STOCK

Trains come in all different shapes and sizes.

I like trains!

Rolling stock is the combined name for all types of rail vehicles. It includes locomotives, rail cars, motor cars and electrical units. A train usually consist of different types of rolling stock. The two main types are locomotive hauled train consisting of one or more locomotives and trailing carriages that do not provide forward traction. This type train is the original type of composition and has been very popular due to its modular nature. Carriages and locomotives could be added or subtracted and adjusted for the specific need of a particular service. This modularity is offset by the relative lack of acceleration associated with only having traction in the locomotive. The second type is the so called "multiple-unit" it is a permanently fixed combination of carriages that have traction on several of its axles. Some multiple-units have traction motors on all of the axles. This gives it very good acceleration and was initially used on lines with short distances between stops, like subways or commuter rail lines. Multiple-units are classified depending on their type of traction. The main types are Electrical Multiple-Units (EMU) or Diesel Multiple-Units (DMU). Recently battery powered multiple-units, and hydrogen fuel cell multiple-units have become available on the market. There are generally few technical obstacles to operate any of the types of rolling stock on a rail line. The rail gauge (distance between the rails) is the main factor and vary from region to region. Western Europe, North America and China use the so called Standard Gauge of 1435mm while Russia and former Russian Empire and USSR countries use the 1520 mm Russian gauge. Many different gauges are used in Asia, Africa and South America mainly because of different colonial authorities competing for control over territories. Having different gauges stopped the competition from using their system.

Rolling stock can often be adapted to fit on different gauges. Track gauges often have associated so called loading gauges which is the open space over the tracks needed for a certain train. For example how big a tunnel needs to be. The UK has the same track gauge as France but a narrower loading gauge, requiring British trains to have narrower cars than the French. As a result British trains can operate on French lines but French trains cant operate on British lines. The speed of the trains are entirely dependent on the amount of traction. High speed trains are operated with both locomotive hauled trains like the French TGV or with multiple units like the Japanese Shinkansen.


Credit: East Japan Railway Company

POLITICS AND POLICIES

Railroads aren't just about technology; political, cultural and economic aspects also plays a major part in understanding why things are done in a certain way.

The development of modern rail infrastructure and high quality services has long been a point of pride in many European and Asian countries. The front runners during the post-war period have been Japan and France. Americas focus and political incentives on driving has left the rail sector in America far behind its European and Asian counterparts.

There exists several factors that makes it more difficult to bring high quality rail to the US. The major one is finance. The U.S has long seen an underfunding of rail and an unpredictable funding structure. Funds have been given in to projects and little funding have been provided at a sufficient level over time. The U.S also has a problem with very high costs. Construction of new lines have been substantially more expensive than their counterparts abroad and often achieving worse quality while paying much more. One glaring example being the Second Avenue Subway in New York. This project cost over 2.2 billion dollars per kilometer while comparable new lines in Berlin, Paris and Copenhagen cost 230-260 million dollars per kilometer. [36] This cost structure is a massive challenge for the U.S and is the main obstacle for high quality rail service and in the long run for sustainable transportation in the US. Other complicating conditions can also be identified:

The safety doctrine of U.S railways has had the standpoint that the main task of the rail system is to handle freight. The security regulations have been adapted too a viewpoint that the system is to large to entirely cover with high quality signaling and since it primarily transports freight the risk to human lives is relatively small. The doctrine revolves around the notion that accidents will inevitably happen and trains need to be built to a standard that they are crash worthy in a derailment or a collision. Due to this the U.S sees severe rail accidents at regular intervals. [37] The European and Japanese safety doctrine works out of the stand point that with the speeds that trains operate at today would led to catastrophic loss of life and that accidents need to be avoided at all costs. The Japanese Shinkansen high speed rail system has proved that this approach to safety is attainable with the proper use of signaling systems, rigorous safety regulations and a large degree of redundancy in the fail safes. The shinkansen has since it started operations in 1964 transported over 10 billion people without a single fatality due to rail operations and has had an extremely low accident rate with only three serious incidents in 55 years. [38]

This discrepancy in approach to regulations has had effects on procurement of new rolling stock and signaling systems. Since the U.S had opted not to align it self to common regulations and approaches it has needed to produce or buy trains to American specifications. This has lead to the U.S not being able to buy "off the shelf" products on an international market which limits competition that increases prices and hampers innovation. U.S public procurement policies has mandated that large orders need to be produced in the US.[39] Some companies have established them selfs in America but have often shut down local production after the order has been delivered. This incentive to produce the trains locally have had a counter productive outcome. A better way to establish long term economic activity would be to buy of the shelf high technology trains on an international market. Gain know-how of how to operate and service these trains and build a pool of skilled professionals before attempting at producing trains in country. The delay of modern trains and cost efficient procurement can be argued to have had more adverse economic effects to a much larger group of people than the loss of relatively few jobs.

Efforts have been made to align U.S regulations to international standards and in 2013 the Federal Railroad Administration voted to create new regulations and adopt a new approach to safety regulations. [40] This has opened the U.S rail market to international suppliers greatly increasing the options operators have to choose suppliers and will in the long run provide healthy competition to domestic train producers.

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36. Matthew Yglesias, *NYC's brand new subway is the most expensive in the world — that's a problem* [website], 2017, New York: Vox Media. https://www.vox.com/policy-and-politics/2017/1/1/14112776/new-york-second-avenue-subway-phase-2 (accessed 28 march 2019)
37. David Tyrell, *US rail equipment crashworthiness standards*, 2002, Washington: US Department of Transportation's Federal Railroad Administration (FRA)
38. Naoki Fujii, *An Overview of Japan's High-Speed Railway : Shinkansen*, 2013, Tokyo: Ministry of Land, Infrastructure, Transport and Tourism
39. Federal Trade Commission, *Complying with the made in USA standard*, 1998, Washington: Federal Trade Commission
40. Jennifer Nunez, *US approves HSR crashworthiness standards* [website], 2013, Falmouth: International Railway journal. https://www.railjournal.com/regions/north-america/us-approves-new-crashworthiness-standards-for-hs-trains/ (accessed 28 march 2019)

TECHNICAL ISSUES

Railroads aren't just about technology; political, cultural and economic aspects also plays a major part in understanding why things are done in a certain way.

The way private rail companies grew and expanded in the U.S created a huge network with a host of different systems and standards for rail equipment. The private competing companies invested in new technologies that would benefit their operations and provide an edge to the competition. The regulating authorities in the U.S at that time had a stand off approach to regulation and didn't try to limit the technological advancements being made.

When the large private rail companies eventually started declining they either merged or went under. The resulting combined network lacked uniform technical standards regarding things like electrification systems and signaling systems. This has made it more difficult to run railways in a more flexible way without having to reinvest in the network. For example, the Metro North lines running north out of Grand Central terminal run on electricity provided by third rail at 750V DC while New Jersey Transit runs on overhead catenary at 25 kV AC. This creates an obstacle to operating trains from north of the city, continuing east or west on the Northeast Corridor.
These technological remnants stop the train operators from creating an integrated rail system without either having to invest in trains that can use both types of systems or having to re-electrify some of the existing lines.

The authorities lack of regulations has also resulted in new investments in signaling and electrification being done without proper coordination or making sure to safeguard interoperability within the rail network. One reason for this can be that different rail operators and track owners doesn't want to be negatively effected by federal regulation that might require them to make expensive investments in to their systems. Its also likely that the approach has been to solve operational issues in the most cost-effective way for the individual operators rather then to take a holistic approach for the network as a whole. Trying to regulate a constantly underfunded rail market is not an easy task when long term holistic investments and development of national standards are costly for both federal authorities and for the operators. And that the existing approach has been the only possible under this policy environment.

Credit: Metro-North Railroad

2. REGIONAL TRANSPORTATION

This chapter adresses regional issues and proposes changes to regional transportation systems

Credit: Library of Congress, Geography and Map Division

THE NEW YORK REGION

The region around New York City is the most populous and the most densely populated region in The United States. It has 20.3 million inhabitants and covers large parts of the states of New Jersey, New York and Connecticut. The New York region was just as the rest of the country heavily influenced by the railroad. In the more western parts of America towns were founded entirely because of the railroads. On the eastern seaboard this wasn't entirely the case. Generally towns and villages predated the railroads but their growth were heavily determined by the existence of a rail line. A good example is Summit, New Jersey. The town was initially just a few homesteads and was a village in the proximity of the much larger town of New Providence, New Jersey. When the Delaware Lackawanna and Western Railroad built its new main line it went through Summit. New Providence was only given railroad access via a branch line. This saw Summit rapidly outgrowing New Providence. [41]

The railroads determined the urban growth in the region and the old railroad networks still provide the basic pattern for the towns and cities today. The end of The Second World War led to an onset of private automobile ownership and highway construction was prioritized in the post-war economy. The long decline in rail traffic that followed has also had an impact in how the region developed. The new highways were much less dependent on favorable geographical conditions and could be built in hillier and more mountainous areas such as norther New Jersey and the Mid-Hudson region. Opening them to suburban development. The rail lines need to follow the flattest route possible and in the Hudson highlands that meant building the rail lines along the waters edge. That left relatively little room for development on the steep banks of the Hudson River.
Most of the riverfront land was utilized for industrial use and the homes were built on the slope rising up from the river. When highways where built they were constructed on top of the height plateau where most of the housing already existed and to easily connect to the new tall bridges being built over the Hudson river.

This shifted the regions urban dynamic from being centered around the narrow stretch of land along the river to a more sprawling typology on top of the height plateau. Then the down turn in manufacturing happened in the 70s and 80s much of the riverfront was abandoned and the former focal point of the urban structure became a backside.

41. Jerry Cheslow, A *Transit Hub With a Thriving Downtown*, 1997, New York: The New York Times,

Credit: George Inness 1855

A SLEEPING GIANT

The rail system in and around New York city was at is greatest extent one of the largest in the world. It had a fine mask structure reaching most parts of the region. The system was not built as a cohesive structure but as several different competing systems. All of the competing systems had their own main lines accessing New York City in different ways. This gave the city a quite large amount of high capacity rail lines approaching the city from many directions.

The way railroads enter and traverse a city can be divided in to three main types. The first is the through running scheme where a main line operates through the inner parts of the city, entering in one direction and exiting in the other. This type of scheme is often linked to a strong central government that has the will and power to requisite the central land needed to build a railroad inside of the city. Examples of this is Stockholm Central station and Amsterdam Centraal. The two other variants are the most common in cities that were large before the invention of trains. The use the terminus system were heavy intercity trains terminate at a terminal station on the outskirts of the old city center. Examples of this being Tokyo, London, Paris and Berlin. Terminal stations function as the interchange between long distance and short distance trains. In Tokyo and Berlin these terminal stations are inter-connected with a loop-line, connecting all terminal stations in the city. Making it much easier to transfer between long distance trains. London and Paris on the other hand lack a loop-line and require transfers to the subway system, making it much more complicated to transfer through that city for further travel. Terminal stations have an inherent lack in capacity due to how they operate. Trains having to exit the same direction they arrived needs a change in position of the driver and back in the days before bi-directional trains required the locomotive to be detached moved to the front of the train and reattached. All this while the train occupied a platform. Today the process is quicker but still require exiting trains to run on the same tracks they arrived on creating a situation where the train operates head on to traffic before being switched to the outgoing tracks. This creates a need for longer distances between incoming trains.

Operating through running trains allows for the same headway as on the line and requires much less dwell time in the station. Having the trains terminate at the outer points of the lines generally means that the traffic has been split in to different lines as the system spreads out. The trains can then occupy a platform at location

Credit: Transport for London

where the traffic is much less intense than in the central core of the network. Many cities are trying to rectify this lack of capacity by creating new through-stations like Tokyo station, Berlin Hauptbahnhof or Vienna Hauptbahnhof. Or to add trough-running platforms at terminal stations. Examples of this is Zürich Hauptbahnhof, Malmö Central in Sweden and most notably the Thameslink and Cross-rail Projects in London. Retrofitting terminal stations to through-station almost always require tunnels to be build under the central parts of the cities in complex and expensive projects. The cost is usually offset by a massive increase in capacity, convenience and possibility for regional growth.

New York has a combination of terminal stations and through-stations due to its past with many different rail operators. Manhattan being an island is not particularly well served by heavy and regional rail in comparison to other world cities. It has two stations serving mid-town and one station serving uptown. Pennsylvania Station is built as a through-station being accessed via tunnels under the Hudson and East Rivers providing direct access to New Jersey and Long Island where trains can continue via the bridges in the so called Hell Gate complex to the mainland and on towards New England. Although being build as a through-station, Pennsylvania Station mainly functions as a terminal station for the New Jersey Transit (NJT) and Long Island Railroad (LIRR) lines. It sees through going intercity from a few Amtrak services but mainly operates as a terminal station. Although meeting almost head-on in at the stations LIRR services and NJT services has never been consolidated in to through running services even though it being feasible.

Grand Central terminal is a true terminal station where all services terminate. Today the station only sees services from Metro-North Railroad. LIRR will see services to Grand Central scheduled to start in 2022 via the new "East side Access" tunnels in to a new low level concourse [42]. LIRR services will also terminate at Grand Central and there are not currently any plans to add through running capacity. New Jersey and Brooklyn also has two terminal stations respectively where transfers to subway and PATH trains are required to continue across the region.

The way railroad operations has evolved over time has meant that tracks and stations can be more efficiently utilized and less infrastructure is needed to run

42. Metropolitan Transportation Authority, *Capital Programs East Side Access* [website], http://web.mta.info/capital/comout_esa_alt.html (accessed 7 april 2019)

the same amount of services. The rail network around New York was built and dimensioned for the operation of steam trains. They needed so called "run-around" tracks and wye tracks to move the locomotive from the front to the back of the trains and to turn the locomotive around. Rail lines had very basic signaling and the lines required more tracks to operate a frequent service or allow for local and express services. Four and even six track lines were common. The right of way, including bridges, tunnels and viaducts are often dimensioned for more track than currently exist.

A good comparison is the Tokaido Shinkansen high speed rail line between Tokyo and Osaka. It only has two tracks and operate a high speed service with very long trains at very short headways and has a daily ridership of over 452,000 passengers.[43] This is only possible because of the advanced signaling systems and excellent safety protocol of the Japanese railways. The relative lack of technological advancements in the U.S rail sector has made operations much less efficient than in other comparable countries. That lack of efficiency has only been possible only due to the redundant capacity of the legacy system. What this means is that systems capacity can be drastically increased using existing technology readily available on the international market and that the existing infrastructure is able to carry much more trains if it was modernized. The redundancy left by the legacy systems also allows for reinstalling tracks and stations along its existing right of ways, making it relatively easy to develop the railroad further in the future and to add operational complexity such as express services and through running services.

Merging the different commuter rail systems would also add a much needed cross regional capacity and would also make it easier for the operators to pool their resources and make long term and strategic investments. By consolidating technical standards and jointly developing and procuring new technologies much money could be saved. Procurement of vehicles are today made separately for the different commuter networks and made to different requirements. This reduces the series of trains bought and increases the cost per unit when development cost has to be split on fewer vehicles. Developing services commonly for all networks would also remove complexity for the traveling public when ticketing systems and information systems are merged and accessed in a single place.

43. R. Matsumoto, D. Okuda, N. Fukasawa, *Method for Forecasting Fluctuation in Railway Passenger Demand for High-speed Rail Services*, 2018, Tokyo: Japan Science and Technology Agency

Credit: Metropolitan Transportation Authority

MODERNIZATION AND REACTIVATION

New York is currently experiencing a housing shortage and a lack of dwellings accessible for low and middle income groups. The city has a strong economy and many opportunities for work but the tough housing market makes it harder for workers to find centrally located housing which increases the commute times. A modern, convenient, comfortable and integrated regional transportations system would bring a much needed boost to the accessibility of affordable and attractive housing. It would also help to break the extremely centralized labor market and create secondary nodes outside of Manhattan.

New Yorks regional transport system has several large challenges that could be addressed by modernization and reinvestments in the rail system.

1. Long travel times
Travel times in the New York area are generally longer than in comparable cities. They lack through running services that makes for very long cross regional journeys with the need for several connections. The reasons for this is mainly connected to old track, old rolling stock, inadequate signaling and lack of cooperation between commuter network operators. The 100 km journey between Västerås and Stockholm in Sweden takes 57 minutes with four intermediate stops. The slightly shorter 91 km journey from Beacon to Grand Central Terminal on the Hudson line takes 94 minutes and only has one intermediate stop. The Hudson Line is in all aspects comparable to the Mälar line and is actually straighter then the Mälar Line. Investments in new tracks, trains, signaling and electrification could drastically reduce travel times in the region.

2. Different systems
The legacy of private railroad operators has left the commuter rail networks separated and is yet too be merged. Even though the Metropolitan Transportation Authority runs New Yorks subways, buses and commuter trains the systems still have different ticketing systems and does not offer full regional transportation passes. Travel to New Jersey is made more complicated by the state line dividing the region in two. A common transportation agency or a much more deepened cooperation and consolidation of tickets and ticket sales would be needed to bring true cross regional travel to the Metropolitan region of New York.

3. High costs
An old system is in much more need for maintenance to keep it running. Much money could be saved by making larger long term investments and consolidating the different networks procurements of vehicles and technology. Defining common technological characteristic of the rolling stock fleet would allow for procurement of large series driving down per unit costs and would stream line maintenance and spare part costs. It would also help to create a flexible fleet that can be utilized all over the network and assets could be moved to where they are needed most when needs shift.

Integration of the commuter rail networks and the MTAs subways and buses would also bring down cost for the traveling public by offering integrated tickets for cross regional travel. Most large metropolitan areas offer combined tickets that allow discounted or unlimited travel of all modes of transport. A trip from Beacon to JFK airport today means buying tickets for Metro-North, The New York subway (the LIRR) and the JFK air train resulting in a 30-40$. An equivalent fare in Paris integrated zoned system is 12$ and in Stockholms unzoned system only about 3.5$. These systems are more subsidized then their American counterpart but the price difference can point a finger to the benefits a consolidated ticket system would bring to the traveling public.

4. Uncomfortable
Regional trains in New York arguably have a lower travel comfort to trains in comparable cities and of journeys of the same length. Regional services of over 45 minutes of travel commonly feature tray tables, power sockets, wifi and some often some kind of snack service (usually a trolley or a vending machine). New York regional rail lacks all of these in the older rolling stock and supplies power sockets only in new and retrofitted units. Due to old tracks and heavier vehicles the ride is also often worse then in other trains.

Due to budget constraints and legislation there are not any plans for addressing any of these comfort issues in coming procurement either. The much hated 2+3 seat arrangement is being faced out in New Jersey transits fleet [44] but will stay in the foreseeable future on the other networks. This inherent lack of comfort is a combination of factors such as budgetary and capacity requirements but maybe also a lack off imagination and visions of the future. The railroads have been operating with such small budgets for such a long time that it might even have become hard to put forward visionary plans as the would be perceived as unrealistic. How comfortable

44. New Jersey Transit, Commuter rail fleet strategy 2014-2020, Page 26, 2014, Newark: New Jersey Transit

a commute is greatly effect how attractive regional commuting is as a whole. A comfortable seat with wifi, a socked and a tray gives the commuter the possibility to work from the train and to maybe be able to leave work earlier or arrive later since parts of the commutes becomes a part of the working day. Comfort also help commuters to relax and to not get worn out by long hours on the train. This thesis will not research all aspects of why cost are so high but it will bring attention to the gap between internationally procured vehicles and vehicles acquired for the American market.

The lack in comfort is hard to understand when comparing New Jersey Transits procurement of new Rail vehicles with the procurement of new regional trains in Sweden for Stockholm's regional network it becomes apparent that something is troublesome with the acquisition of new vehicles in New York. New Jersey Transits new vehicles that are being acquired have a per unit cost of 5.9 million dollars. [45] The will only feature USB chargers and lack, tray tables, power sockets, and possibly wifi. Mälartåg the Stockholm regional operator is buying their units at 3,25 million dollars per unit. [46] Mälartåg will receive a much more speced out train than the American for a much lower price. It will features all the above mentioned amenities and have a higher speed. If American trains could be bought at the same price and with same level of comfort as on the international market, then they could help to revolutionize regional transit and help to transfer funds back in to the maintenance of the rail lines. (See next page)

5. The lack of a secondary system

New York City has an extensive transportation network with subways, buses, commuter trains and ferries. New Jersey has some light rail lines and many bus routes heading in to the city. The rest of the New York region is predominantly car oriented and lacks a secondary transportation system other than commuter trains and intercity trains. The need for a private car to do everyday errands creates a hurdle for people to pay for another way of getting around. Having an alternative to driving in the local scale also incentivize people to use longer distance public transit. The need for people to drive to the trains also creates a need for parking that takes up valuable real estate close to the station where homes and services should be built.

45. William C. Vantuono, *For NJ Transit, another rolling stock innovation* [website], 2018, New York: Railway Age, https://www.railwayage.com/passenger/commuterregional/for-njt-another-rolling-stock-innovation/?fbclid=IwAR3XK8B0q2PrauDOyRMc2Cwgqj4XVW2lWu3rhEaTuEiRDslP3tf0E2SRJi0
46. Mälartrafik, *Upphandling Etapp 2* [in Swedish] [website], 2018, Stockholm: Mälartåg, https://malardalstrafik.se/upphandling-etapp-2


Credit: Metropolitan Transportation Authority

Existing Metro-North Express service rolling stock

New trains for NJT being introduced in 2022, bought for 5,9 million dollars per unit

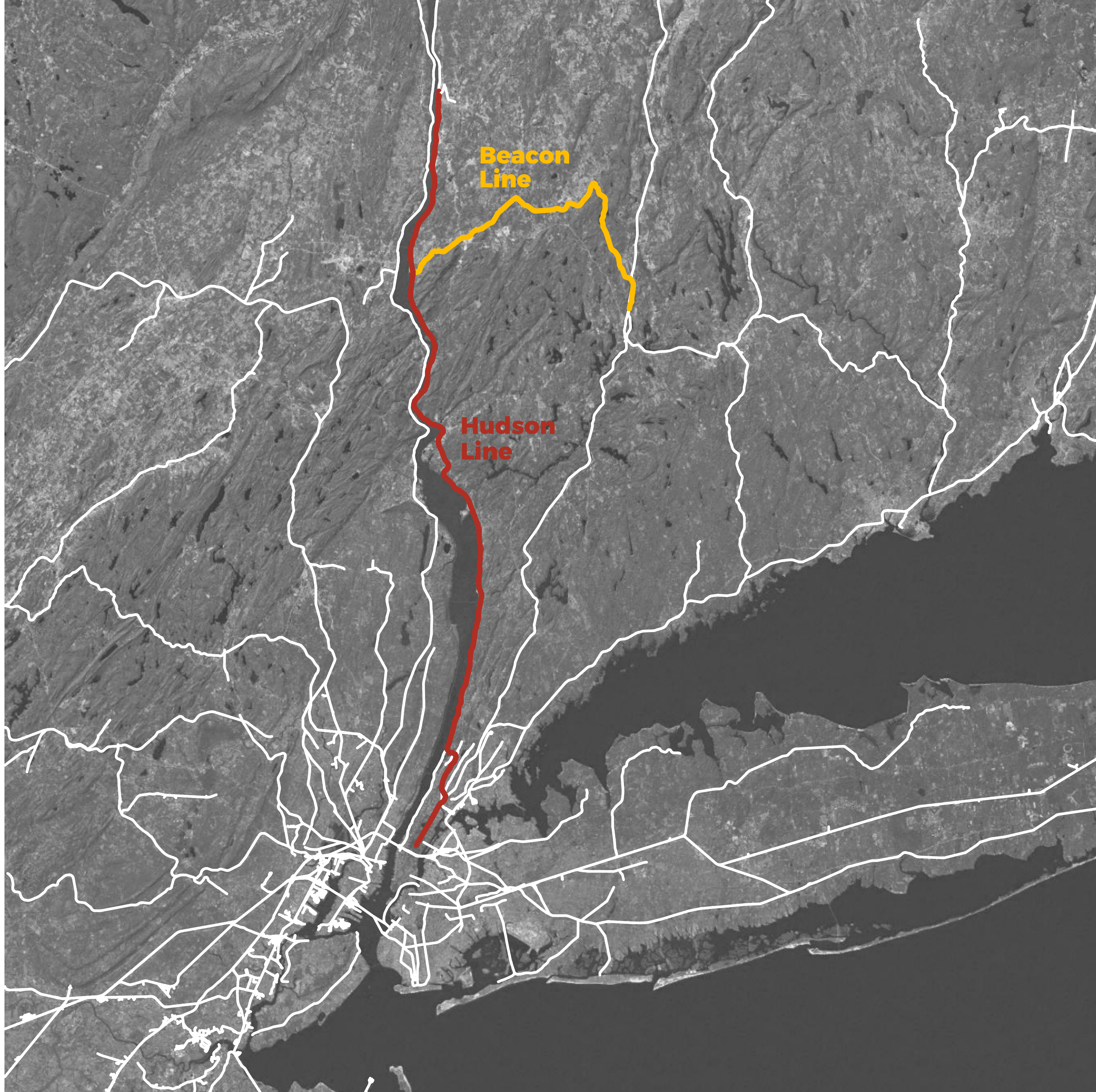
New regional trains for Mälartåg in Sweden introduced in 2019, bought for 3,25 million dollars per unit

TRANSPORTATION PROPOSALS

The main question of this thesis is what opportunities a change in transportation availability can bring to an area. The choice of the MTA Hudson Main Line and the MTA Beacon line are to serve as examples for two types of rail lines. Main lines and local/regional lines. These examples are intended to serve as inspiration and good examples to show the huge potential that lies in the existing network of railways. It also serves to show the effects of better transportation options. The effects mainly consist of regional growth that gives more people the possibility to access the very centralized urban labor markets.

The choice of lines are also intended to show the potential in urban development that increased regional connections allow for. By looking at both the secondary and primary systems a cohesive picture can be painted that shows the symbiotic relationship between high speed longer distance travel and local travel. It will show that getting people out of their cars is key to accessing land suitable for development. And that developing areas accessed by public transit creates positive synergies that helps to create more sustainable lifestyles in the local communities. The situations that are illustrated by this thesis is by no means specific to these communities are hopefully applicable to many regions where there are underutilized and disused rail lines. The research has its basis in European and specifically Swedish railroad practices. It will use examples of geometrically similar lines in Sweden. All of the Swedish lines connect less populated regions then the New York region and these findings will apply well to less populated areas in the U.S as well. The choice to compare with Swedish lines was made out of several reasons. Sweden has seen a similar situation of long times of deterioration of its railroads with a recent renaissance that started in the 90s. Sweden is also a good in-between option because of its financial limitations.

It sets the bar at a reasonable level and shows that great effect can be given with relatively limited investments. The New York region of course compares better to Tokyo, London or Paris but those regions has a much longer legacy of running regional rail networks and didn't see the same level of decline it its rail networks. Choosing an in-between approach aims to give the thesis more directly applicable results that fit better in to New Yorks current level of spending and would provide examples of realistic steps that could be taken towards reclaiming New Yorks place as one of the greatest transit oriented regions in the world.



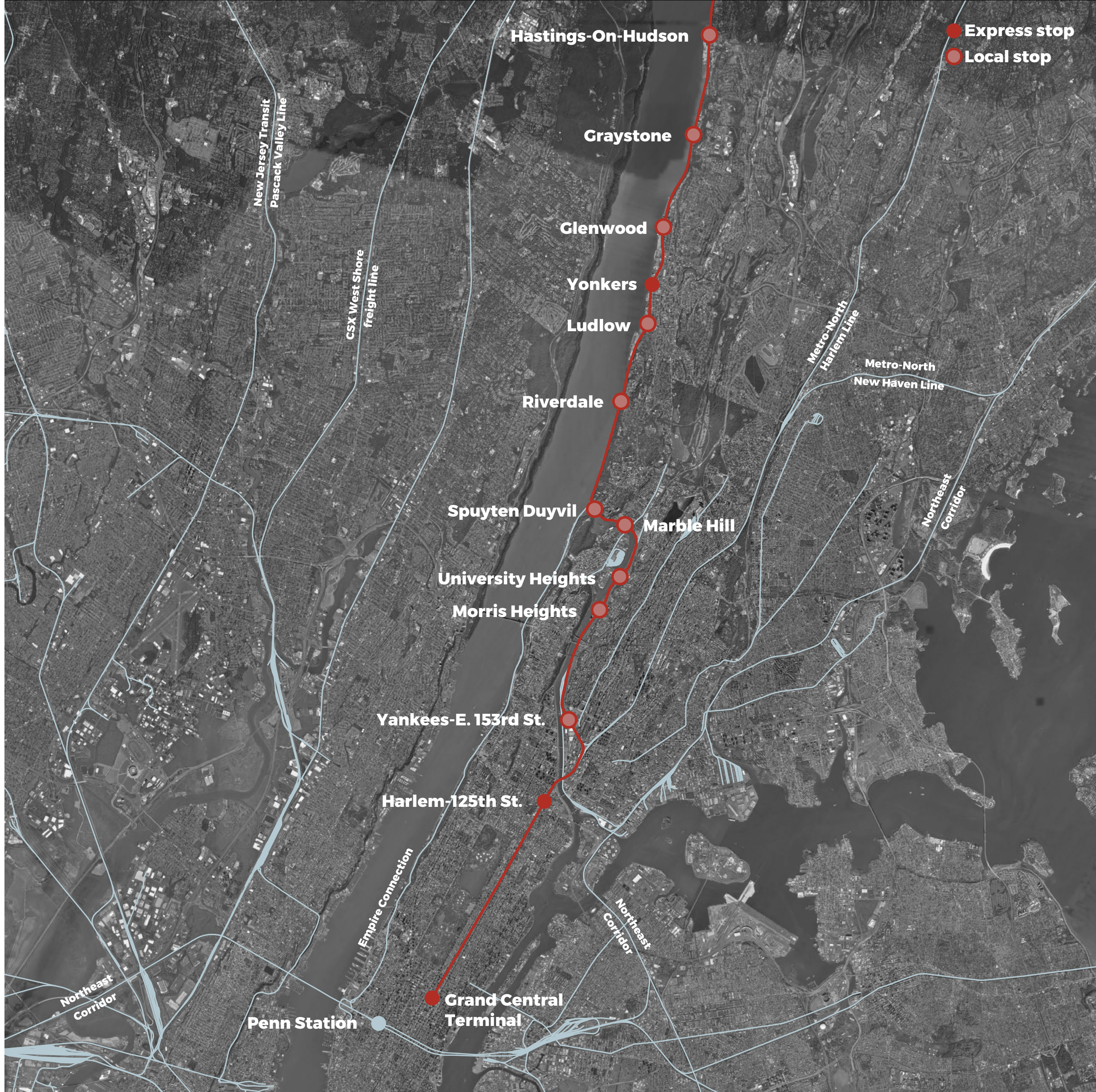
HUDSON LINE PROPOSAL

The Metro North Hudson line is the main rail artery north out of New York City. It runs MTA local services north along the Hudson river as far as Croton-Harmon (64 km) and MTA express services as far as Poughkeepsie 130km north of the city. It also sees Amtrak intercity trains towards Buffalo and Albany. The line currently have a low speed compared to what its track geometry should allow for, and the calculations made in this thesis (see Dormant Transit, Appendix A for calculations and comparisons) show that the running speed on the line could be greatly increased. A higher speed, greater acceleration, larger capacity and more efficient service configuration would allow the journey times on the line to be greatly reduced. Shorter journeys to the further reaches off the region would in turn help to develop these communities and create a more sustainable transportation system for the towns along the Hudson valley.

The line starts at the Grand Central Terminal (GST) in the eastern part of mid-town Manhattan and runs north below Park avenue to 97th street where it emerges out of the Grand Central tunnels and runs on an elevated four track viaduct to 135th street in Harlem were it turns east over the Harlem river. The Manhattan portion of the line is shared with MTA Harlem and New Haven Lines.

This part of the line is the main bottle neck in the system along with Grand Central Terminal, that doesn't feature through running services. 125th street Harlem station is the only other Metro-North stop on Manhattan and serves both local and express services.

The lines diverge in the South Bronx where the Harlem and New Haven lines head to the northeast and the Hudson line continues north along Harlem and later Hudson rivers. The part of the line running in the Bronx has 2-4 tracks and has a quite low standard and speed reducing both running times and capacity. The line has five local stops in the Bronx. These stations lack direct connection to the subway. Interchange is possible via a short walk at 125th street Harlem and Marble Hill stations. Between Marble Hill and Spuyten Duyvil the line runs in a narrow cut that only allow for two tracks. Having the line widened to four tracks in the Bronx would mean that express trains wouldn't have to slow down for slower stopping local trains and could run much faster along this portion of the line. It would still need to merge with the Harlem and new Haven lines at 135th street but could run faster for longer, reducing journey times for express services. The Harlem river joins the Hudson at Spuyten Duyvil. This is also the merging point between Amtrak's

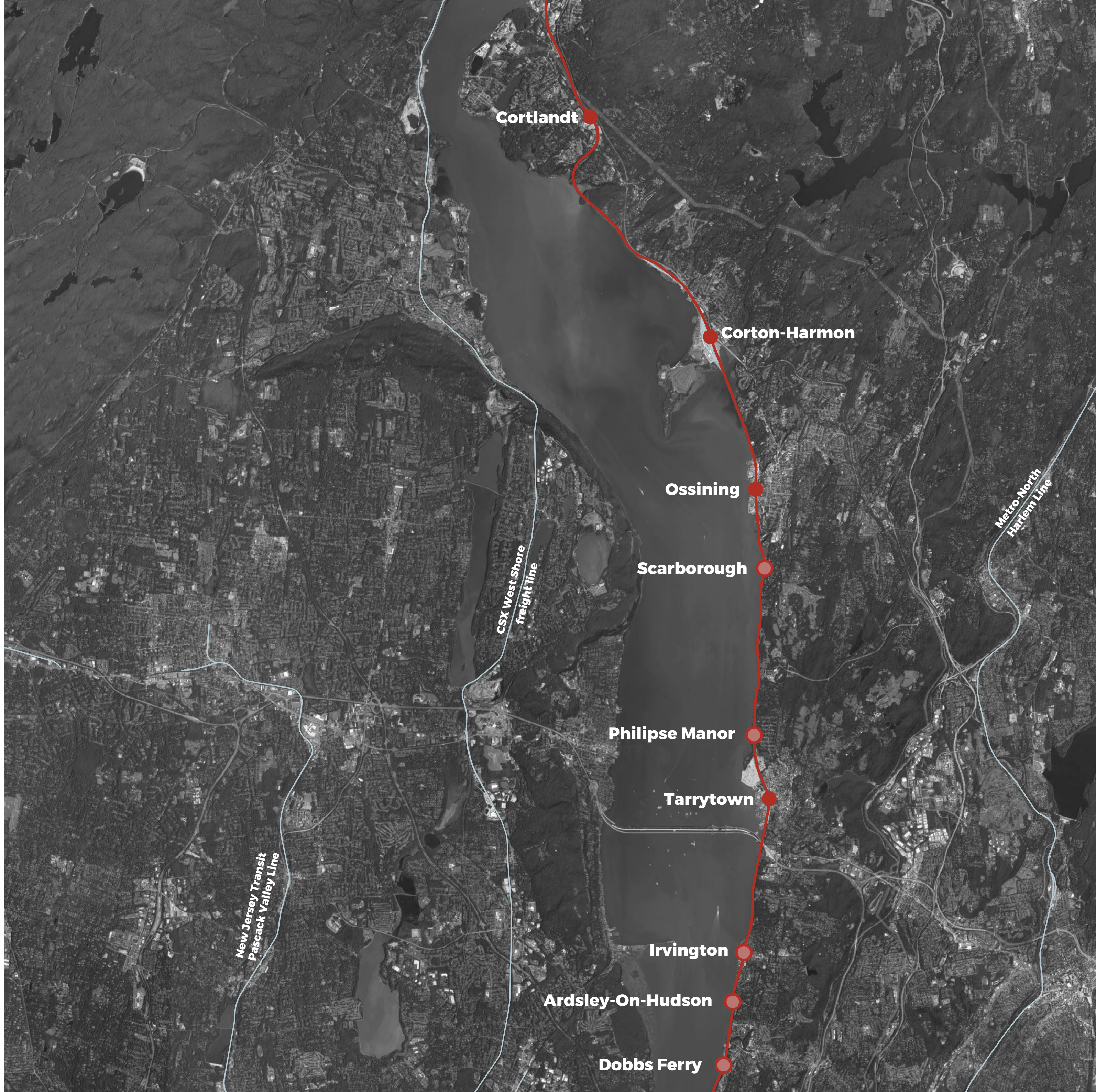


Empire Connection line that runs along Manhattans west side and provides access to Penn station and the through running North east corridor. The sharp bend at Spuyten Duyvil is the point where the relatively fast section of the line running along the shore of the Hudson river ends and slower Bronx and Manhattan sections starts.
This was the site of the tragic 2013 derailment that left four people dead and over 60 injured. The accident occurred because the train failed to slow down before the sharp curve. The conductor had fallen asleep with the accelerator at max setting. The train didn't have any on-board safety systems to stop and over-speed situation from occurring and the train derailed on the sharp curve. [47]

The rest of the line to Poughkeepsie follows the east shore of the Hudson river. It has twenty intermediate stations with local services terminating at Croton–Harmon. Connection to the Amtrak Intercity service is possible as Poughkeepsie, Croton–Harmon and Yonkers. The line from Spuyten Duyvil to Croton–Harmon has four tracks. Croton–Harmon to Peekskill has three and the section between Peekskill to Poughkeepsie is double tracked with the exception of a triple track portion at Beacon station. The rail embankment is usually wider than the existing tracks require, and has had more tracks in the past. The section between Spuyten Duyvil and Croton–Harmon has had as many as six tracks. Croton–Harmon to Poughkeepsie had 2-4 tracks with the section between Peekskill and Cold spring being the only real choke point due to its narrow and winding passage past the Bear Mountain State park.

The Line is entirely grade separated meaning that there are no level crossings, raising safety on the line considerably. The maximum speed operated on the line is 128km/h (80mph) [48] which is considerably lower then the 180-250km/h that is standard for inter-city main lines internationally. The reasons for the low speeds are the relatively poor condition of the rails, the lack of signaling safety systems and the lack of high voltage electrification. The line is electrified from GST to Croton–Harmon using a 700V DC third rail system. North of Croton–Harmon the line lacks electrification and the services are run using diesel locomotives. The line also lacks passive train control.

47. National Transportation Safety Board, *Railroad Accident Brief: Metro-North Derailment* [website], 2014, Washington DC, National Transportation Safety Board, https://www.ntsb.gov/investigations/AccidentReports/Reports/RAB1412.pdf
48. National Transportation Safety Board, *Bulletin Order* [website], 2014, Washington DC, National Transportation Safety Board, https://dms.ntsb.gov/public/58000-58499/58036/583678.pdf



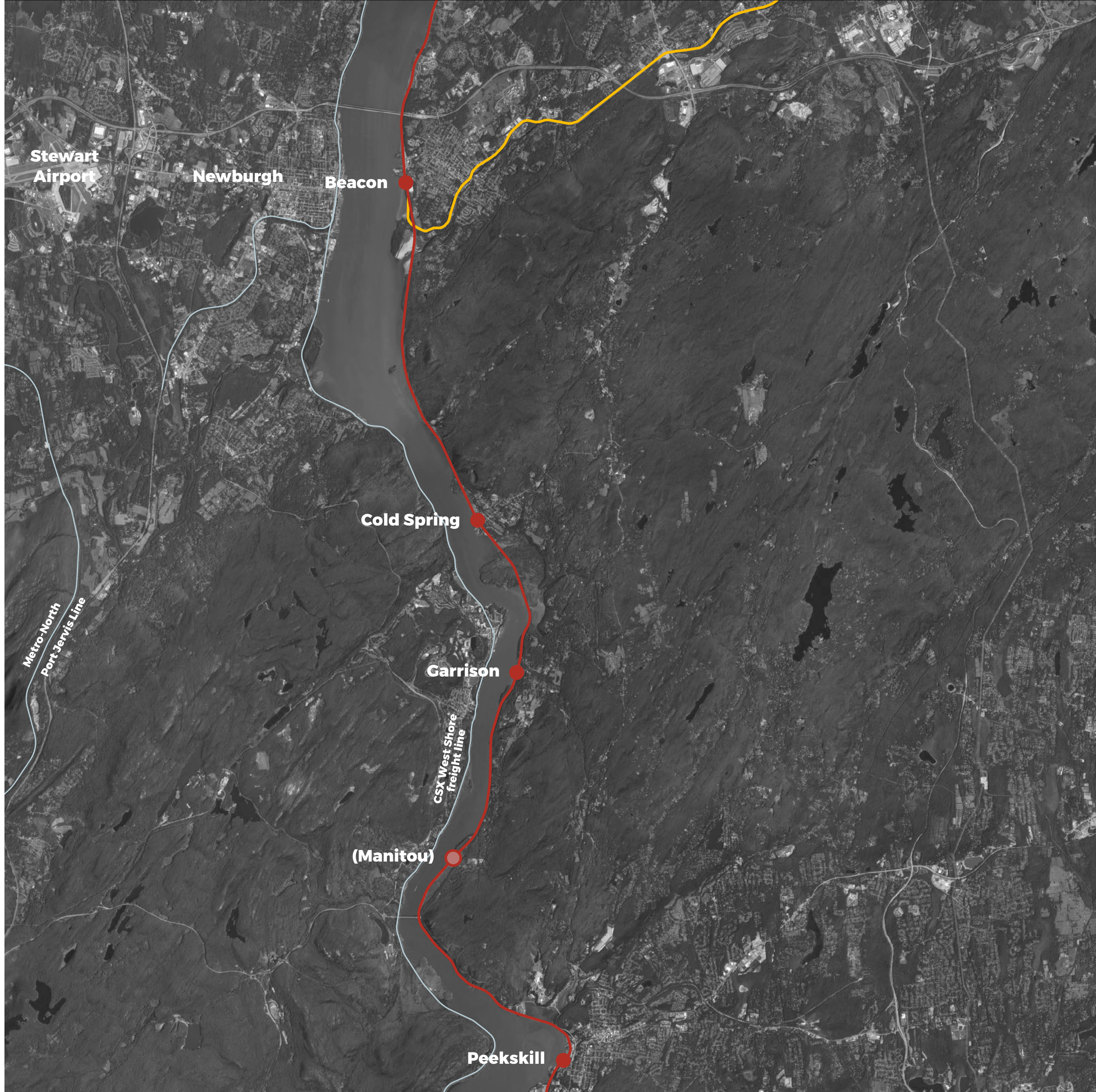
Proposed changes to the line

Disclaimer
The proposed changes in this thesis serve to highlight issues and compare results between different similar railway systems. The findings aim to show what possibilities should be possible given the conditions of this rail line. The research is done in a structured way and use figures and data accessed in articles and official instructions. The results of this research will be approximates and in some cases based on assumptions when proper in-depth research couldn't be done in a subject outside this thesis area of expertise. This is an Urban design thesis and it wont answer all technical aspects associated with modernizing or reactivating rail lines. The result should however provide a good indicator as to what is possible and what effects this has on urban development.

Electrification
The current 700V DC third rail electrification system only covers the southern part of the line that is operated by local trains. The third rail system was selected in 1908 due to it being a more mature technology compared to an overhead system. Third rail systems have several important limitations when it comes to main line railroads. A third rail system can only operate DC current at lower voltages due to its proximity to the ground and the risk of electrical arcing. They also lack the output to power a heavy train at high speeds or to power heavy electrical equipment like air conditioners. The 700V DC current of the existing system need many more electrical sub-stations because of its poorer transfer capability compared to the overhead 25kV AC used on the Northeast corridor.

Overhead wires need a higher free space above the train which increases the dimensions needed in tunnels. This adds cost in new construction but since the existing line has very few tunnels this should not be a significant factor. Third rail could be kept in the tunnels at GST if it was deemed too expensive to change the system or if the height of the tunnels are insufficient. It is common on modern Electrical Multiple Unit trains (EMU) to be fitted with dual or multiple electrification systems. This is already fitted to Metro-North operating on the New Haven branch that use both 700V DC and 25kV AC.

Overpasses might need to be augmented to fit overhead wires, usually this can be avoided by lowering the trackbed instead of raising existing bridges. By installing an overhead 25kV AC system on the entirety of the line all the way to Poughkeepsie many positive effects could be achieved:



- **Faster speeds** by using electrical multiple unit trains
- **Lower maintenance costs** by reducing the number of sub-stations and separating track and electrification systems.
- **Easier maintenance** by being able to use less labor intensive mechanized maintenance routines.
- **Conforming to new standards**

By adapting too the standard main line electrification further through running and inter operation can be developed.

Signaling system

By introducing an advanced signaling system like the European Rail Traffic Management System (ERTMS) operations could be significantly upgraded on the existing infrastructure. Headways could be reduced which greatly would increase capacity. Safety would also be increased substantially and accidents like the 2013 Spuyten Duyvil derailment would be almost impossible to happen again.

New signaling would also reduce costs. A fully equipped line would allow for lighter high speed rolling stock to be used because of its FRA Their III compliance. [49] This reduces wear on the rails. So called in-cab signaling would eliminate the need for track side signals which reduced maintenance further.

Track change

The elimination of the third rail system and track side signals would allow for a much better management and track change routine. By not having the electrification systems connected to the track or the extensive ductwork needed for electricity and signal wires, much of the clutter and complexity in the track infrastructure could be removed.

This would allow for much easier change of tracks using track laying machines. They can lay new continuously welded rails with heavier concrete ties while at the same time align and rebalasting the tracks. Doing so would give the Hudson line the standard of a newly built rail line allowing for much greater speeds and a much more comfortable ride. The heavier concrete rail ties (that cant be used with third rail) would reduce the movement of the rails reducing the need for regular realignment.

Noise reduction

The existing rail line is extremely noisy. It operates heavy diesel equipment over rundown infrastructure creating very high noise levels. Regulations also stipulate that trains need to sound the horn when they are approaching stations. A new Their III compliant rail line should be able to be exempt from having to sound the

49. Robert C. Lauby, *FRA & The Next Generation of High Speed Rail Equipment*, 2017, Washington DC: U.S. Department of Transportation, Federal Railroad Administration.

Credit: Network Rail

extremely loud horn by installing audible warnings of approaching trains at the stations as is common practice in many other places. Similar exemptions has been given to the Brightline in Florida.

EMU trains are much quieter than diesel trains, even when operated at much higher speeds. Most of the sound is emitted from the wheels and the under mounted electric engines. Diesel engines often emit sounds from high mounted exhausts, this in combination with rattling makes traditional diesel operated trains much harder to noise mitigate against. Installation of low noise reducing walls would be made much easier by the elimination of track side equipment. Low walls placed close to the tracks utilize a phenomenon called "chamber dampening" that traps noise under the train and reduces it very efficiently.

Results

The resulting rail line would be able to operate trains at up to 220km/h (see Dormant Transit, Appendix A for calculations and comparisons). It would also allow for much faster accelerations. This would provide journey time reductions of 30-40%.
It would also reduce long term costs by reducing the need for maintenance. The line would also become more comfortable to ride, safer and less of a nuisance to its surroundings. The transportation capacity along the line would also be greatly increased.

Journey time examples:
Beacon station - Grand Central Terminal

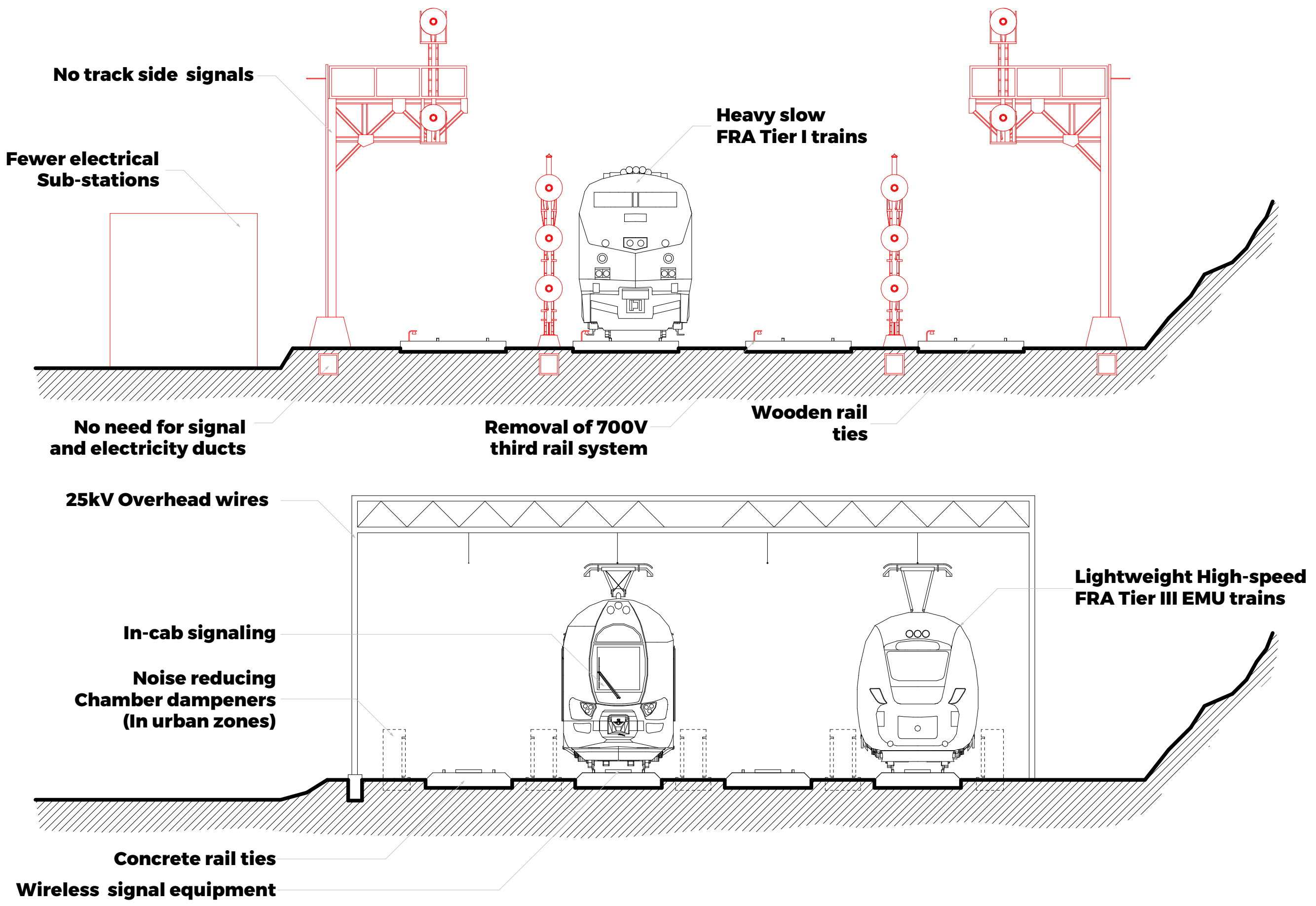
Legacy Tier I Diesel Train

Express service (1 Stop)	1h 14 min
Limited-Express (7 Stops)	1h 24 min

Tier III EMU Regional Train

Express service (1 Stop)	44 min
Limited-Express (7 Stops)	52 min

With journey times of well under one hour, towns like Beacon and Cold Spring would be put within a very comfortable commute from mid-town Manhattan. Journey times would not be much longer then traveling from South Brooklyn to Mid-town on the subway. Commuters already use the existing service extensively and an increase in comfort and a shorter journey would very likely attract many more riders to the line. This would ease road congestion, reduce CO2 emissions and help people to access a larger labor market. It would also help too alleviate New Yorks housing shortage by putting town like Newburgh within a reasonable commute from the city.



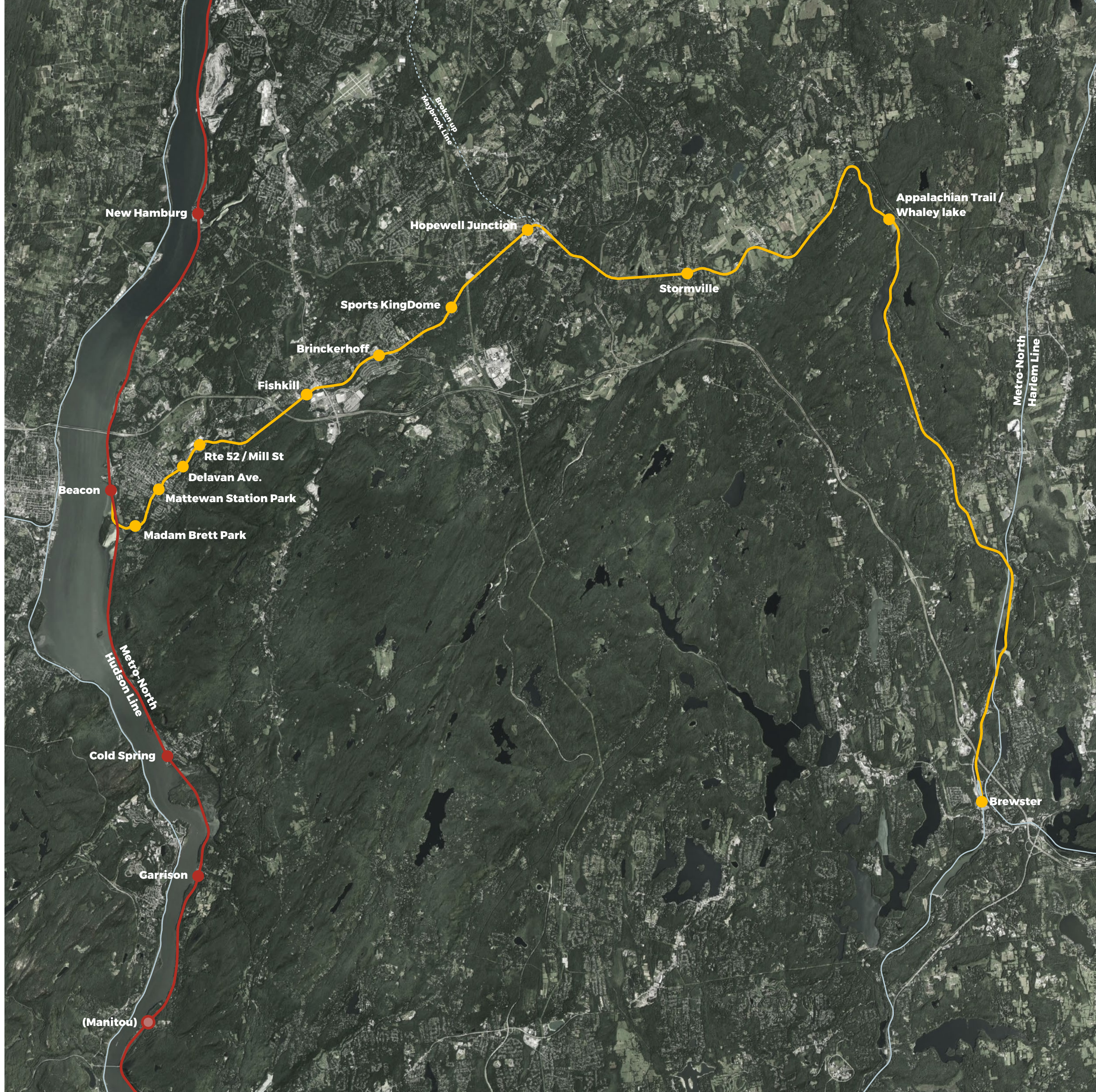
BEACON LINE PROPOSAL

The Beacon line is a rail line that runs through Dutchess county, New York and Fairfield County, Connecticut. The line is currently not used but is maintained to a minimum standard to allow MTA to move equipment between its Hudson, Harlem and New Haven lines. This thesis proposes an activation of either the whole line or the western part of the line.

The line is made up of two old railroads. The section between Brewster and Hopewell Junction was the New York, New Haven and Hartford Railroads (NH) Maybrook line which used to be a double track main line between New Haven and Maybrook. The line originally ran beyond Hopewell Junction and crossed the Hudson river at Poughkeepsie. The line north of Hopewell junction has been broken up and is now used as a hiking trail. The remaining part is still in place but has been converted to single track. The track embankments and bridges are still dimensioned for two tracks.

The line west of Hopewell Junction was the single track Beacon Secondary Track also called the Beacon branch. It provided a connection between the NHs system and New York centrals Hudson line. It served as a link between the NYCs water level route and the NHs line that runs on the highland plateau and across the high bridges over the Hudson river. This line runs in more densely populated areas and connects towns along the line while the Maybrook line mostly runs in mountainous rural areas. Today the entire line is single tracked with almost no passing loops. Major roads and highways are grade separated with the exception of Route 9 in Fishkill. Some smaller roads are grade separated but there are many road-crossings at grade along the line. The line doesn't have any tunnels but has about 15-20 bridges none of them very long.

The line is strategically located in the region and several studies have been made into reactivating the line. The previous studies have all taken a limited scope looking into reactivation of the westernmost part of the line. The service level imagined has been as a heritage trolley line or running second hand diesel multiple units (DMU) over the line. Running trains west of Fishkill avoids the main hurdle of the line, a necessary grade separation over Route 9 just east of the town of Fishkill. Operating a small scale service over this portion of the line would serve mainly as a tourist route but have some local benefits such as offering travel from eastern Beacon to Beacon main station. It would also help to alleviate some of the need for parking at Beacon station. This thesis will propose a service



Beacon station

Madam Brett Park Along Tiaronda Ave

Old Mattewan station building seen from Churhill st crossing

Old Mattewan station from main street

Madam Brett Park Fishkill creek

Approaching Mattewan station from Churchill st crossing

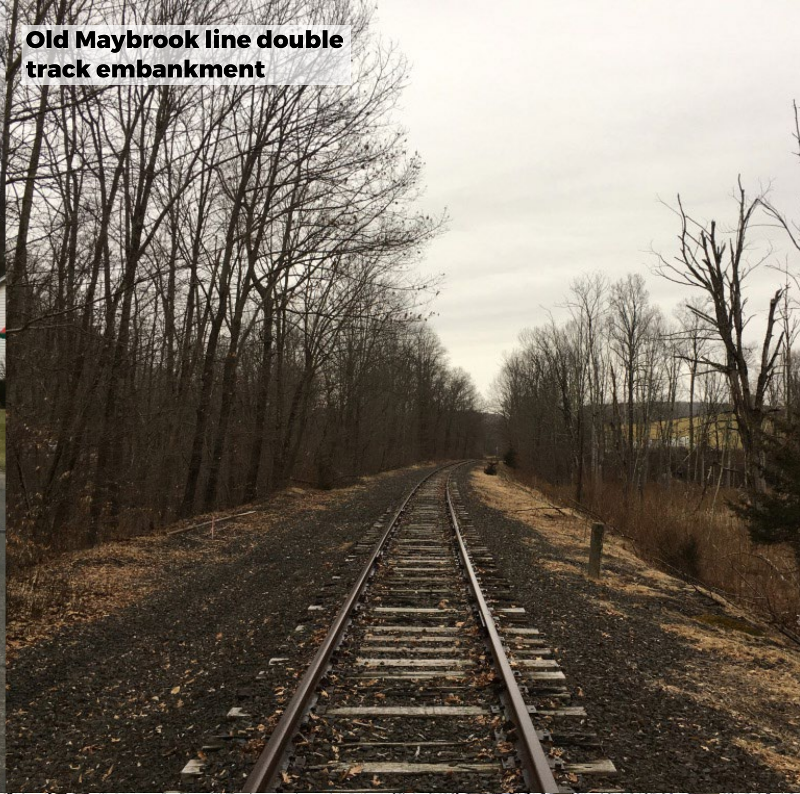
Old hatt factory converted to houding, shops and cafés in close proximity to the rail line

East Main street crossing next to the Round house

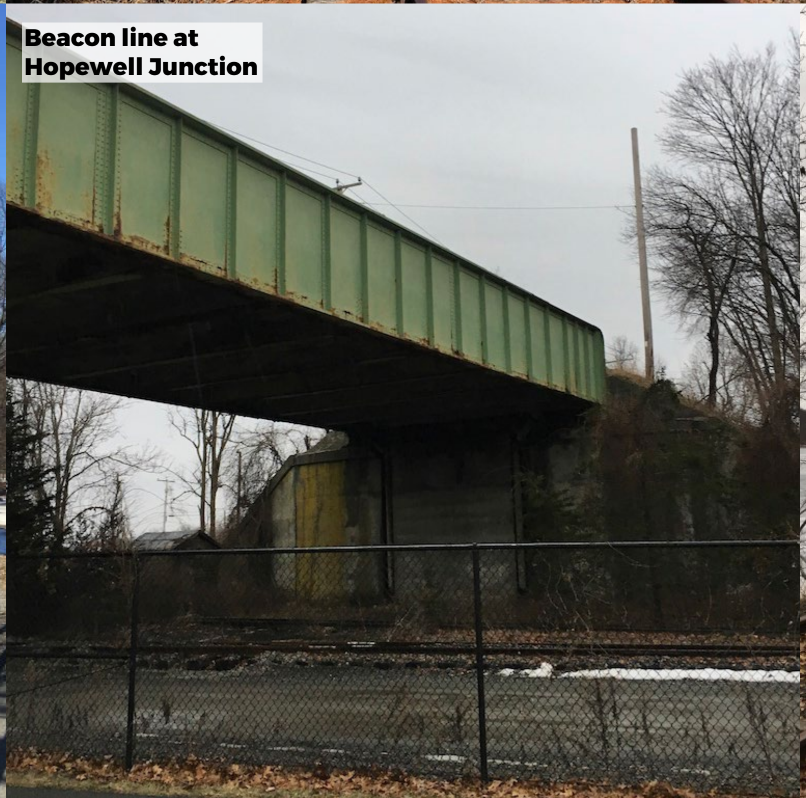

Route 52 / Mill St leaving Beacon

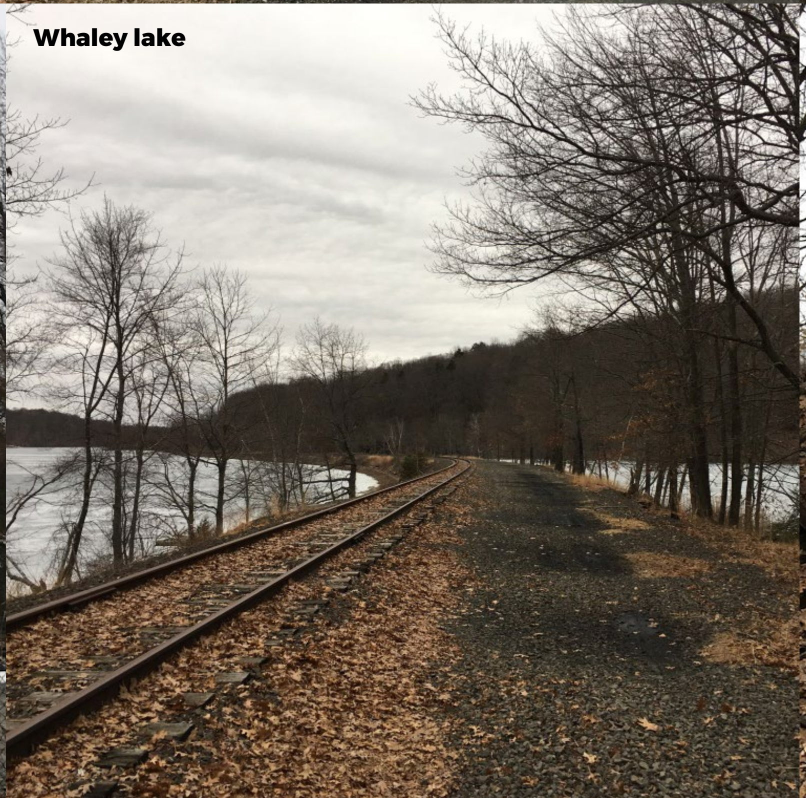

Fishkill approaching route 9


Stormville
Old route 52 crossing


Old Maybrook line double track embankment


Rebuilt station house at Hopewell Junction


Beacon line at Hopewell Junction


Whaley lake


Appalachian trail crossing the rail line

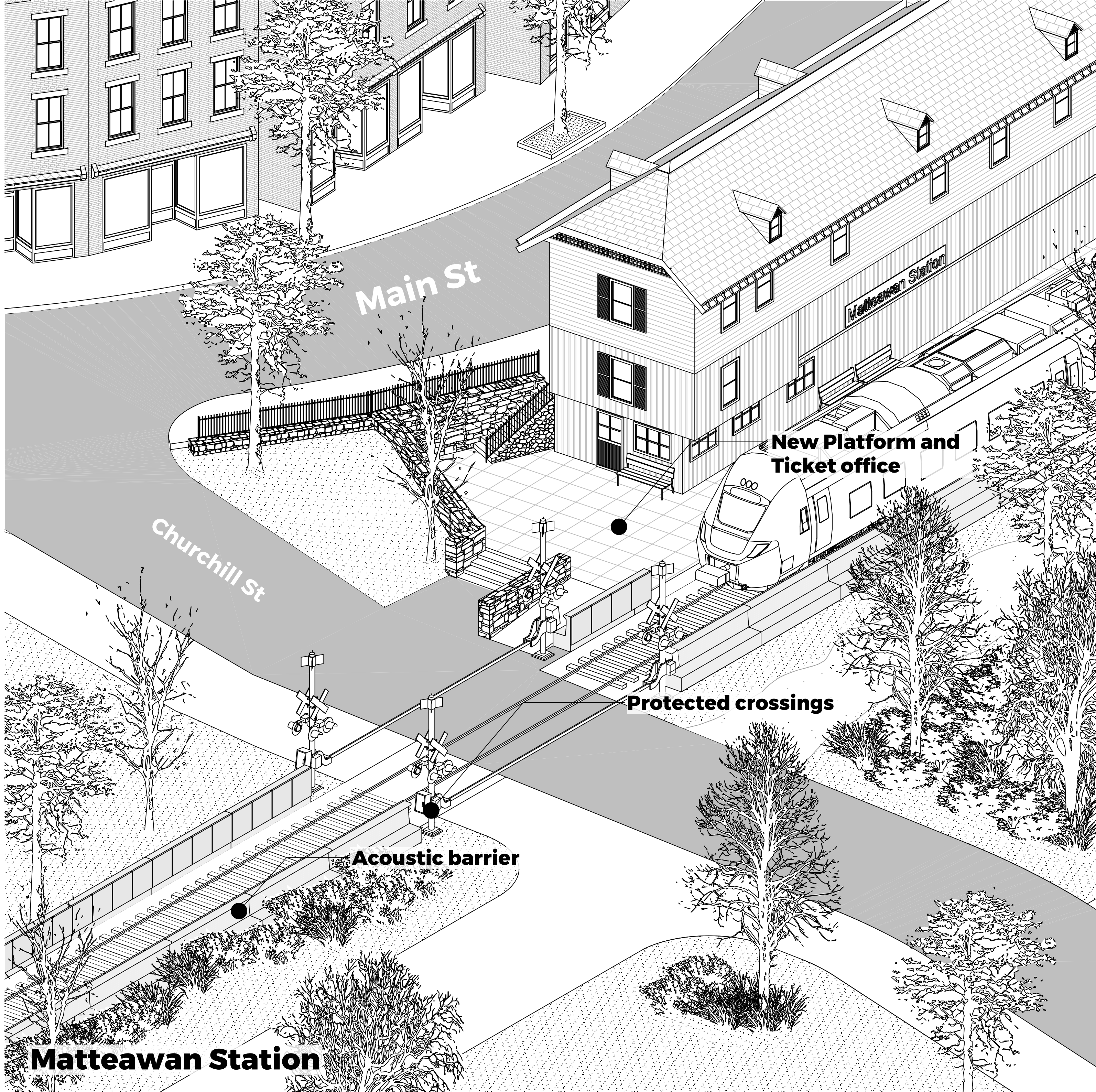
that is intended to provide both regional and local services over the Beacon line. It will also examine several levels of regional ambitions aiming to provide a new route east/west through the Mid-Hudson region.

The line has a mainly rural alignment, running through wooded and mountainous areas. In its western part between Beacon station and Fishkill the line runs along the north bank of the Fishkill Creek. This part is very scenic but also offers a complex situation. The line passes the eastern parts of the city of Beacon and runs in the town itself. It passes just south of main street in an area that used to be industrial but has recently been developed with new housing, hotels, cafés and restaurants. It crosses Churchill Street and East Main Street in level crossings.

Reopening the line would reintroduce a barrier in the town that many had forgotten existed. These crossings would need to be well protected and fencing would need to be installed to stop people from crossing the tracks illegally. This would create a major hazard if not carried out properly. Noise levels would be increased mainly through ground vibrations but also from the trains them selfs. Chamber dampening acoustic barriers would need to be installed and maybe some kind of vibration mitigating solutions in the track bed. This section is only about 400m long but offers the second most difficult situation to handle. The line passes towns at several points but never in place as urban as in Beacon. And there are very few points were the line crosses city streets. The line could be brought up to a standard similar too many local/regional railways in Europe.

A good comparison is the Blekinge Coast line in the south of Sweden connecting Karlskrona to the southern main line at Hässleholm. The line was initially constructed as a narrow gauge private railway but was later nationalised and widened to standard gauge. The lines history is a very good comparison as it saw very low usage during the narrow gauge period and there were several plans for breaking up the rail line. When it was eventually widened, freight traffic picked up significantly. The line was electrified between 2005 and 2007 and was brought up to the same standard as the rest of the national rail system.

After its electrification the line could offer direct services from Karlskrona to Malmö and on across the Öresund Bridge on to Copenhagen. This provides the quite isolated communities of about 90,000 people with a single seat direct connection to the local economic centers of Malmö and Lund as well as Copenhagen international airport and Copenhagen Main Station. The ridership increased dramatically from about 200,000 in 1995 to



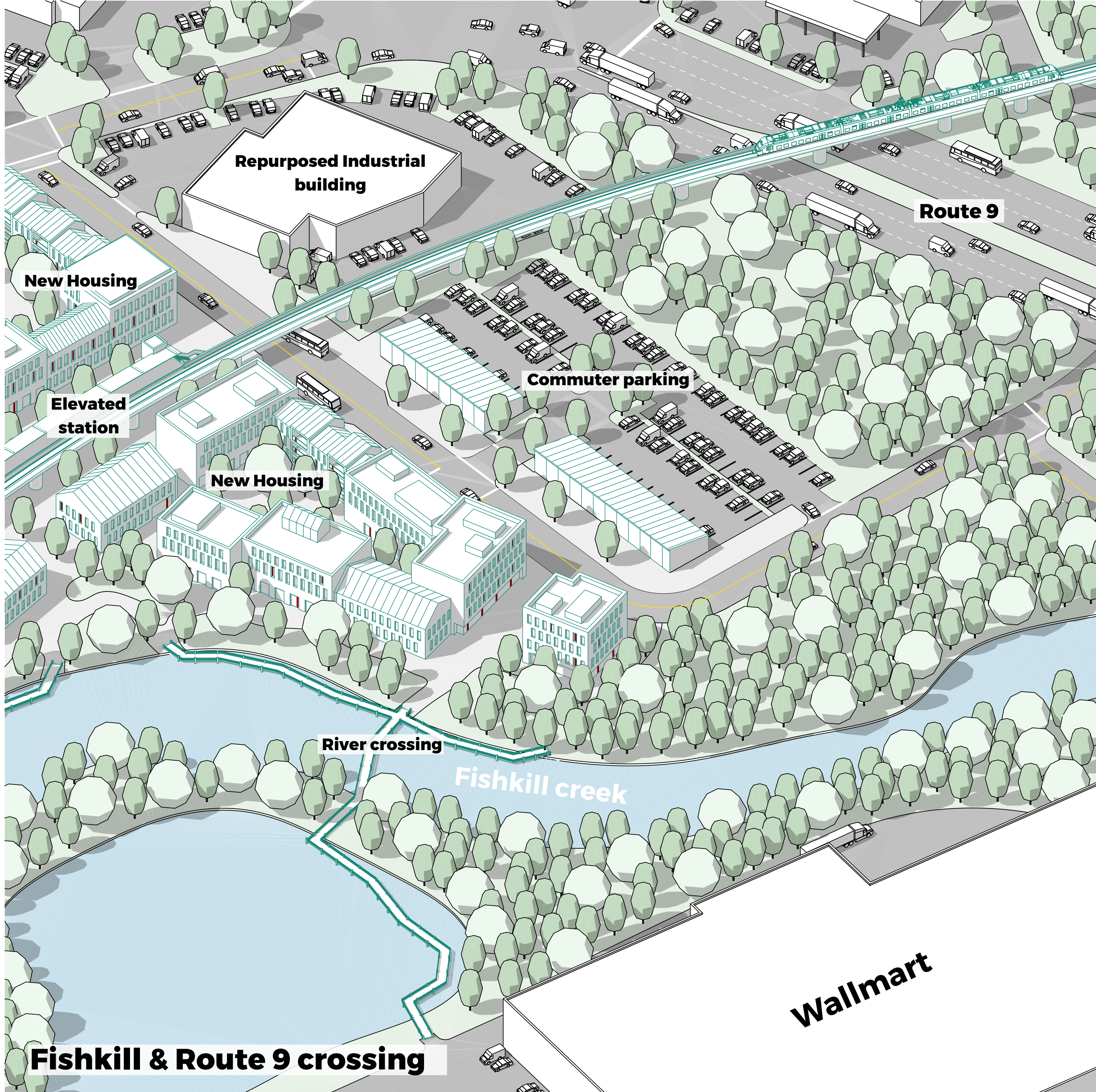
over 2 million yearly riders in 2016. [50] It is highly telling that bringing a rail line up to the same technical standard as the rest of its surrounding network helps to bring its utilisation up and to increase its ridership significantly.
Bringing the Hudson and Beacon lines up to the same technical standard as the Northeast Corridor would most likely have a very large effect on ridership. Offering easy connections to New York City or even single seat rides across the region would have great effects for peoples commuting opportunities and would open up for a much greater job market for Mid-Hudson communities.

The line could be operated at 160km/h in straight rural sections but generally at slower speeds. Journey times would be about 22 minutes from Beacon station to Hopewell Junction with seven intermediate stops and about 45-50 mins from Beacon to Brewster. This would provide a journey time slightly faster then driving on the highway, but would not be effected by road congestion. By having most of the parking at Beacon station dispersed along the line, total journey times can be shortened further when people can either avoid driving all together or more easily find parking at their local train station. The total journey time between Grand Central Terminal and Hopewell junction would be one hour and eleven minutes, including a five minute transfer at Beacon Station. That is almost 15 minutes shorter than the existing 1h 24 min limited express service from GST to Beacon Station.

Reactivation of the line could be done in several ways:

Minimal standard
The line could be brought up to a minimal standard and some kind of non-electrified vehicle could be procured to operate an hourly service as far as Fishkill. This would be possible without major track works and could be done without having to construct passing loops or install complex signaling when only a single vehicle operates over the line. This option would allow for a service to run over the line but it would likely have a limited impact on peoples travel habits. It would have to operate at a much lower speed than otherwise possible due to the condition of the track and the lack of safety installations at crossings. The service would not be competitive in journey times compared with the highway, but would be a convenient option for commuters that could avoid having to

50. Region Blekinge, *Länstransportplan för Blekinge* [in Swedish], 2018, Karlskrona, Region Blekinge, https://regionblekinge.se/download/18.1d469c2d16662db3e431104c/1545298893890/Region_Blekinge_lanstransportplan_2018-2029.pdf



Fishkill & Route 9 crossing

drive to Beacon Station. It is also likely that the service would be a popular tourist attraction with its scenic route along the Fishkill Creek. A few vehicles would have to be purchased to operate the service and a service depot would have to be constructed on a siding, most likely in the wooded areas close to Glenham where there is accessible land close to the tracks. The vehicles could be of any non-electrified type. A multiple unit type of train with drivers cabs at both ends would be necessary and traction could be provided by either diesel, fuel cells or battery packs. Diesel is generally much noisier and would create a nuisance for people living across the line. Fuel cells is good solution but is a very new technology for the railway sector and would probably be significantly more expensive and there are no second hand vehicles available for purchase. Buying a very modern technology on very limited numbers is likely to be quite expensive. The same goes for battery powered trains, they are relatively new for the railway sector and they wouldn't be available as second hand vehicles. They could work very well in combination with an electrified Hudson line where they could charge their batteries while dwelling at the station. Given the short distance to Fishkill even a short stop at Beacon would be sufficient to charge the batteries for a return trip.

Upgraded Line, Non-electrified

To get maximum capacity out of a single track line, passing loops and signaling needs to be installed. This is to allow for trains to operate in both directions on the line and to enable more trains to operate on the line. An un-upgraded line with no passing loops could operate an hourly service as far as Fishkill and could match the service pattern of the Hudson line. This would leave no room for adding additional capacity either over the Beacon line or if there would be an increase in services over the Hudson line.

To be able to run more trains over the line passing loops need to be added. The amount and placement of passing loops dictate the number of trains that is possible to run. It also dictates how susceptible the line is too delays due to trains having to wait for long periods of time at sidings when they can't proceed if an oncoming train is running late, resulting in long lingering delays. Parts of the line running along the Fishkill Creek or in the town of Beacon are very narrow and doesn't allow for adding passing loops. This stretch of track takes about 10-13 minutes to clear and can be seen to be the main limiting factor of the lines theoretical capacity. By adding passing loops it should be possible to run a service every 15 mins in each direction (8 trains an hour). Passing loops should preferably be placed at stations to combine dwell times with time for boarding and disembarking.

While the addition of passing loops is being done a complete relay of tracks should be done along the line. This might seem like a drastic and expensive measure but relaying of tracks are done by mechanical tracklayer and is generally carried out as a maintenance measure once every 15-20 years. The Beacon line is long overdue. A relay, and reballast of the line could be done very efficiently due to its very limited complexity. The line would be relayed with concrete rail ties and continuously welded track. This would bring the standard up the the one of a brand new railroad.
Trains could operate at much higher speeds, the ride would be much more comfortable and it would bring down maintenance cost for both line and vehicles. A relay of the rail line is the only way of getting competitive journey times compared to driving. It would also bring down noise along the line.

Installing signaling is necessary to enable more than one train to operate along the line and to control level crossings. Passive control systems is needed if the line should be operated at speeds of up to 160km/h and is necessary to avoid head-on collisions. Several smaller bridges need to be reconstructed to allow for higher speeds but this could likely be done off site and a crane could simply replace the bridge spann. A longer viaduct will need to be constructed in Fishkill to create a grade separated crossing over Route 9. It will need to be a minimum of 550m long to provide sufficient clearance over the highway and to have an acceptable incline. If it would be made about 700m long an unobstructed access between Fishkill and the Fishkill Creek could be created and the lands south of the rail line could be repurposed as mixed use or housing thus extending central Fishkill southward and giving it direct creek side access. The town could be linked across the creek to the shopping area along I-84.

Just like for the earlier option several types of multiple unit trains could be used. Battery and fuel cell trains could be used efficiently but would likely be expensive. Diesel trains could be a viable option but are much noisier. Not having electrical traction would give the trains poorer acceleration characteristics and would create longer journey times. Interoperation on to the Hudson Line would not be impossible but would require Bi-Mode train sets (given that the hudson line is electrified). These are relatively common but adds operational and maintenance complexity.

Upgraded Line, Electrified

Upgrading an electrifying the Beacon Line would give it the standard of any new main or regional railroad. This would allow for the line to be used by the same rolling stock as the rest of the network. Having commonality of both technical standards and rolling stock would give the line great benefits. It could be operated at higher speeds, with shorter journeys as a result. It could without adding operational complexity, operate over the Hudson line in to NYC and possibly even through the region, integrating the Beacon line in to the regional network instead of treating it as a separate entity. The possibility of creating very convenient and quick journeys into New York City should not be under-appreciated. Offering simple connections at Beacon Station of even through running trains in to NYC would create a backbone of commuters that would make the line economically viable. With a frequent enough services the line would also become a competitive option to driving and it is likely that people would use the line to get around in their local area too. It would help younger people that can't drive, too in a more independent way visit friends or go to activities. It would help senior citizens to access shopping, and services given that the line would be entirely ADA (Americans with Disabilities Act) compliant.

Being able to use the same rolling stock as a main line train would be very beneficial when it comes to procurement and maintenance. In Sweden its common for transportation authorities to scope their rolling stock requirements jointly and to procure common series of trains in different variations via a jointly owned leasing company. A good example of this is the X60 series of trains that was bought primarily for the Stockholm commuter rail network. The initial order was for 71 six car trains but with an option for many more. By agreeing on a common technical standard before hand, six different transportation authorities across Sweden could procure trains at a much lower per unit cost than otherwise would have been possible. The order has to date provided the authorities with 290 trains in 3-6 car configurations for several different authorities. In central Sweden an order for just two train sets was placed and they could access very modern EMU trains for a fraction of the cost of buying two trains separately. Pooling resources in this way is only possible due to Sweden's uniform technical standard of its rail lines.

Six-car X60 units operating in a two unit formation for the Stockholm Commuter rail network

four-car X61 unit operating on a rural line for Skånetrafiken in the south of Sweden

Credit: Jarnväg.net

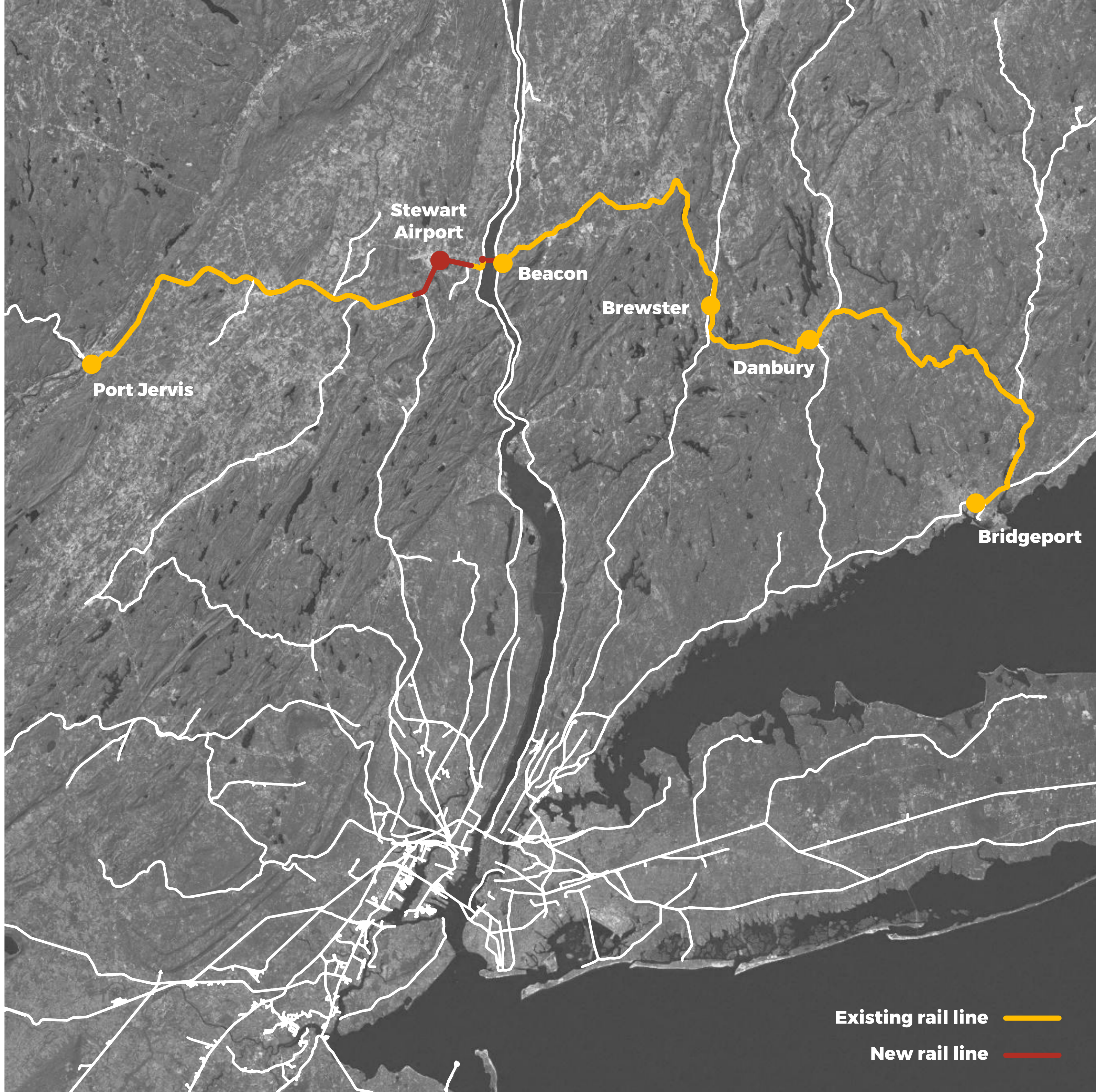
STRATEGIC REGIONAL OPPORTUNITIES

Rail lines crossing the Hudson river have through the regions history been a highly sought after commodity. It has been extremely difficult to create an east/west connection. The only heavy rail connection crossing the Hudson river in southern New York state is the Penn station tunnels. The only other crossing is just south of Albany 190km north of New York city. Before the railroads decline car floats were operated over the Hudson river at several points. The Hudson river is a very important trade route with its access to the American inland via the Erie Canal. Bridges where hard to built over the river because it would limit the hight of ships sailing up the river. Only very high bridges were built. The high bridge at Poughkeepsie linked the Mid-Hudson river in an east/west axis via the Maybrook line. The Beacon line linked the high level rail lines with the fast and flat water level route.

When the northern part of the Maybrook line was broken up a very strategically important connection was severed. The line was broken up on both sides of the Hudson river and reconstructing it would be very costly. The only link that remains in place is to connect the Hudson Line to the Port Jarvis line via a cross Hudson tunnel just north of Beacon Station. This would create an additional access point for trains traveling from the west to access Manhattan. It would also create an east/west connection that is today only possible by car or riding on the Northeast corridor. A similar plan was put forward for the reconstructed Tappan Zee Bridge but was scrapped due to budgetary constraints.

The tunnel proposed would leave the Hudson line just north of Beacon station and would helix downward at 25 ‰ incline, which is sufficient for multiple unit trains and lighter locomotive hauled trains. It would not allow for freight trains due to them requiring much flatter inclines, resulting in a much longer tunnel. The helix ramps would be dimensioned to reach a required depth of about 30-60 meters. The Newburgh Bay is only about 24m deep at its deepest point[51] but bedrock could be located much deeper than the river floor. A solution with immersed tunnel sections could be used just like in the Stockholm City Line Project[52] to avoid having to place the tunnel at a very large depth. After crossing the river the line would helix

51. US Department of Commerce National Oceanic and Atmospheric Administration Coast Survey, *Chart 12343 Hudson River, New York to Wappinger Creek*, 2013, US Department of Commerce National Oceanic and Atmospheric Administration Coast Survey, Washington. DC
52. Railway Technology, *Stockholm City Line*, 2014, Railway Technology, Manchester, UK https://www.railway-technology.com/projects/stockholmcityline/



back to the surface and connect to the existing West Shore rail line just north of Newburgh. The line would then use the existing rail line to leave Newburgh to the west. A new 9km surface railroad would link to the Port Jarvis line via Stewart Airport.

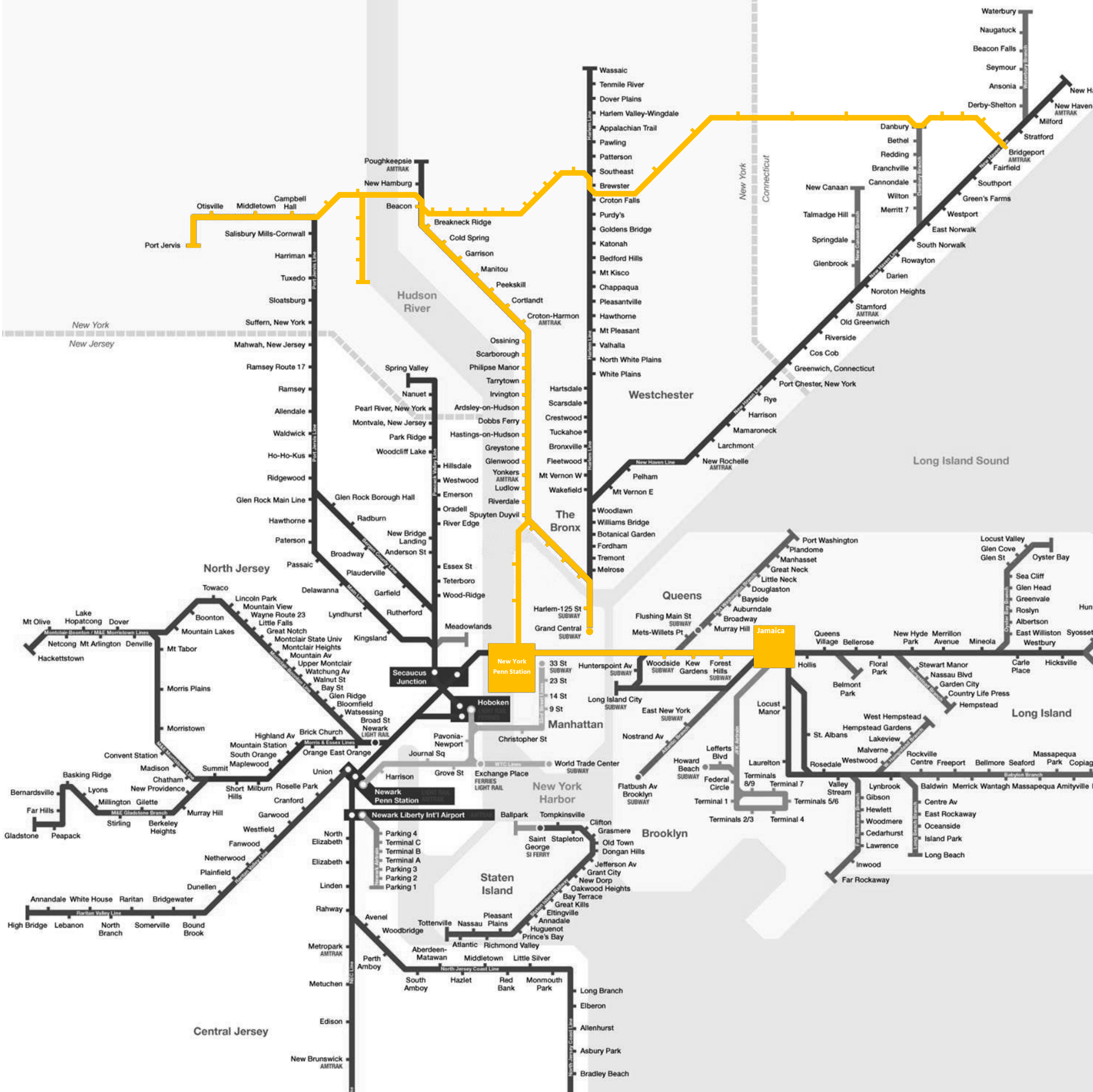
Creating an additional river crossing and reactivating the only east/west rail line still in existence would create a framework for a greatly extended regional rail system. It would help to break up the hub and spoke pattern of the system and link Metro Norths services as well as the Port Jarvis Line. Combining this with a modernised and expanded Eastside access, a modernised Hudson Line and through running on to LIRR lines would create brand new and greatly extended travel opportunities for the entire region. It would also help to bring efficient high capacity public transit to regions that lack those today.

Examples of possible services:

Cross regional (Port Jervis - Stewart Airport - Beacon - Danbury - Bridgeport)
The Cross regional would operate along the new east west axis and would have a journey time of about 2.5-3 hours end to end. It would primarily service as a connection to the New Yorks bound trains connecting at several places along the line. It would bring cross regional journey times down and will allow passengers to avoid having to travel to Manhattan to Transfer. A trip from Bridgeport to Beacon would be reduced from about 3.5 hours to 2. It would also give people living north of New York a convenient connection to Stewart Airport.

Port Jervis Express (Port Jervis - Stewart Airport - Beacon - Penn station - Jamaica)
Bringing some express Port Jervis services into Manhattan via the Hudson Line would greatly improve Manhattan access for communities west of the Hudson River. It could use the East side access to connect to Penn station and run through to Jamaica. This would create a two seat connection between Stewart Airport and JFK. Jamaica to Stewart Airport would have a journey time of about 1h 15min. It would also offer the only single seat ride from Midtown Manhattan to an international airport with a Penn station - Stewart Airport journey time of about 50-55 minutes.

West Point Service (West Point - Newburgh - Beacon - GCT)
The West shore rail line could be used to bring direct services to West Point via Newburgh and Beacon in to Manhattan. This service would take about 1h 10mins.



3. LOCAL COMMUNITIES

This chapter discribes local communities and how the are effected by the proposed development

BEACON LINE COMMUNITIES

Dutchess County has a population of about 300,000 people. The Beacon Line runs in the southern part of the county and can be estimated to have an area of effect of about 150,000 people. For a relatively short secondary rail line this is quite a large amount of people being effected by its reactivation. The Hudson line runs through a comparatively densely populated area and has an area of effect covering well over one million people. Given that cities with both 150,000 people and one million people can operate extensive rail networks in their own right its safe to assume that these lines have an extremely good potential to operate well utilised services.

The main transportation issue for the region has been that the rail lines operate a very slow and inefficient service in to New York where the main job market is. This has lead to many people commuting by car. Highway congestion is very bad in this part of the region and journey times are very long. Being able to bring down journey times on the trains to New York to less than and hour would have a large effect on the amount of people choosing to commute. This is off course positive but it would also bring a challenge. The region is sprawling and many people would need to drive to the train station. This is already the case and huge parking areas occupy valuable real estate close to the train stations. Developing these areas without accounting for parking would create a better local community but would hamper the travel options for communities further away significantly. The areas along the Hudson Line generally lacks functioning public transit outside of the Hudson line it self. Some towns operate feeder busses to and from the train station but these only operate in conjunction to Hudson line services and are not a viable mobility option for any other purpose of getting to and from the train.

By reactivating the Beacon Line a secondary transit system can be established and local communities further away from the main line can be served by convenient public transit. Doing so allows parking to be dispersed along the line and moved away from Beacon Station. It also allows for central areas in the towns along the line to be developed in to denser mixed-use neighbourhoods. This will help to reshape the urban fabric in these towns. Businesses and services will inevitably congregate closer to the train stations when large amounts of people use them daily. The train stations can hopefully function as a catalyst for walkability and reduced car dependency in these towns.

BEACON / MADAM BRETT PARK / MATTEAWAN

The City of Beacon sits on an isthmus between the Hudson River and the Fishkill Creek. The Hudson line runs along the Hudson river and the Beacon Line runs along the Fishkill Creek. Beacon Main street crosses the isthmus from river to creek. Main Street is the main dense urban axis of the town. The low lying areas along the rivers have traditionally been used for manufacturing but has either been demolished all together or abandoned. Some old industrial building has been repurposed as housing, shops, hotels, cafés and most notably the famous Dia Modern Art museum. Much of the low lying areas close to the river have been left abandoned or is being used for utilitarian purposes such as parking, solar farms or waste water management.

This urban dynamic is odd. Riverfront areas are traditionally very sought after for housing and recreation. Beacons history with industries using the running water of the rivers and labour housing being placed along the slopes of the river valley has left these areas being considered a bit of a backside. The rail lines primarily served the industry in these regions and it is a little bit of a lucky coincidence that the most attractive land has been left unoccupied and is accessible with public transit.

The city of Beacon will be serviced by three train stations. Beacon station it self, Madam Brett Park station and Matteawan Station. Madam Brett Park will be a platform along the line and will serve a very scenic hiking area as well as being used by the people living in Dutchess Junction. The old industrial ruins adjutant to the rail line could also be repurposed as mixed use in the future. Matteawan Station is an old existing station building and sits on the opposite end of Main Street and will serve the eastern part of the city. There are several suitable areas in Beacon that could be developed into mix-use neighbourhoods. Primarily the Beacon station area but also places along the Fishkill creek. Beacon has by far the most urban population of the towns along the Beacon line with 15,000 people living in the town it self. It has an excellent starting point to be developed in to a very walkable and bikable town.

Many people could possible opt out of owing a car If more services could be located in dense urban neighbourhoods close to the train stations. Something that is hard but not unheard of today.

ROUTE 52 / DELAVAN AVE.

This area sits on the outskirts of Beacon and will be served by two stops. Delavan Ave. station will be a side platform on the line and have nice views of the Fishkill creek. The most adjacent area is mostly used for auto repair and shops, but also a church and importantly the Hedgewood Home For Adults, an assisted living facility. Giving this facility access to public transit is important because it would help tenants who can't drive to access the town as well as providing visiting families with convenient transportation. The station is also within 800m of Beacon High School, Rombout middle school and the public park. This gives parents that commute the possibility of seeing their kids off to school on their way to work.

Route 52 / Mill St. Station sits along route 52 between Beacon and Fishkill. The area has some housing and several large industrial or logistics type businesses. This stop would allow for this area to be more densely utilised and give people working and living in the area a convenient transit stop. The station is also within walking distance of the Downstate Correctional Facility and would bring a public transit option to both workers and visitors.

This area is severely lacking in walking and biking infrastructure and improvements are necessary to be give these stations the conditions to function as intended.

FISHKILL

Fishkill is a small town of about 2100 people. It functions as the centre of a much larger sprawling area. This is where most of the people in the area go to do their shopping. Many large stores such as Wallmart are located here as well as a massive logistics centre. Fishkill is located at the intersection of Route 9 and interstate 84. The town sees a lot of traffic and most of the people using its shops and services live in the surrounding areas and not in the town it self.

Fishkill has a well preserved and quaint main street with multi family houses from the last turn of the century. The rail line cuts the town of from having direct creek side access. It is lined by industrial buildings on both sides. The line also crosses the very busy Route 9 in a level crossing. Running services on the line would require this crossing to be grade separated. Elevating the line over the highway is preferable given its proximity to the creek and the associated flooding risks a cut would bring. Elevating the line would also give the town creek side access and create a possibility to cross the creek and access the shopping area by foot or bike. Something that is nearly impossible today.

Fishkill station would be a little over an hour away from Grand Central Terminal via an upgraded Hudson line and a reactivated Beacon line. The industrial areas bordering the rail line could be repurposed as a mix use neighbourhood. This would expand the central parts of Fishkill to the creek and link it to the shopping area. Fishkill could by doing so be transformed from an extremely car-dependent sprawling town to a walkable and quaint little city. It would also have huge development potential given the ample space taken up by parking and big box stores.
Having the combination of a lot of buildable land adjacent to the scenic creek, a historical main street and Manhattan access in little over and hour could transform the town in to a very popular place to live.

BRINCKERHOFF / SPORTS KINGDOME

Brinckerhoff is a small hamlet within the town of Fishkill. It has about 3000 inhabitants but act as a secondary smaller shopping node for its surrounding area, with the main one being the one in Fishkill along I-84.

The town centre consists of a strip mall and a few blocks of row houses while the surrounding area consist entirely of single family houses. Brinckerhoff sits at the crossing of route 52 and route 82 an easy road connections to the old disused 300 acre IBM plant. This plant is in the process of being turned into a mini-city / Business park and it will accommodate shopping, offices and housing. Brinckerhoff will be the closest rail station accessible by car and will probably need a considerable commuter parking area to accommodate all cars if the old IBM campus becomes fully developed in the future. The existing strip mall could also be developed in to a mix use neighbourhood. The Brinckerhoff station would have a journey time of 17 minutes from Beacon and an additional 49 minutes (including a 5 min transfer) to GST bringing the total journey time to about 1h 10 minutes. This would make it an attractive place to live for people commuting to both Beacon locally or New York Regionally.

There will be a smaller station a few kilometre east of Brinkerhoff that will have walking access (about 1,5 kilometre) to the new proposed Sports KingDome that is planned for construction adjacent to the old IBM campus. This stop is closer but lacks direct road connection and will primarily serve as a seasonal stop in conjunction to games being played at the dome.

HOPEWELL JUNCTION

Hopewell Junction was founded as a small railway town at the junction between the Maybrook Lina and the Beacon Line. Only about 375 people live in the town itself but it serve as the node in a larger conglomeration of single family house neighbourhoods. The station will be placed just north of the town centre right before the sharp bend in the line. The placement is intended to tie together the Hopewell Deport railway heritage park with the strip mall and school to the southwest. The area along the rail line is primarily industrial today and provides a good opportunity to develop a denser transit oriented neighbourhood along the Worthlekill Creek.

Hopewell junction would be 22 minute journey from beacon and could be reached in about 1h and 20 minutes. Its worth noting that this is still quicker than the existing GST - Beacon limited express service.

STORMVILLE

Stormville is a small hamlet in the Town of East Fishkill. It sits in beautiful rural surroundings. The station will be located centrally in the town adjacent to Old State road. It will serve the community as well as the staff and visitors of the large Green Haven Correctional Facility. Journey times to Beacon will be about 28 minutes. Stormville sits on a relatively straight and flat part of the line and this is where higher top speeds off the trains will play a larger part in journey time reductions compared to faster acceleration in the curvier more urban section.

WHALEY LAKE

Whaley lake is the highest point of the line where it passes over the Taconic mountain range. The line sits in an entirely rural and mountainous area and the station won’t be located in a town or village. It will serve two main purposes. Primarily as a commuter station for people living in the surrounding areas but also as an access point for the Appalachian trail. It will also serve the many summer camps in the area. Whaley lake is the eastern most station covered in detail by this thesis and sits on the geographical divider between the communities in the area of influence of the Hudson Line and the Harlem line. After Whaley lake the line descends in to the Harlem Valley and reach Pawling and Brewster where transfer will be available to the Metro North Harlem line. Journey times from Beacon will be about 35 minutes and about 25-30 minutes to Brewster.

OTHER EFFECTS

Renovating the Hudson Line as proposed in this thesis would have a massive impact on the entire region north of New York city. It would lead to both increased capacity and shorter journeys. Many communities along the line would have journey times comparable to neighbourhoods in the five boroughs. Offering fast single seat journeys to midtown or even across the region would make the Mid-hudson area very accessible and likely also a very popular place to live. The increased standard of the line would have wide reaching implications in many more communities than the ones situated along the line itself would get greatly increased access to New York city.

A more attractive railroad will undoubtedly lead to higher utilisation but this also offers a larger challenge for the development of walkable transit oriented communities. Increases in rail journeys are likely to also increase the amount of people diving to their local train station. Which in turn would led to a conflict over space adjacent to the station. Its there for very important to supply a public transit option for the journey between the station and peoples homes. Or at least closer to their homes where last mile transportation options can be used, such as bikes and e-scooters. Shorter journey times would lead to places further out on the line becoming much more accessible from the city. It would also lead to places in the proximity of the line that today aren't considered commutable to be included into the New York regions job market. This would quite likely be of more important to these communities then the journey time reductions are for the towns along the line. It would totally transform the economic basis for many communities that would get access to an entirely new job market. It would also help New York city that is struggling with a housing shortage. Many people would be able to find much

more affordable housing when places like Newburgh that has very low rent levels become a viable living option. This while at the same time helping to improve the tax base of these poor communities. An injection of people moving to these towns would hopefully help to increase the over all economic situation and help to improve school results and reduce crime levels. In the case of Newburgh an increase in safety would be a huge benefit as the city was ranked the 10th most dangerous city in the U.S in a 2012 survey[53].

53. A. Schiller, *NeighborhoodScout's Most Dangerous Cities – 2013*, 2013, Neighborhood Scout, Worcester, Massachusetts, https://www.neighborhoodscout.com/blog/top100dangerous-2013

Lander Street in 2017, Newburgh, New York

Credit: Joe Santacroce

NEWBURGH

Newburgh and Beacon sits on opposite shores of the Hudson river. Newburgh is the larger city with about 28,000 people while Beacon is smaller at about 15,000 people. Both cities has a very similar history being established around the running waters off tributaries flowing down into the Hudson River. The running water was used to power factories and manufacturing. Newburgh was for a long time the more prosperous of the two cities and was at times referred to as the 6th borough of New York. The loss of manufacturing hit both cities extremely hard and much of the cities where either demolished or left abandoned. Between 1950 and 1980 Newburgh lost almost a third of its population and unemployment and poverty was rampant.

Beacon had started to recuperate by the 90s and early 2000s. The town had become a popular destination for day trips from the city. Much of this tourism was centred around shopping in thrift stores and buying locally produced art. This and a combination of beautiful natural scenery, old quaint buildings and easy access to the the city from Manhattan would lead to the formation of a local economy centred around restaurants, boutiques and shops. Many local breweries, craft food producers and hotels have also established businesses in the town. The Dia Modern Art Museum has also acted as an economic catalyst, much like the Guggenheim museum did for the city of Bilbao in Spain.

Newburgh on the other hand lacks an efficient connection to Manhattan and wasn't able to be as attractive to visitors in the same way as Beacon. Commuting from either of the cities is difficult. It is slow and expensive but many people still opt to do it. Journey times from Beacon are 1h 24 minutes for most train and 1h 14 mins for a few express services. This means that many people have to commute 3-4 hours door to door daily from Beacon and over 5 hours daily from Newburgh. This difficulty in accessing the New York job market and also accessing the New York visitors market for local businesses has had a very large effect on the recuperation of the cities after the loss of manufacturing. Beacon today has a median yearly income of 68,561$ [54] while Newburgh has almost half at 36,822$[55]. Poverty rates are about 9.4% and 31.2% respectively. It has not been proven but there are strong

54. United States Census Bureau , *Beacon, New york Population: American Community Survey (ACS) 5-year estimates, 2017*, United States Census Bureau
55. United States Census Bureau , *Newburgh, New york Population: American Community Survey (ACS) 5-year estimates, 2017*, United States Census Bureau

Waters Street 1900

Waters Street 2018

Credit: Joe Santacroce

indications that having access to the Hudson line have been vital for Beacons recuperation. In discussions with locals it was made clear that commuting was extremely cumbersome and difficult. Ticket prices are very high with a monthly pass costing 575$ for the Hudson line alone. Needing to transfer to the subway in Manhattan adds an additional 110$ mostly. The offset has been that living costs are much lower in Duchess or Orange County compared to the city. The high cost has made it very difficult for two people in the same household to commute to New York city. A family would have a minimum of 1150$ in commuting costs alone. The long journey times makes it harder for parents to get their kids too and from school and they would have to spend more money on daycare. The solution has typically been that one parent works locally and takes a larger responsibility at home while the other spouse commutes long hours daily.

Providing shorter journeys into New York would aid both Beacon and Newburgh primarily in creating more economic activity. It would also help to ease peoples everyday lives, when parents get to spend more time with their children. They would also be less exhausted by the long and uncomfortable commute. Higher ridership and a more modern line would hopefully bring down costs for MTA so that ticket prices could be lowered. Lower ticket prices combined with shorter journeys would make it possible for both spouses to commute, creating further ridership helping to create a positive loop.

Newburgh could be a very large beneficiary of these positive effects given the city's challenging economic situation and its lacking access in to New York city. A ferry or bus connection could place Newburgh only about an hour and 10 minutes from midtown Manhattan and with a tunnel connection (as proposed on page 88) the town could be only about 50 minutes away. The almost entirely demolished waterfront of Newburgh could be reconstructed and would entirely be within walking distance from the ferry or a new train station.

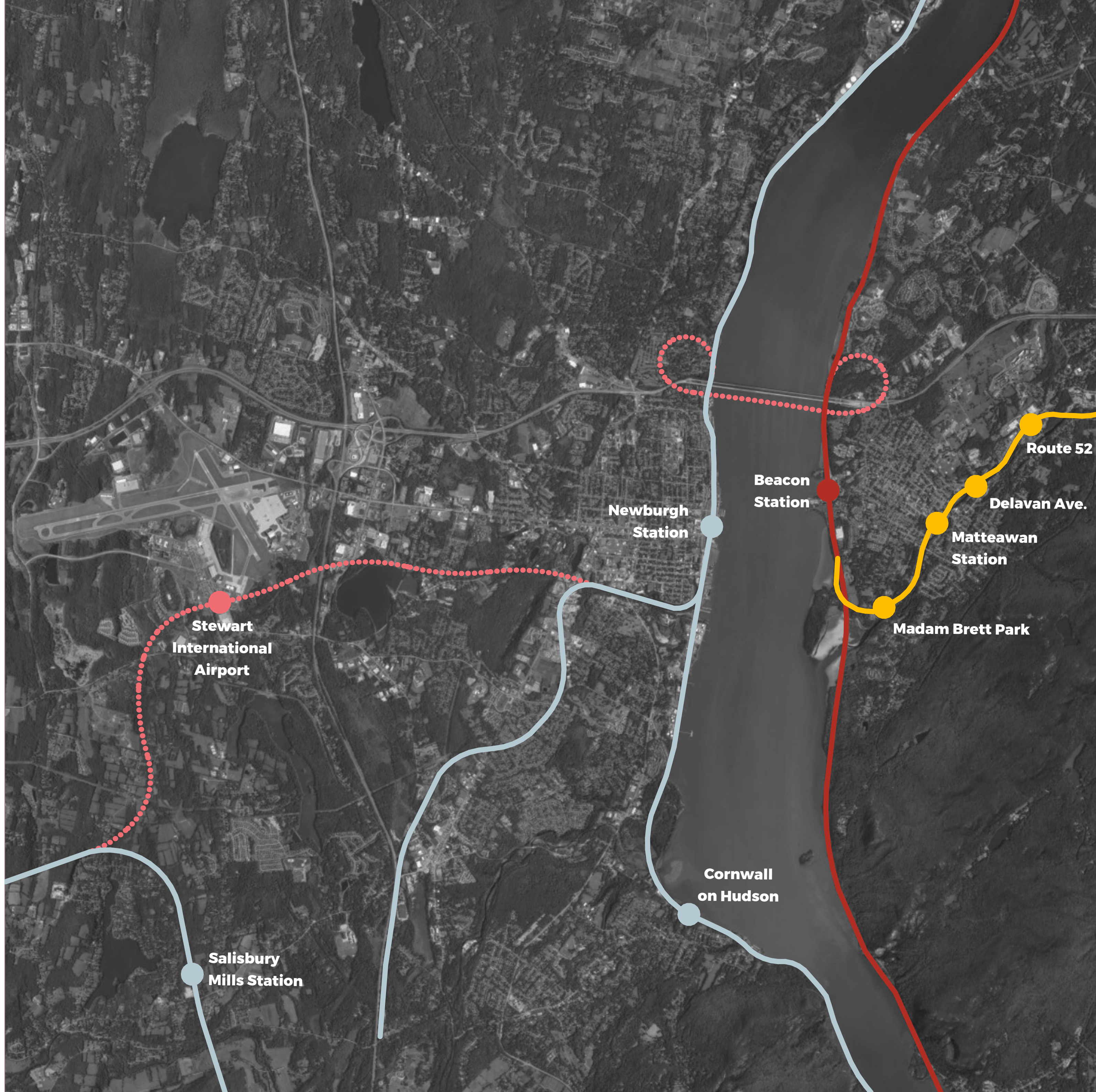
Newburgh's rich architectural heritage and undeveloped waterfront provides the city with outstanding opportunities to become a very attractive place to live if efficient transportation becomes available. Bringing new inhabitants too Newburgh would undoubtedly help the city to combat its lack of opportunities. It would provide a better customer base for local businesses and help to create a more functioning local economy. A strong local economy would help to create local jobs and create opportunities and activities locally. This can hopefully substantially alleviate the very challenging crime and gang problems the city is currently facing.

STEWART AIRPORT

Creating a new regional rail connection between the Beacon Line and the Port Jervis line would be very beneficial to the entire Mid-Hudson region. Communities west of the Hudson would be provided with faster journeys and direct access to Manhattan. The three main airports of New York would also be more efficiently complimented by Stewart Airport.

Stewart Airport would be the only New York airport with single seat access from Manhattan and would only be an hour from Midtown. Communities along the Hudson, Harlem, Beacon and Port Jervis lines would be either a single or double seat ride from the airport. Stewart would be the most convenient airport for everybody living north of Midtown Manhattan. Being this easily accessible from New York would help to improve to popularity of the airport a lot and would help to attract new to airlines operate out of the airport.

Having an international airport north of New York city would help communities to attract large businesses to their towns and further strengthen their economic situation.



4. DESIGN SITE

This chapter discribes the main design site and the main design proposal.

Credit: Library of Congress, Geography and Map Division

BEACON STATION

The current Beacon station sits on the east bank of the Hudson River in an area historically called Fishkill Landing. The site previously housed many factories and a busy port. But most of those structures were demolished on the 60s and 70s to make way for commuter parking lots. The MTA currently owns and operates about 1200 parking spaces on the site.

With the introduction of the Beacon rail line and an upgrade of the current bus system the majority of these parking spaces could be removed and the remaining could be house in parking garages under a newly developed neighborhood.

The current Beacon station is dimensioned for low traffic. It has a single narrow platform serving two tracks. A third by-pass track runs on the east side of the line and allow for long distance trains to pass when local trains are dwelling at the station. The platform length is adjusted for eight car trains. The south exit is an underpass under the tracks that is accessible via a ramp from the parking lot and via stairs or an elevator the platform. The corridor under the tracks is narrow and creates long lines even with todays relativley limited number of commuters. The North exit consists of stairs over the tracks. The platform houses several ticket machines a wind shelter and a small store.

Other than the station and its parking lots the Fishkill landing area only houses a auto body shop, a warehouse for a construction company and a few homes. Parking makes up the vast majority of the land use on the site. The site is low lying and largely flat and is surrounded by steep hills. The topography is higher i the north of the site and slightly lower on the south end.

The site is accessed by two streets. West Main Street connects to central Beacon in the north and Railroad Drive connects in the South. Beekman Street runs above the site and is the eastern limit of the scope of this design proposal even though further development is necessary to tie the town to the riverside once again.

SITE ANALYSIS

The Hudson rail line generally runs right next to the bank of the Hudson river and most of the riverside communities have a significant barrier between the towns and the river, Beacon is no exception. At a few point small peninsulas and point protrude in to the river and create areas with an open shoreline. In Beacon there are three points where the rail lines runs slightly inland from the shore. Denning Point to the south. Scenic Hudson Long Dock Park i the middle and Pete and Toshi Seeger park to the north. Long Dock, and Seeger Parks lies directly in connection to the station area site. These parks are recreation areas while Denning Point is a nature preservation area.

Limited river side access is symptomatic in the Hudson river due to it having rail lines running along both shores. The Beacon shore is comparatively large but access is limited. Two roads access the riverside via bridges over the rail line. Pedestrian access is provided via the tunnel at the south entrance of beacon station or over Long Dock Road from Beekman Street. None of these routes are very attractive with one being a gloomy tunnel and the other being a road that requires a detour. This layout disincentives people to access the riverside by foot and many people opt to drive even though the relatively short distance.
The built up areas surrounding the sites sits on different ridge lines and heights and lack direct routes to adjacent areas. Walking in a straight line or trying to get "over there" is often not possible and long detours are often required. This is part due to the steep nature of the terrain but also very often due to lacking pedestrian infrastructure and stairs.

The site gives the impression of being of being disconnected from the rest of the town and feels largely abandoned even though its is arguably the most conveniently located plot of land in the whole county.

There is ongoing development to approach the station area and close the distance from the town to the station. There are proposed and ongoing development on the Edge Water site overlooking the station area and in-between Beekman St. and North Ave. just south of the courthouse. This thesis limits is scope to the site that closest to the station because it aims to study the effects of reduced car-dependency and avoid proposing designs for areas that are accessible to development anyway.

The reason for this is to study the potential of a shift towards a more rail-centric transportations system and to bring light to what challenges are associated with such a development.

The key aspects in the proposal are to create a stronger connection between the town of Beacon and the Hudson river. By doing so the town will also be tied closer to Beacon Station and to a new and expanded transportation hub. The desired effect is to create a more interconnected Beacon where car-dependency is drastically decreased by providing an easy and pleasant town to move around in by foot or by bike.

Another important goal is to create a town that is less dependant on good weather and lighting conditions to incentiveise walking, biking and outside activities. This can be achieved by creating both open and closed urban spaces and streets that have a combination of outwards faceing functions to provide eyes on the street with homes that populate the area durring all hours of the day. Essentially a mixed-use neighborhood that is design around a comfortable microclimate. Another important factor in year round utilization of for example the river side parks are to be close to them. Few people will make a point of traveling to the park during dark winters evenings if it requires a long walk in the dark or a car ride to an isolated park. By having proximity to the parks more people are likely to use them and by doing so they provide a safe atmosphere that attracts further visitors thus creating a positive spiral.

The Hudson river is prone to heavy winds in the winter and creating protected streets and squares are key to creating a comfortable climate year around.

The main factor in being able to create any of these mentioned values is the placement of the rail line. Creating connections over or under the rail lines are key to adressing these stated issues. Connections over the rail line are difficult due too the relativley flat terrain next to the track that creates a need for large and inconvinient bridges or ramps. Tunnels are hard because of the very shallow water table and the sencitivity to flood events.

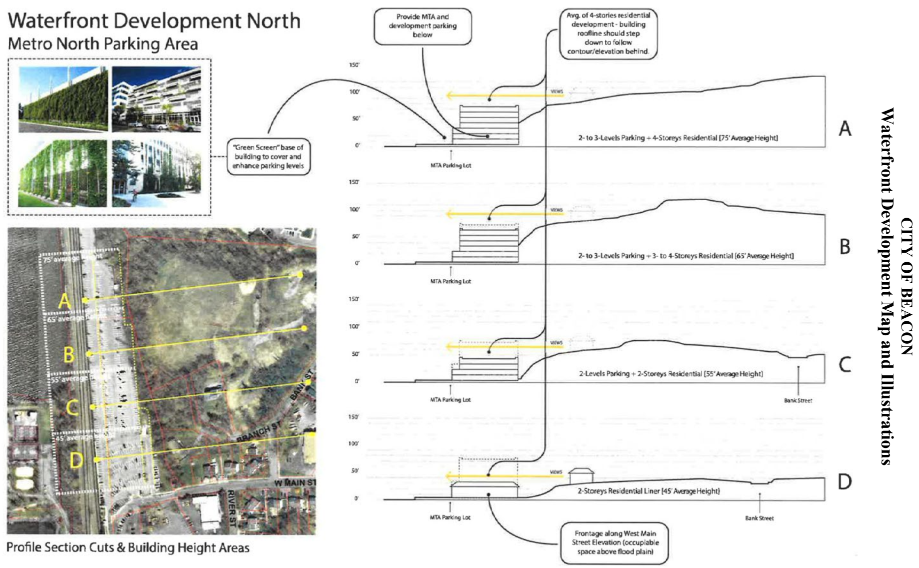
The choosen solutions is to elevate the track for about mile neares to beacon station. This provides access to Beacons riverside parks and protects the rail line from flood events.


Ongoing development
Ongoing development
Main St.
West Main St.
Beekman St.
North Ave.
Police station
DESIGN SITE
Beacon station
Pete and Toshi Seeger Park
Long Dock Park
DIA Beacon

DESIGN PRINCIPALS

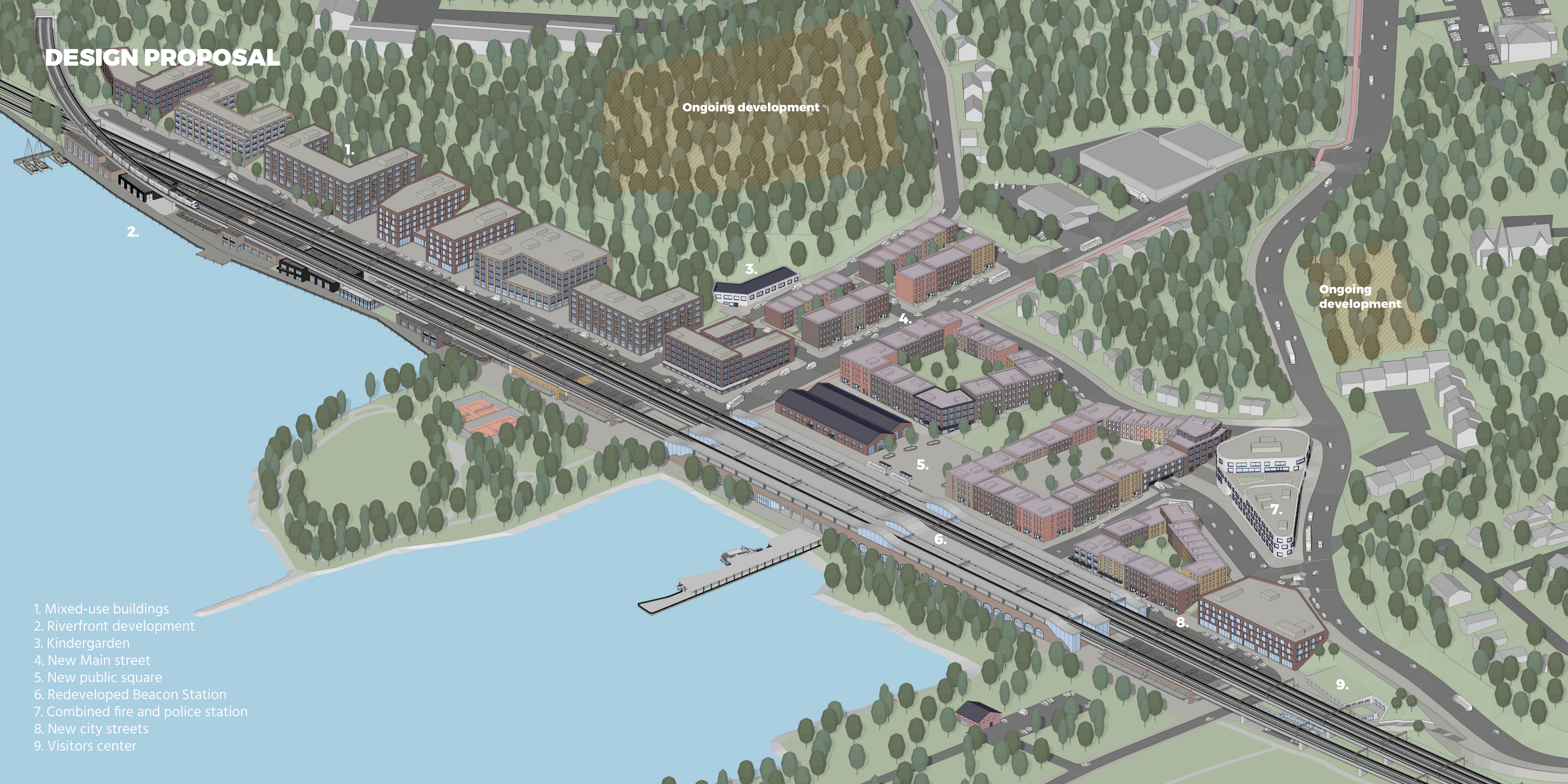
The design proposal aims to create an ambitious yet realistic urban structure for the site. It largely follows the existing city zoning rules but makes some deviations to be able to create more well functioning buildings and to create streetscapes that Provides for the stated goals of safety, mixed use and micro climate. Houses along for example River Street are taller than zoning requirements because that they wouldn't frame the street if they adhered to the rules. The buildings are sized and design in a way that are in-line with the intentions of the zoning rules but may deviate somewhat.

The building designs aim to follow the will of the City of Beacon to keep the characteristic low rise brick architecture and expand on that design language to create contemporary interpretations of the existing building stock and by doing so try keeping the atmosphere and charm of the old Beacon.



Zoning document for the northern part of the site

DESIGN PROPOSAL



1. Mixed-use buildings
2. Riverfront development
3. Kindergarden
4. New Main street
5. New public square
6. Redeveloped Beacon Station
7. Combined fire and police station
8. New city streets
9. Visitors center


Reformed
Church of Beacon
DIA: Beacon
Modern Art
Museum
1.
2.
3.
4.
5.
6.
7.
8.
9.
Scenic Husdon
Long Dock Park
Ferry and tour
boat terminal
Pete and Toshi
Seeger Park
Kayak rental
Newburgh - Beacon Ferry
1. Mixed-use buildings
2. Riverfront development
3. Kindergarden
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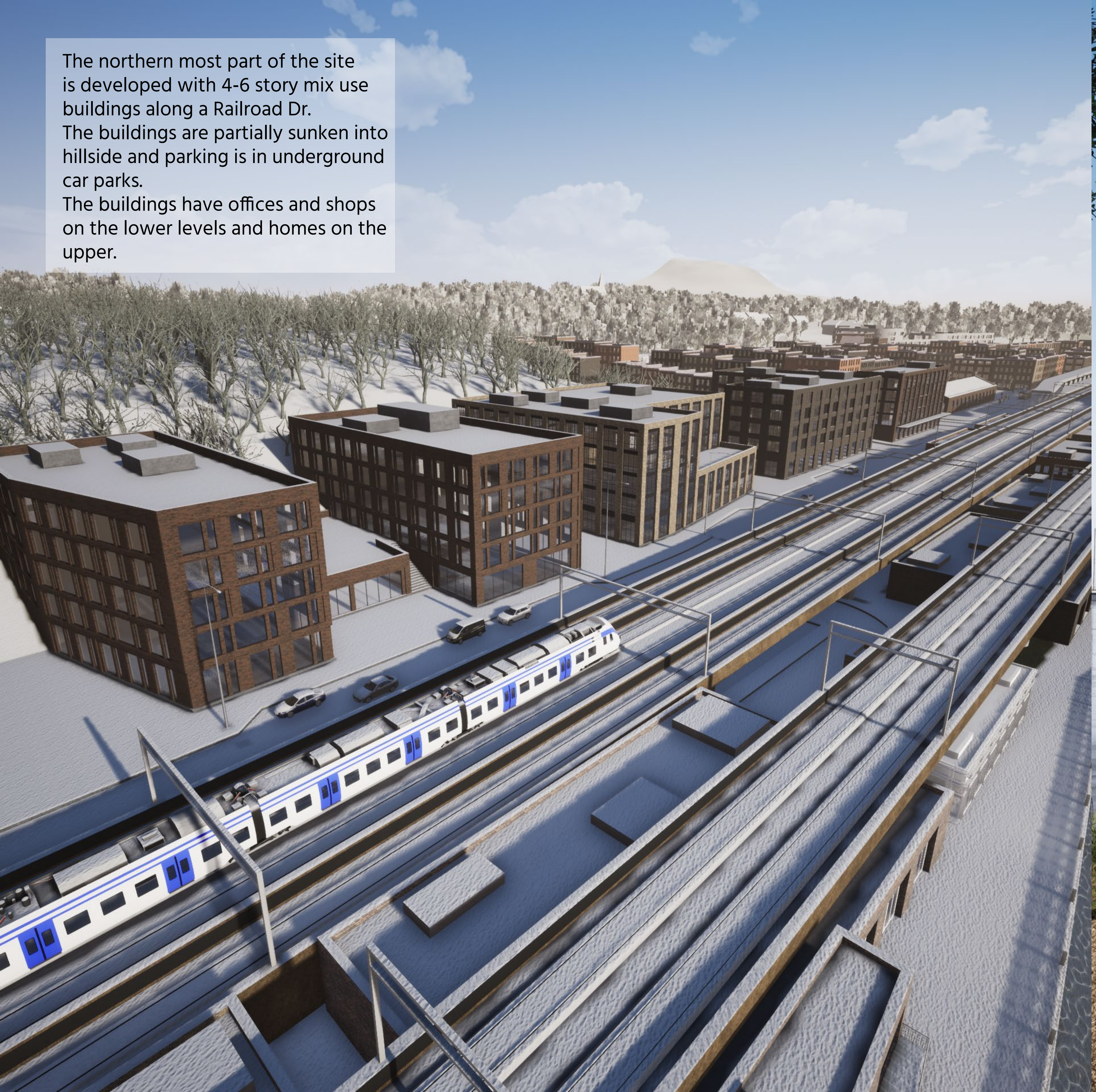
Section through Railroad Dr


Section through West Main St



The northern most part of the site is developed with 4-6 story mix use buildings along a Railroad Dr.
The buildings are partially sunken into hillside and parking is in underground car parks.
The buildings have offices and shops on the lower levels and homes on the upper.

A new riverfront walk is built along the elevated rail line. New quayside café and restaurants are placed underneath the line.

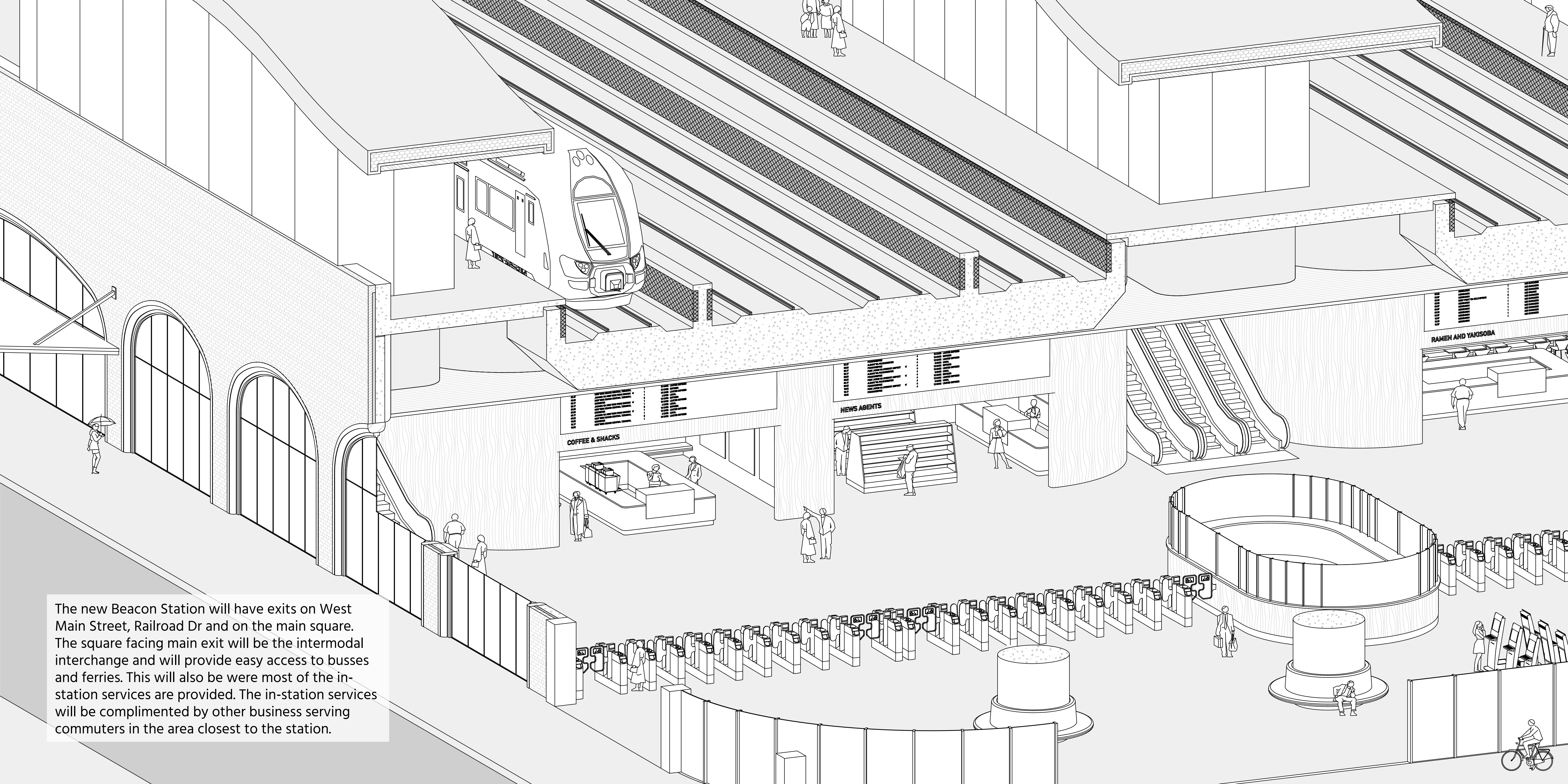
A daycare facility is built to along the extended Branch St. to provide easy drop of and pick up kids by commuting parents. The location next to the wooded hillside close to the station is good because of the ease access to nature daycare activities as well as being on the way for parents wont need to drive their children to daycare before getting on the train.

West Main street is widened slightly and new sidewalks are added new 3-4 story buildings line the street. The elevated rail line provides unobstructed access to Pete and Toshi Seeger park.

A new public square it built opposite the train station centrally on the site. A market hall borders the square on one side and housing on the other. A park runs from the Square to River Street and helps to create a walking and visual connection with church on the ridge line. Under ground parking is located under the courtyards of the adjacent blocks and under the park.

The new Beacon Station has three platforms serving the Hudson and Beacon lines. Two express tracks allow Amtrak trains to pass the station at speed. The ground floor of the station is occupied by stores, cafés and restaurants.

The new public square and adjoining park creates a prominent public space that functions as Beacons entry point and urban node. It has visaul ties to the church in old Beacon and to the riverside. Three modes of transit intersect here creating a regional transit hub for rail, bus and river traffic. The square will be Beacons first and only square and will house a number of public events and gatherings.



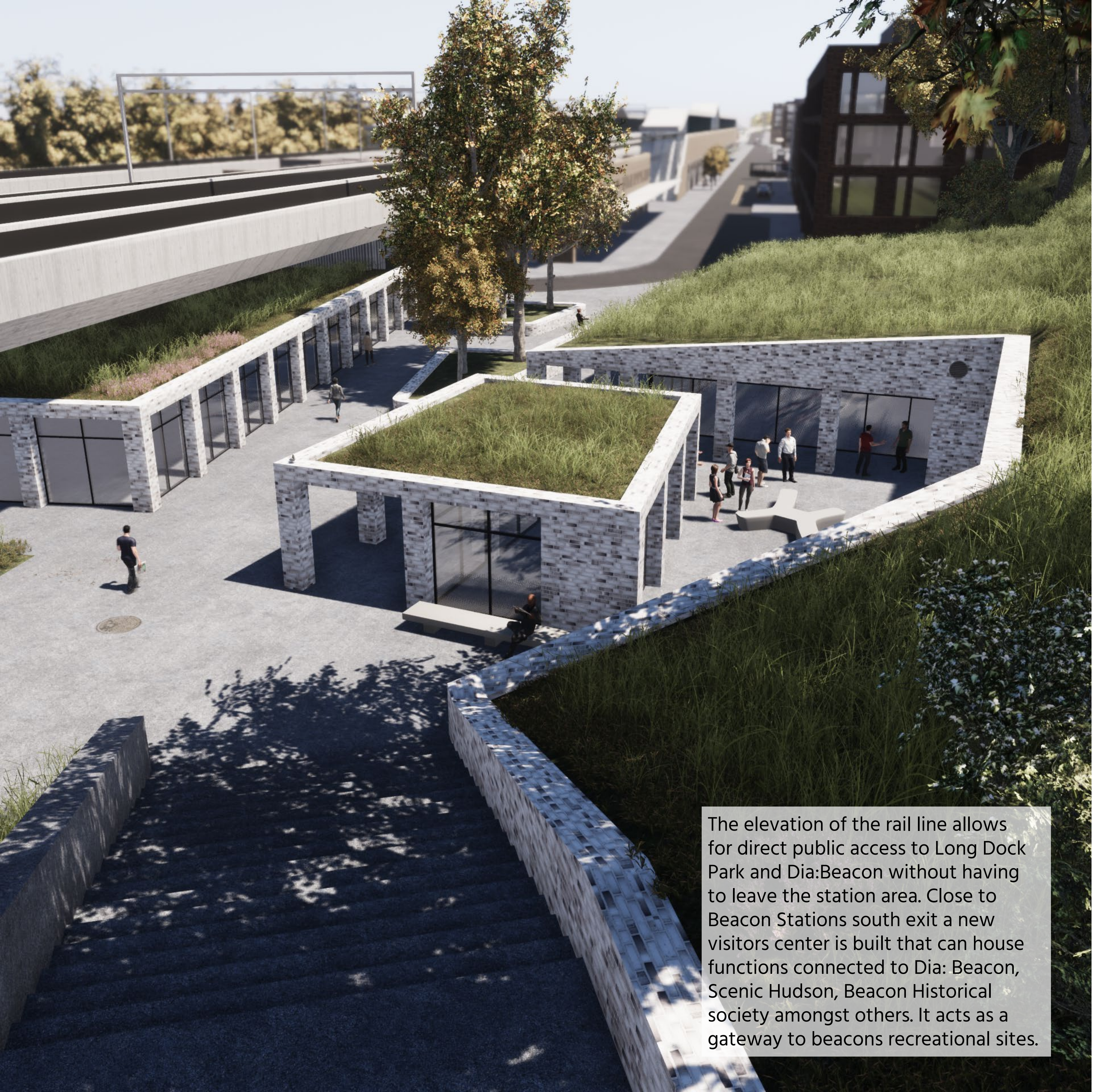
The new Beacon Station will have exits on West Main Street, Railroad Dr and on the main square. The square facing main exit will be the intermodal interchange and will provide easy access to busses and ferries. This will also be were most of the in-station services are provided. The in-station services will be complimented by other business serving commuters in the area closest to the station.

The new public park and main square will serve as Beacons main public space. Something that is lacking today. It will provide a place for public functions and events as well as for recreation and commerce. The square, park and underpass creates a visual axis that ties the old church of Beacon to the Hudson shore and thus help to integrate the old and new parts of the city that are relatively far apart and vertically separated.

The new and elevated Beacon station creates a greatly improved travel experience with accessible and comfortable station amenities. The centrally located outdoor concource creates a seamless interchange between ferries, trains and busses. The area under the tracks are utilized for shops and services and face both the city and the riverside. Covered plattforms and heated station areas creates a much better year round passenger experience in the rough microclimate of the Hudson Valley.

The current police station site is developed in to a joint fire/rescue and police station. The new building houses all administration and offices needed as well as a three truck fire house facing Beekman St. The police utilize an underground car park accessed via the public car park entrance at the corner of Railroad Dr.

The road that is today Railroad Dr. is developed in to a city street that serves as the neighborhoods main street. It is protected from wind from the river and offers a comfortable environment all year around even though it is less then 100m from the shore.



The elevation of the rail line allows for direct public access to Long Dock Park and Dia:Beacon without having to leave the station area. Close to Beacon Stations south exit a new visitors center is built that can house functions connected to Dia: Beacon, Scenic Hudson, Beacon Historical society amongst others. It acts as a gateway to beacons recreational sites.

CONCLUSIONS

This thesis has presented a wide range of benefits steaming from an activation of the Beacon Line and maybe more importantly a modernization of the Hudson line. They range from shorter journey times to making land accessible for development. It is strongly believed that such an investment would be a catalyst for urban development, sustainable transportation and as an extension of that more sustainable lifes.

It has become clear during this work that an holistic approach to public transit is needed to unlock the potential that comes with the vast capacity of rail-based transportation. These transportation systems are dependent on all their components and opting out of one might drastically hamper its results.

It is clear that the potential that lies in New Yorks under utilised and obsolete regional transport system is enormous. Great effect should relatively easily and cheaply be accessible if the right investments are made. Few cities in the world has and existing infrastructure framework that could accommodate as much sustainable growth as New York has.

Using disused rail-based infrastructure to facilitate the regions growth can be very cost efficient and would help to reorient the scattered and car-centric outer reaches of the region into a polycentric cluster of small interconnected walkable towns. By shifting the flow of people from highways to railways more people would travel through the central parts of these towns. The increased flow of people would attract businesses and services and help to revitalise small cities and towns all over the region while at the same time helping its inhabitants to live more sustainable lifes.