Momentum

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A train departure board and clock the main hall at Paris' historic Gare de l'Est.

Credit: Nolan Hicks

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A special acknowledgment to: The 70,000 men and women of the MTA who move New York everyday. Just like that.

Version: 1.1

Two Metro-North M8s are shown, one in the foreground and the other in the background

Credit: Claire Aguayo

1 Foreword:

America's cities are confronting interlocking crises in the aftermath of the coronavirus pandemic. Long-standing housing shortages are choking cities by depriving them of residents; surges in cars and traffic are choking cities by depriving them of their ability to move people in and through the metropolitan areas. The combined effect is to starve cities of the very thing that makes them go — people, throttling their comeback. It echoes the freeway-induced depopulation that pushed cities to the brink in the 1970s. There has been progress on housing. The furor over soaring rents and homelessness has forced the first reassessments of zoning regulations in a generation. Several major cities have passed reforms, including New York, Los Angeles, Boston, Austin and Minneapolis. The switch from transit to cars is proving far harder to tackle.

It's simple physics. A 600-foot train can hold 1,000 people or more; a string of cars 600 feet long would hold no more than 60 people, assuming one person per car, even if each car was smaller than a Mini Cooper. Getting people back on transit is essential to bringing our cities back to full health. In London, the launch the Elizabeth Line led to a jump in return to office rates, fueling the city's recovery. Paris has seen similar success and is mounting a massive expansion of its metro, the Grand Paris Express project, and of its commuter rail system, the RER.

The infrastructure we have inherited, had we consistently upgraded and funded it like the Europeans have done with theirs, would allow many old-mainline US cities to deliver passenger rail service that rivals what's found abroad. But our agencies don't receive the funding to provide it. Their finances have been stressed further in the aftermath of the pandemic. The top budget official at Philadelphia's system, SEPTA, bluntly says he will be forced to resort to fare hikes and service cuts so deep they would amount to "managing the decline of the system" without new funding.[1] Many other major agencies, including in Chicago, Washington and the San Francisco Bay Area, have issued similar warnings. By necessity, starved agencies focus on survival and have little capability to present a forward-looking case for what properly funded transit can provide. This means politicians face little pressure to do more than ensure the current system doesn't collapse. Stasis ensues.

This report aims to break the logjam by presenting an expansive case for our commuter and intercity rail networks and their capabilities, if they are modernized around a shared common standard. It outlines what that high-throughput infrastructure standard would look like; and details, using real-world routes, how it would slash trip times for existing service and build capacity for further expansions. It includes best practice for system specifications, an economic model for costing projects, a discussion of design choices and a review of common objections. Think of this paper as a standards manual for rail electrification and modernization. It aims to empower riders, advocates, planners and politicians seeking to improve rail service and invigorate our communities. Its goal is simple: Momentum for transit.

1 Fitzgerald, Thomas. "SEPTA rides may cost 21% more starting in January; severe service cuts could soon follow." The Philadelphia Inquirer. Nov. 12, 2024. https://www.inquirer.com/transportation/septa-fare-hike-service-cuts-20241112.html

2 Summary

Getting people onto trains has never been more important. Transit is one of the most effective tools policy makers have to battle congestion and pollution. Speeding up and expanding service is proven to grow ridership and induce mode-change, creating a virtuous cycle that boosts transit. Adoption of a high-throughput infrastructure framework would allow commuter and intercity rail services to deliver trip time savings on existing routes that are so substantial that commuting or traveling by train would become markedly quicker than driving and competitive with flying. Widespread implementation of this framework would allow passenger rail services to finally meet the Congressionally-mandated goal of modern, fast and efficient service that provides a viable alternative to the automobile and air travel.

The infrastructure framework — Momentum — speeds travel with a four-pronged attack on 'dead time.' That's the cumulative time penalty incurred at each stop for deceleration into the station, boarding and disembarking, and then re-accelerating back up to speed. Modeling shows that full implementation can shorten commutes by as much as 29% and slash an hour or more off of many inter-city services.[2,3] In short, the framework will allow American rail planners to deliver the aggregate benefits of high-speed rail at lower costs, while minimizing the regulatory and political risks.

The first half of the program focuses on stations. It calls for the construction of universal high-level platforms along the improved routes. This will speed boarding and disembarking by allowing passengers to easily walk on and off trains, instead of requiring that they use stairs or lifts, a concept known as level boarding. Level boarding also improves accessibility by making it easier to board for disabled and elderly people and those with young children. Second, universal high-level platforms allow rail operators to switch to passenger rail car designs with much wider doors, which further speeds boarding and improves accessibility for passengers in wheelchairs. Level boarding combined with the optimized passenger car designs saves 30-60 seconds per stop for commuter services and two minutes-plus per stop for Amtrak's intercity services.

The second half of the program focuses on the acceleration and deceleration performance of trainsets. Diesel trains accelerate slowly because diesel engines do not get up to speed quickly, they are extremely heavy and the source of traction is limited to the locomotive at the front. Momentum tackles this with a two-part solution. It calls for electrifying routes and for the adoption of electrical multiple unit trains — essentially, all-wheel drive for trains — to dramatically improve acceleration. It can take 120-180 seconds for a diesel locomotive hauling 6-8 passenger cars to get up to 80 mph;[4] but an electric multiple power unit train (EMU) can do it in 60 seconds. That's another 80 seconds in savings per stop. And with EMUs, the subway-style distributed traction system means there is no time penalty for running longer trains, a substantial benefit when compared to locomotives.

The biggest beneficiaries of the Momentum framework are routes with several stops. A hypothetical service with 12 stops at stations with low platforms operated by a diesel locomotive would lose 56 minutes to dwells, acceleration and deceleration — cumulatively, dead time. The high-throughput framework would slash the dead time down to 31 minutes, a savings of 25 minutes.

The most likely candidates for these improvements are the lines that are substantially or completely owned by the public. Additionally, this analysis found that government agencies and lawmakers can unlock tremendous value for the public by purchasing underutilized freight railroad lines or rights-of-way and repurposing them for high-throughput passenger rail service.

This makes commuter railroads an obvious candidate. The MBTA's service between Providence and Boston is operated by diesel locomotives serving stations with a mix of low-level and high-level platforms. This configuration means the trip takes 73 minutes, which is even with driving. Momentum slashes that to 54 minutes. This flips the value proposition between transit and cars by making the train 25% faster. It also simplifies scheduling on the corridor by bringing MBTA service speeds closer to Amtrak's inter-city services, potentially allowing those to go faster too. Our research shows the high-throughput framework would provide a step-change improvement to intercity services, too. Take the route between Chicago and Detroit, large portions of which are publicly owned. Amtrak #352 travels between the two cities in 5h25m. Momentum, combined with long-planned improvements to the Chicago approach, would slash trip times to 3h50m. That's an hour faster than driving and even with flying, when counting time spent at

2 Momentum analysis of improvements to travel times from the end of line on the Long Island Rail Road's Oyster Bay Branch

3 Momentum analysis of Amtrak's Empire Corridor and Wolverine services

4 NJ Transit diesels hauling eight single-level passenger cars would take about 120 seconds to reach 80mph. That grows to about 140-150 seconds for a diesel hauling multi-level cars because of the extra weight. The MTA/LIRR diesels hauling six bilevels take 180 seconds. See Section 11.

the airport.

Momentum fills a substantial gap in American rail planning, which has been largely confined to two different service types off the Northeast Corridor: First, low-frequency diesel service that operates on existing rights-of-way with theoretical top speeds of between 80-110 mph, speeds rarely reached because of diesel's poor performance. Second, greenfield high-speed rail projects, which boast top speeds of up to 220 mph. However, HSR projects struggle to get off the ground because of extremely high price tags, intense regulatory reviews required for obtaining new rights-of-way and construction and substantial opposition from communities along the routes.

Momentum tackles each challenge: First, it reduces the footprint of the projects by focusing on modernizing existing rights of way. This avoids regulatory burdens and legal risks associated with entirely new routes.[5] Second, upgrading existing routes means that all communities that currently receive service will benefit, changing the winners-losers dynamic that has fueled opposition to high-speed rail proposals. Third, it is a fraction of the cost of California High-Speed Rail's $232 million-plus per mile average cost.[6,7] The most intensive application of the framework is projected to cost $84-$95 million per mile (2027$ dollars), while upgrading routes that are already grade separated or run through rural areas would be far cheaper, approximately $28-41 million per mile. These are conservative cost estimates, based on real-world examples of projects planned or built recently in the U.S. and Britain. Fourth, it lays in the infrastructure for future upgrades to true high-speed rail service.

The research shows that Momentum is most applicable to parts of the country with substantial amounts of publicly-owned or underutilized privately-owned tracks, predominately the Northeast and Midwest. Beyond available infrastructure, both regions are home to established commuter and intercity operations that have constituencies and political support, key ingredients to building support for funding.

5 Goldwyn, Eric; Levy, Alon; Ensari, Elif; Chitti, Marco. "How to Improve Domestic High-Speed Rail Project Delivery." NYU-Marron Institute of Urban Management. 2024. https://transitcosts.com/high-speed-rail/

6 Average of $202 million per route mile was derived from the $34.7 billion estimated price tag (exclusive of rolling stock) divided against the 171-route mile segment length. Adjusted from 2023$ to 2027$ assuming 3.5% inflation.

7 United States. California. High Speed Rail Authority. "2023 Project Report Update." Pg 2. https://www.documentcloud.org/documents/25473749-2023-project-update-report-final-022823/

3 The Basics

Credit: Marc Hermann/MTA

3 The 'Momentum' basics

The Momentum framework consists of a series of infrastructure designs focused on making the most out of existing rights-of-way by boosting speed and efficiency wherever possible, as detailed below. These improvements are most likely to be installed on existing rights-of-way already owned by the public or on underutilized freight routes that are sold back to taxpayers for expansion of passenger service. High-level platforms that sit at the same height as the trains' doors allow riders to step on and off, saving time at every station stop. Those efficiencies grow when railroads optimize passenger car designs with wider doors. Swapping diesel for electric power improves acceleration, saving time by getting trains up to speed more quickly. Those gains are increased by using high-performance designs with subway-style propulsion instead of locomotives. The benefits compound at every stop and add up over the course of a route. Real-world trip time improvements of 13%-29% are obtainable for both commuter and intercity services.

This would give cities, suburbs and outlying towns and hamlets significant new opportunities to strengthen their communities and economies, while tackling traffic and pollution. Faster service makes it easier for workers to return to their desks, boosting business districts; or to come to town for dinner and a show, boosting shopping and theater districts. Conversely, faster service makes it easier for city dwellers to see family or to make weekend trips for shopping, relaxing and the outdoors.

A review of 17,000-plus pages of documents spanning five decades from the United States, France, the United Kingdom and Australia — including planning and ridership studies, capital program proposals, environmental impact statements, reviews, audits, and after-action reports — not only bolstered the findings of the Momentum models, it revealed that components of this framework undergirded key inter-city and commuter railroad improvement programs in the 1960s and 1970s.

British Rail's modernization of the key rail line linking London to Liverpool, Manchester and Glasgow slashed trip times through use of electrification and high-performance trainsets.[8,9] It spurred substantial ridership growth even amid a larger structural decline. Trips between Manchester and London jumped by 27% and trips between London and Liverpool shot up 58%.[10,11] New York State used the same playbook — expanded electrification, and high-performance trainsets, plus level boarding — to reequip Metro-North and the Long Island Rail Road between the mid-1960s and the mid-1980s.[12] Newspaper articles show that riders responded positively to the two major electrification projects of the era, the Ronkonkoma Branch and the Upper Harlem Line. Today, the LIRR and Metro-North are two of the most used railroads in the country.

The federal government's Metroliner and Electrak programs during the 1960s and 1970s were anchored in these designs, too. They transformed Amtrak's Washington-to-New York service into a money maker and provided the railroad with one of very few bright spots during its first decades of existence. In the 1990s, Congress finally allocated the money to extend the improvements as was first planned in the 1970s to the north end of the line, from New Haven to Boston. Within a few years, Amtrak had won the bulk of the market from the airlines.

However, beyond the Northeast Corridor in recent years, the U.S. has only applied this design framework to metro services and green-field high speed systems, like California's High Speed Rail program. For example, three significant studies of major inter-city rail corridors — Chicago to St. Louis, Chicago to Detroit and New York City to Albany — did not evaluate electrification or universal installation of high-level platforms as ways to boost performance using existing rights-of-way. Documents show that electrification in one of those major studies was only viewed to deliver substantial gains if train top speeds exceeded 125mph.[13,14] Level boarding was viewed as a nice-to-have that improved accessibility and reliability, instead of an essential tool to speed service.[15]

8 United Kingdom. British Rail. 'Your New Railway: London – Midlands Electrification'. April 1966. https://www.documentcloud.org/documents/25453279-liverpool-london-launch/

9 United Kingdom. British Rail. 'Electric all the way: London to Glasgow'. 1974.

10 Evans, Andrew. 'Intercity Travel and the London Midland Electrification'. Journal of Transport Economics and Policy. January 1969, Vol. 3, No. 1. Pg 69-95. https://www.documentcloud.org/documents/25453283-study-evans-intercitytravellondon-1969/

11 Evans hypothesized the difference between Manchester and Liverpool could be attributed to British Rail making new discounted fares available for Liverpool at the time of electrification.

12 United States, New York. Metropolitan Commuter Transportation Authority. 'Metropolitan Transportation — a program for action. Report to Nelson Rockefeller, Governor of New York.' 1968. https://ia600208.us.archive.org/1/items/metropolitantran00newy/metropolitantran00newy.pdf

13 The New York State Department of Transportation's Empire Corridor Environmental Impact Statement describes 125mph as "the first speed threshold for electrically powered trains" and only examined electrification between Albany and Buffalo. It did not study electrifying the far more heavily traveled and densely scheduled section of the line from Croton-Harmon to Albany. Nor, did it consider Croton-Harmon to Poughkeepsie, which is entirely publicly owned, despite the obvious applicability.

14 United States. New York. State Department of Transportation. "Empire Corridor Tier 1 Draft EIS [Environmental Impact Statement]." Pg ES-8. https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/

15 "Empire Corridor Tier 1 Draft EIS [Environmental Impact Statement]." Pg 3-24,

3.1 A game-changer for existing routes

Our models found that rights of way rated for traditional speeds, 80-125 mph, would benefit immensely from the Momentum program. Application of those models to the three aforementioned real-world intercity routes — New York City-Albany, Chicago-Detroit, Chicago-St. Louis — showed that the high-throughput framework would transform trains from being the slowest mode of travel to out-competing driving without any stops. New York to Albany would take approximately two hours; Chicago-Detroit could be as fast as 3h50m;[16,17] Chicago-St. Louis would take four hours.[18] The gains are such that train travel times would fall to within an hour of trip times by plane for routes that are up to 300 miles. This represents an order-of-magnitude improvement in the competitiveness of passenger rail using existing routes. The Northeast Corridor shows that this level of performance is sufficient for rail to win substantial market share and, potentially, even operate at a profit.

The Chicago to Detroit route is just one example of the Momentum's game-changing ability, particularly when paired with other-long planned improvements. The current service between Chicago and Grand Rapids has a trip time of 4h4m, which makes it an hour slower than driving between the two cities. The route, as currently configured, attempts to minimize the time penalty from the diesel service by skipping all stations between Chicago and St. Joseph. North of St. Joseph, the route is no quicker than 65mph for the remaining 80-plus miles to Grand Rapids and makes intermediate stops in Bangor and Holland. Momentum would provide a quicker and more useful service. This revamped line would run along the shared and improved electrified route with the Detroit-bound Wolverine from Chicago to New Buffalo, where it would turn north and follow its current route. Momentum plus the Chicago improvements would cut trip times to 3h18m. Electrification would unlock further improvements, like higher top speeds. This would allow trains to hit 110mph between New Buffalo and Grand Rapids which would save even more time. The combined package cuts trip times to 2h35m minutes. That's faster than driving and as quick as flying when, again, factoring in airport time.

Momentum, then, offers the potential for transformative improvements to commuter and intercity service in the U.S. through the combination and application of proven design principles.

3.2 Component: Level Boarding (High-Level Platforms)

One of the surest ways to speed up rail travel is to decrease the amount of time that trains need to spend at each station, which is dictated by how much time it takes to board and disembark passengers. Many passenger rail systems require riders to use stairs to board and disembark from trains. This is because they still have stations with low-level platforms, which are just eight inches tall. That means there's a 40 inch gap between the top of the platform and the doors of the train, which are 48 inches high in the U.S. Navigating the stairs slows down the boarding and disembarking process in even the best-case scenario. Furthermore, it limits accessibility for the elderly and the disabled, plus it makes it more difficult to travel with bags or small children.

The Pennsylvania Railroad helped pioneer — and the MTA massively expanded — using a key design feature from subways systems to speed this process up: Level boarding.[19,20] It elevates the station platforms to the same height as the trains, 48 inches, allowing passengers to easily walk on and off. This eliminates the need for stairs and significantly speeds up alighting. High level platforms and level boarding are twice as efficient as low-level boarding, according to measurements from one commuter railroad.[21] Level boarding also makes the amount of time it takes to board and disembark passengers much more consistent and predictable because it dramatically improves accessibility, making it easier and quicker for people with restricted mobility, bags or families to get on and off.

The amount of time saved depends on the busyness of the station. If only three or four people use a stop per train in the peak hour, the performance gains are limited. However, even for moderately busy stations (say, a couple of dozen people or more getting off per train in the peak) the benefits

23 (Glossary). https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/

16 United States. Department of Transportation. Federal Railroad Administration. "Chicago - Detroit/Pontiac Passenger Rail Corridor Program." 2014. Ch. 2. https://www.documentcloud.org/documents/25482939-chi-det-chapter-2-alternatives-considered/

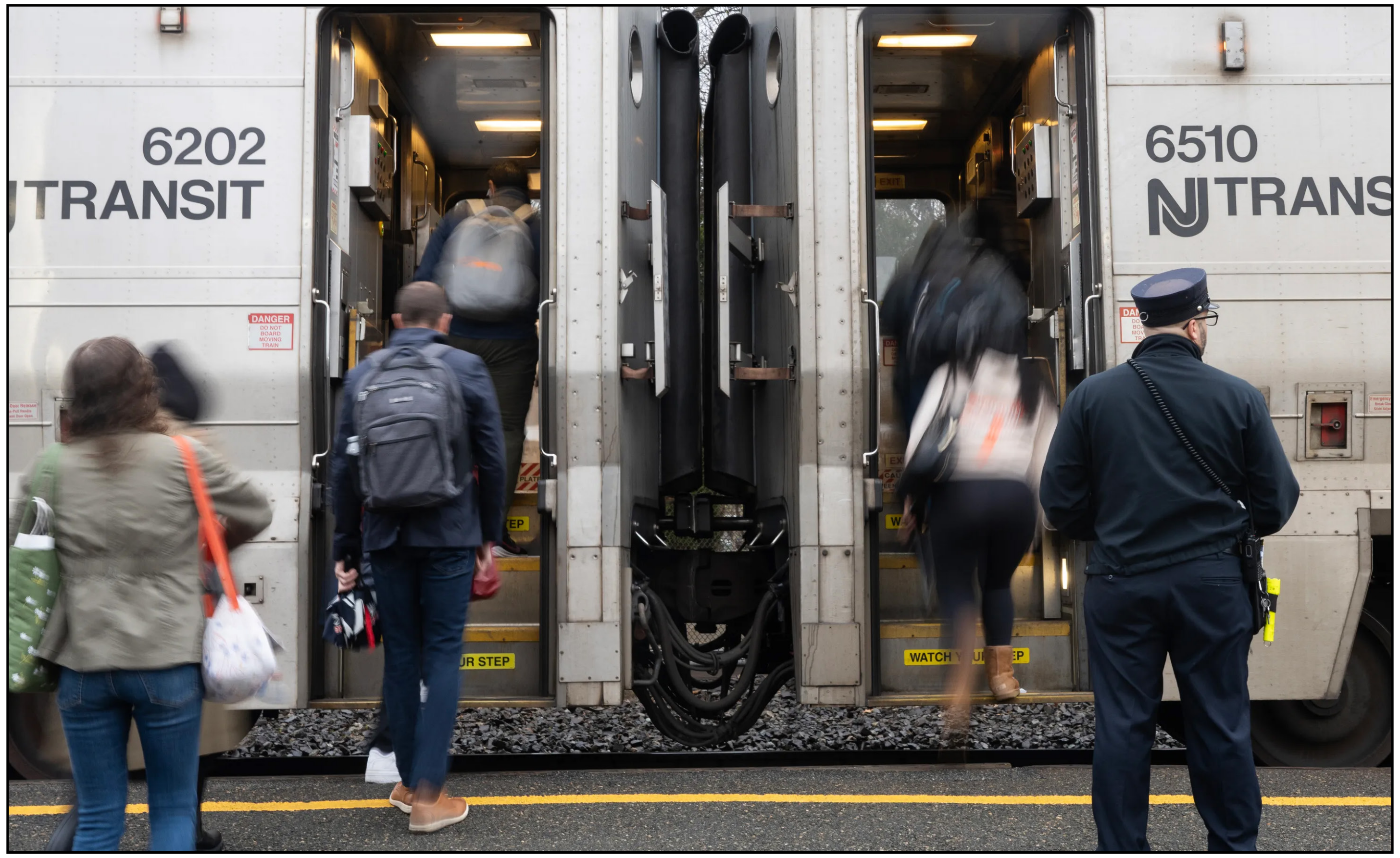
17 Time estimate includes construction of long-planned southeast Chicago-era capacity improvements. Route 2 assumed. https://railroads.dot.gov/sites/fra.dot.gov/files/2024-10/Chicago%20-%20Detroit-Pontiac%20Passenger%20Rail%20Corridor%20Program.pdf

18 The Chicago-St. Louis route currently contends with slow speeds in the approaches to its terminals, Chicago to Joliet, Ill. and Alton, Ill. to St. Louis, each of which are schedule to take about 50 minutes each.

19 It's unclear exactly when the Pennsylvania Railroad first began to use high platforms. But they were included in the original designs for the New York Penn Station, which opened in 1910, "[t]o accelerate the loading and unloading of the trains."

20 Raymond, Charles W. "The New York Tunnel Extension of the Pennsylvania Railroad." American Society of Engineers. Paper #1150. 1910. https://www.gutenberg.org/files/18229/18229-h/18229-h.htm

21 Interviewees L, Q



Commuters are required to use stairs to board trains at many NJ Transit stops. Additionally, the doorways are narrow, making it harder for riders to board. This slows down service and reduces accessibility for the elderly and the disabled.

Credit: The Bergen Record, northjersey.com

stack up quickly. These times below are rough average dwell times for a station of moderate busyness to illustrate the effect of level boarding.

Time to alight (commuter, non-terminal):

- Low-level platforms: 90-plus seconds
- High-level platforms: 60 seconds

Time to alight (intercity, non-terminal):

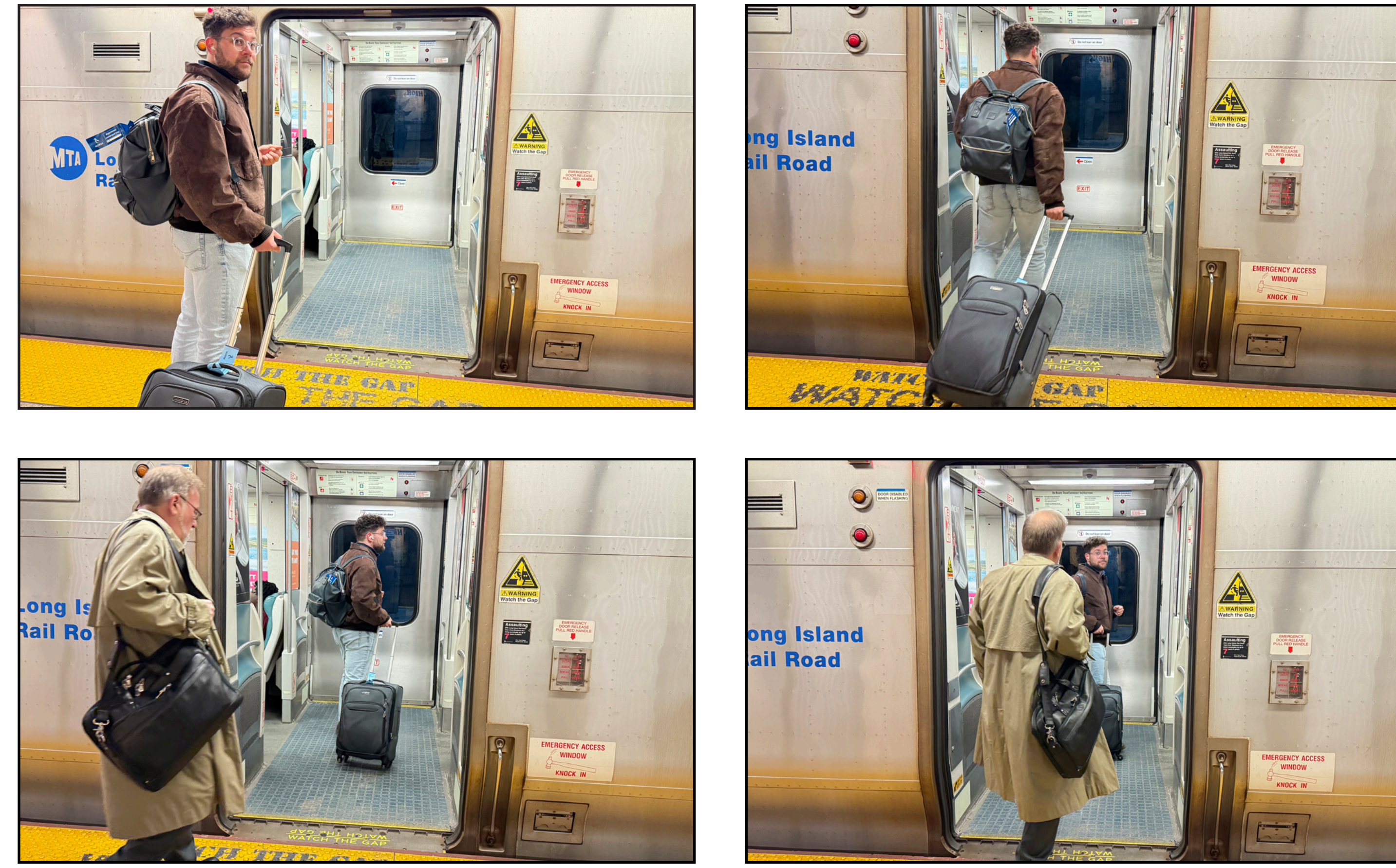
- Low level platforms: 240-plus seconds[22]
- High level platforms: 120 seconds[23]

3.3 Component: Optimized passenger car designs

Adopting universal high-level platforms and level boarding across a route — or an entire network — allows railroads to optimize their passenger car designs to further speed up boarding and disembarking, and further improve accessibility. Low-level platforms require railroads like Philadelphia's

22 United States. Federal Railroad Administration. "FRA Long Distance Service Study." Pg 116. February 2024. https://fralongdistancerailstudy.org/meeting-materials/; https://www.documentcloud.org/documents/25475552-rural-service-study/

23 Two minutes is the typical dwell along the Northeast Corridor for an Amtrak Northeast Regional Train, according to schedules generated from GTFS data feeds. https://railrat.net/routes/NortheastRegional/



This photo sequence illustrates how level boarding and wide doorways facilitate easy movement on and off trains, reducing dwells and getting riders to their destinations more quickly.

Credit: Nolan Hicks

SEPTA, New Jersey Transit and Boston's MBTA to purchase passenger cars that typically have two sets of narrow doors: One with stairs so riders can climb up from the low-level platforms; and the second at the 48 inch height to use for stations with high platforms. These doors are typically 32 inches wide, requiring riders to enter and exit single-file.[24, 25]

The MTA has made high-level platforms the standard across both of its commuter railroad systems, the Long Island Rail Road and Metro-North. That, in turn, allowed the MTA to adopt a passenger car design that features two sets of doors that are both 50 inches wide.[26] That's 18 inches wider than the designs found elsewhere on the Northeast Corridor because the MTA's design does not have to split space due to universal level boarding. This design change speeds up boarding and disembarking because passengers can enter and exit two-at-a-time, instead of in single file. The wider doors also make it easier for people in wheelchairs, or with walkers, or who have bags to easily get on and off of trains.

24 United States. Maryland. Maryland Area Rail Commuter. "Summary Minutes MARC Riders Advisory Council Meeting." May 2013. Pg 11. https://www.documentcloud.org/documents/25473800-multilevel-specs/

25 Campisi, Anthony. "SEPTA issues new timeline for Silverliner V cars." WHYY (Philadelphia public radio). Oct. 2009. https://whyy.org/articles/septa-issues-new-time-line-silverliner-v-cars/;

26 Bombardier. "Design Data for Electric Multiple Units". https://www.document-cloud.org/documents/25473801-m7-specs/

Level boarding with optimized train design (Commuter):

- Narrow doors: 60 seconds per stop[27]
- Wide doors: 30 seconds per stop[28,29]

Level boarding alighting with optimized train designs (Inter-city):

- Narrow doors: 120 seconds per stop[30]
- Wide doors: 60 seconds per stop

3.4 Component: Diesel vs. Electric

Diesel trains suffer from extremely slow acceleration when compared to their electric counterparts. For the MBTA, the poor performance combined with frequent stops means that a diesel commuter train running between Providence and Boston goes no faster than 75 mph even as it runs on the same tracks where Amtrak's electric trains can hit 150mph. For Amtrak and Metro-North, it means that speeds on the Hudson Line don't exceed 80 mph between Croton-Harmon and Poughkeepsie, despite relatively straight track that should support higher speeds.

Top speeds are just one component of going faster. Electric trains can shorten travel times thanks to their better acceleration and performance, potentially cutting an average of 25 seconds off of each stop on a route where diesels could reach 80 mph. Additionally, the better performance means that top speeds may be able to be increased on routes where poor diesel performance limits top speeds, like on the Hudson Line or the 65-mph limit on the LIRR's Montauk branch.

Time to 80-mph (Single-level, 8-car train):

- Diesel locomotive: 120 seconds[31,32]
- Electric locomotive: 95 seconds[33]
  - Multi-levels are approximately 15% slower due to increased weight (110 seconds)

27 This was a rule of thumb constantly cited in interviews. However, it's important to note that this is variable and changes depending on how many passengers are using each stop.

28 United States. New York. State Department of Transportation. "Hudson Line Railroad Corridor Transportation Plan." 2005. Pg. 12. https://www.documentcloud.org/documents/25499074-2005-hudson-river-line-plan/

29 Confirmed by interviews and observation of MTA operations via MTA Radar. https://radar.mta.info/

30 This was a rule of thumb constantly cited in interviews. However, it's important to note that this is variable and changes depending on how many passengers are using each stop.

31 Obtained

32 The MTA says it takes about 180 seconds for their diesel locomotives to hit 80 mph, see Section 11.

33 Obtained

3.5 Component: EMUs vs. Locomotives

The gains from electrification are maximized by adopting trains with higher-performance characteristics, formally known as electric multiple unit trains. EMUs offer superior performance to the traditional train setup, where the passenger cars are pulled or pushed by locomotives because they can put down far more traction. A traditional train has to get the entire weight moving by pushing or pulling the train from one end or the other. EMUs have several cars with self-contained motors that can put traction down on the rails. It's the equivalent of all-wheel drive, but on the rails. Additionally, spreading traction across the length of the train also means that, unlike with locomotive-hauled trains, the acceleration performance does not degrade as a train gets longer.

These characteristics make EMUs particularly well-suited for routes with several stops, where the benefits of quicker and consistent acceleration add up. The MTA uses EMUs on its commuter railroads, known as the Metropolitans. Philadelphia's SEPTA makes widespread use of them too. Its model is called the Silverliner. NJ Transit has some as well, called the Jersey Arrows.

Time to 80-mph (single level, 8-car train):

- Electric locomotive: 95 seconds
- EMU: 60 seconds[34]

3.6 Outcome: Momentum's compounding service benefits:

The Momentum benefits build on each other. For commuter services, it would take a diesel locomotive pulling eight single-level passenger cars approximately 120 seconds to get up to 80 mph. Plus, it would take another 90 seconds to board and disembark passengers at a moderately busy station with low platforms. That's a combined penalty of approximately 210 seconds per stop. The Momentum framework, fully applied, reduces that to approximately 90 seconds per stop — a saving of 120 seconds (two minutes), per stop. Over a 12-stop route, that adds up to 24 minutes in each direction.

For intercity services, the trains also take 120 seconds to get up to speed, but the dwells increase to 240 seconds (four minutes) or more at each station. That's a total penalty of approximately 360 seconds (six minutes) per stop. The Momentum framework, fully applied, not only means that

34 Composite time. The Jersey Arrows runs from 0-80 mph in about 57 seconds; SEPTA Silverliners can do it in about 61 seconds; the MTA's M8s can do it in 68 seconds, according to the RFP specifications.

Momentum's time savings

Per stop:

Commuter routes: 120 seconds per stop (2 minutes)

Intercity routes: 240 seconds per stop (4 minutes)

Providence-Boston

Current: 73 minutes
Momentum: 54 minutes

Chicago-Detroit

Current: 5h:25m
W/Chicago Capacity: 4h25m
W/Momentum: 3h33m-3h50m

the trains would accelerate to 80mph in just 60 seconds, but that each stop would now only take 60 seconds thanks to level boarding. That's a combined savings of 240 seconds (four minutes) per stop. Over a route with 10 stops, like Chicago-St. Louis, that adds up to a service that's 40 minutes faster from improved efficiency alone.

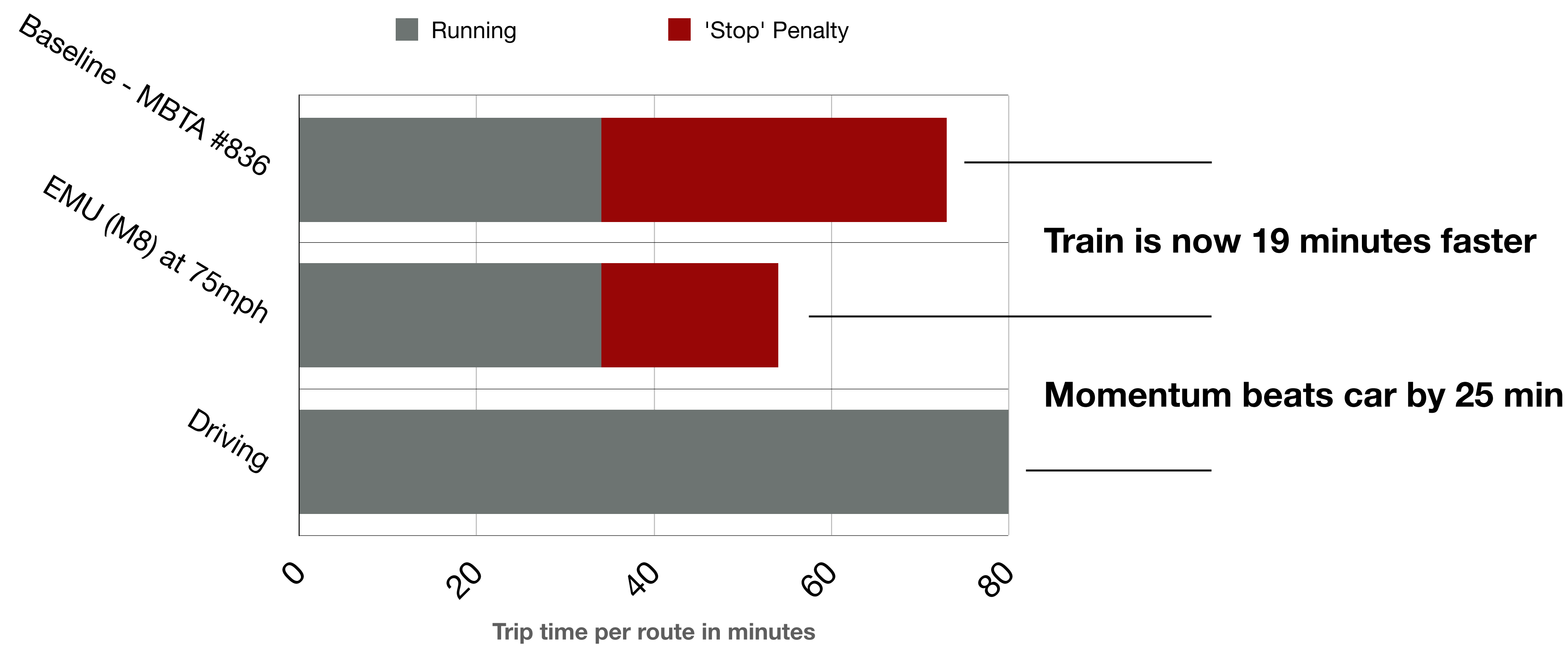
3.7 Outcome: A universal rail infrastructure framework

One major challenge confronting passenger rail service in the U.S. is that the comparative small size of the operators and their differing standards for train design and service mean that there is a lack of industry scale. This problem is compounded by Buy America manufacturing requirements imposed by the federal government, which makes it difficult to source components — particularly rolling stock — from Europe or other places where the passenger rail industry is much more sizable. For example, the MTA's commuter railroad train designs are highly optimized to reduce travel times. However, these designs can only be used on the MTA's railroads because it is one of the only operators in the U.S. to have adopted universal high-level platforms. Adopting a shared infrastructure design framework, like Momentum, would help rail providers by allowing for the standardization of train designs, which, in turn, would help boost competition and keep train manufacturing plants busy. The goal would be to eventually reach a purchasing scale that hasn't been seen since the collapse and divvying up of the old Pennsylvania Railroad, reducing costs and speeding procurement. Additionally, a shared and unified infrastructure framework would remove the interoperability concerns that are frequently cited by Amtrak and transit operators as a major barrier to expanding service between New York and New Jersey.

3.8 Outcome: Improved reliability

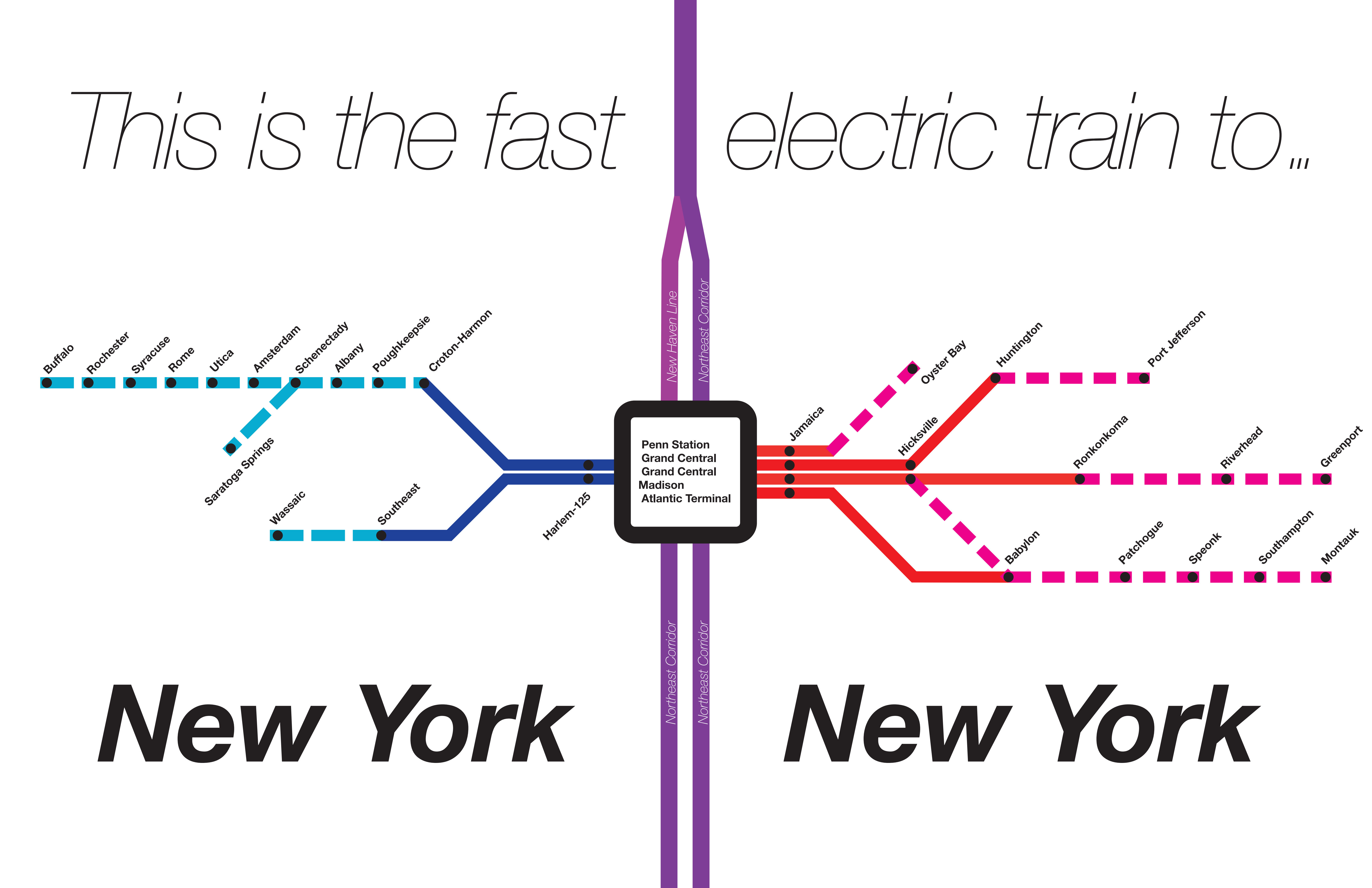
Beyond speed, electrification paired with EMUs would

A comparison Providence-Boston trip times



dramatically improve service reliability across the country. This data is limited but statistics on reliability by fleet published by the MTA show that EMUs are far more reliable than locomotive-hauled trains. Metro-North uses the same diesel locomotives commonly found in Amtrak's fleet: the General Electric Genesis locomotives. The GEs average 43,000 miles between failures.[35] (The reliability of the LIRR's diesel locomotives, which were made by Electro-Motive Diesel, is even worse at 19,000 miles between breakdowns).[36] By comparison, the MTA's fleet of M8 EMUs posts an average distance between failure of more than 746,000 miles (June 2024, rolling 12-month average).[37]

35 US. New York. Metropolitan Transportation Authority. https://data.ny.gov/Transportation/MTA-Metro-North-Mean-Distance-Between-Failures-Beg/4qd6-ptxx/about_data
36 NY-MTA. https://data.ny.gov/Transportation/MTA-LIRR-Mean-Distance-Between-Failures-Beginning-/cpjs-d6ua/about_data
37 NY-MTA. https://data.ny.gov/Transportation/MTA-Metro-North-Mean-Distance-Between-Failures-Beg/4qd6-ptxx/about_data



This is the fast
electric train to...
New Haven Line
Northeast Corridor
Buffalo
Rochester
Syracuse
Rome
Utica
Amsterdam
Schenectady
Albany
Poughkeepsie
Croton-Harmon
Saratoga Springs
Wassaic
Southeast
Harlem-125
Penn Station
Grand Central
Grand Central
Madison
Atlantic Terminal
Jamaica
Oyster Bay
Huntington
Port Jefferson
Hicksville
Ronkonkoma
Riverhead
Greenport
Babylon
Patchogue
Speonk
Southampton
Montauk
Northeast Corridor
Northeast Corridor
New York
New York

4

Electric ‘Empire’

A Grand Central-bound M8 passes an Penn Station-bound Amtrak train on the New Haven Line.

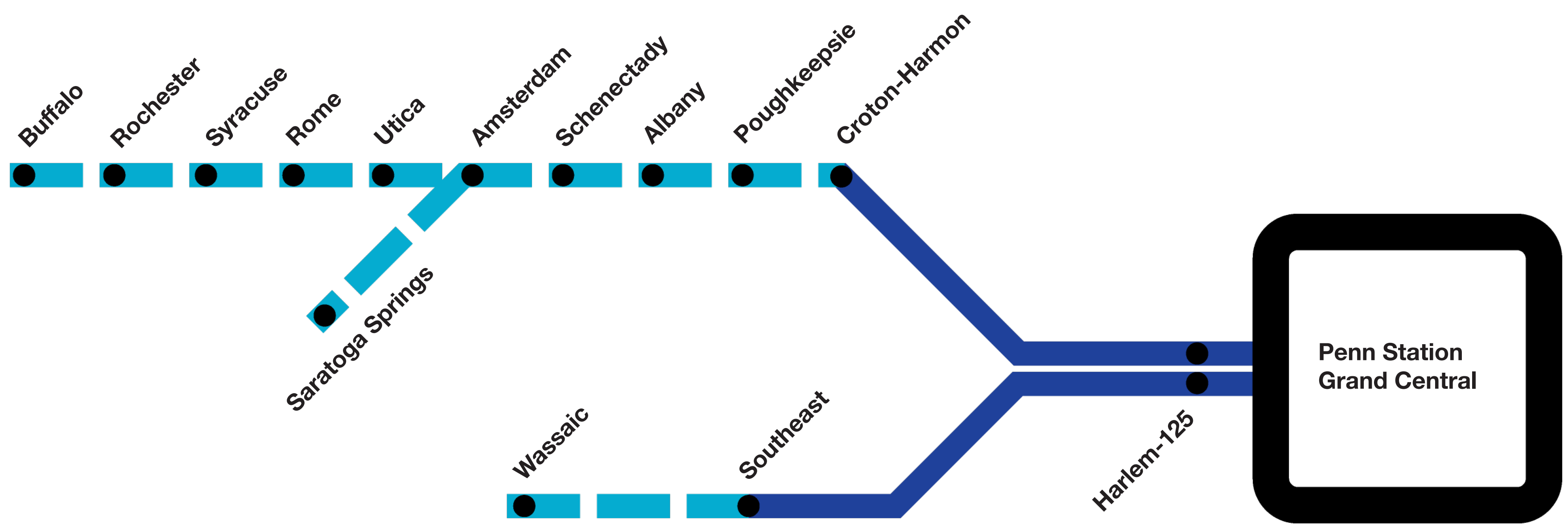
Credit: Jason Rabinowitz

4 An Electric ‘Empire’ State

There is perhaps no better case study to illustrate how a high-throughput infrastructure framework can transform underutilized railroad rights-of-way into an engine of mobility and opportunity than New York. The state is home to three sprawling networks of main lines. The eastern network was built or consolidated by the Long Island Rail Road, which is now part of the Metropolitan Transportation Authority. It also inherited a famed network of western lines largely built by the New York Central Railroad, which stretches from New York City to Albany and Buffalo and beyond. However, the 1970s collapse of the railroad industry left the management, maintenance and operation of this portion of the system badly splintered between at least four entities: the MTA, the New York State Department of Transportation, Amtrak and a freight railroad, CSX. The third network, the New Haven Line, conceptually bisects the eastern and western networks. It is managed and operated by the MTA as part of a joint agreement between New York State and Connecticut.

The New Haven Line was among the very first lines in the entire country to have its length electrified. Subsequent major investments upgraded the entire route to the high-level platforms, which allowed for the adoption of the optimized

Network West



passenger train car designs that speed up boarding and disembarking.[38] But, it is beset by curves that lower speeds. However, the Momentum infrastructure framework allows Metro-North to squeeze a great deal of capacity out of a sub-optimal situation. The result is frequent service that is often faster than driving and an essential component to life in Westchester County and southeast Connecticut.[39] The New Haven Line not only makes it far easier than it otherwise would be to commute into New York City, it has also allowed Connecticut's major cities to tap into the Big Apple's jobs engine and fuel their local economies.[40]

The New Haven Line shows how a modernized and unified Network West has to reinvigorate communities throughout the Hudson Valley, Capital Region, Mohawk Valley and beyond to Buffalo. A fully upgraded, unified and electrified Hudson Line would serve as the backbone of the network. The comparative straightness of the route would allow trains to race between New York and points north and west at speeds far higher than those on the New Haven Line. The main peak direction between New York City and Poughkeepsie — which makes all stops north of Croton-Harmon — would take just 88 minutes, saving riders potentially 23 minutes each way. Trains could sprint between New York City and Albany in 1h54-2h4m, depending on the level of investment.

Beyond Albany, the program would put the vast physical plant left behind by the New York Central fully back to work. It calls for purchasing the Water Level Route back from CSX, returning it to its four-track configuration and dedicating two of those tracks to passenger service. Electrification and modernization would make Utica just a three-hour trip from New York City (3h4m-3h18m), which is 90-plus minutes quicker than service today. That would make Utica as easy to get to from Manhattan as Washington D.C. It would mean that New York and Syracuse would be less than four hours apart, making it closer by train to the Big Apple than Boston. A full build-out would cut up to three hours off of the trip between New York and Buffalo, turning it into a trip potentially as quick as just 5h32m.[41, 42] That means you could get on a train in Buffalo at 7am and be in New York by lunch-time. It's also far quicker than driving, despite the route's geographic inefficiencies.

In sum, the Network West would deliver one of the biggest expansions and accelerations of transportation between New York City and upstate communities in history. This network is often referred to as the Empire Corridor in planning documents, but it is treated in practice as a series of disjointed segments. That obviously would not work well for a program of this level of ambition. This report views the line as a cohesive system — as the old New York Central did — hence the Network West designation. Executing this project would require unifying ownership and management of the line, which this paper proposes be done through the MTA. The Network West program is detailed in Section 5.

Network West Trip Times

NYC-Poughkeepsie:

Current: 1h51m (Local)
Momentum: 1h28 (Local)

23 minutes faster

NYC-Albany:

Current: 2h25m - 2h41m
Momentum: 1h54m - 2h5m

31-36 minutes faster

NYC-Utica:

Current: 4h30m - 5h05m
Momentum: 3h4m - 3h18m

86-107 minutes faster

NYC-Syracuse:

Current: 5h39m-6h11m
Momentum: 3h42m-3h55m

117-141 minutes faster

NYC-Buffalo (Exch.):

Current: 8h-17m-8h35m
Momentum: 5h32m-5h47m

165-172 minutes faster

38 Prial, Frank J. "Penn Central Disappoints Ronan." *The New York Times*. Sept. 18, 1972. Pg 1. https://www.nytimes.com/1972/09/18/archives/penn-central-disappoints-ronan.html

39 Joyce-Johnson, Seamus C., "'Its Cargo Is People': Repositioning Commuter Rail as Public Transit to Save the New York–New Haven Line, 1960–1990." Yale University. 2019. (Harvey M. Applebaum '59 Award). https://elischolar.library.yale.edu/applebaum_award/18/

40 Prevost, Lisa. "Now Arriving: Reverse Commuters." The New York Times. August 12, 2007. https://www.nytimes.com/2007/08/12/realestate/12wczo.html

41 Momentum analysis

42 Momentum's analysis built three scenarios: The first assumes electrification, and corresponding right-of-way improvements to the existing Water Level route to allow for top speeds on the various segments between Albany and Buffalo of 110-125mph; the second added improvements to the approach to New York Penn Station and the power system of the Lower Hudson Line for improved speeds; the third looked at potential benefits of a new high-speed (165mph) right-of-way constructed between Syracuse-Rochester-Buffalo. That could cut trip times between NY-Penn and Buffalo-Exchange to 5h4m.

Network East (LIRR) Trips

NYC-Port Jefferson:

Current: 109 minutes
Momentum: 90 minutes

19 minutes faster

NYC-Oyster Bay:

Current: 78 minutes
Momentum: 58 minutes

20 minutes faster

NYC-Patchogue:

Current: 87-90 minutes
Momentum: 71-74 minutes

16 minutes faster

NYC-Southampton:

Current: 2h31m (151m)
Momentum: 2 hours (120m)

31 minutes faster

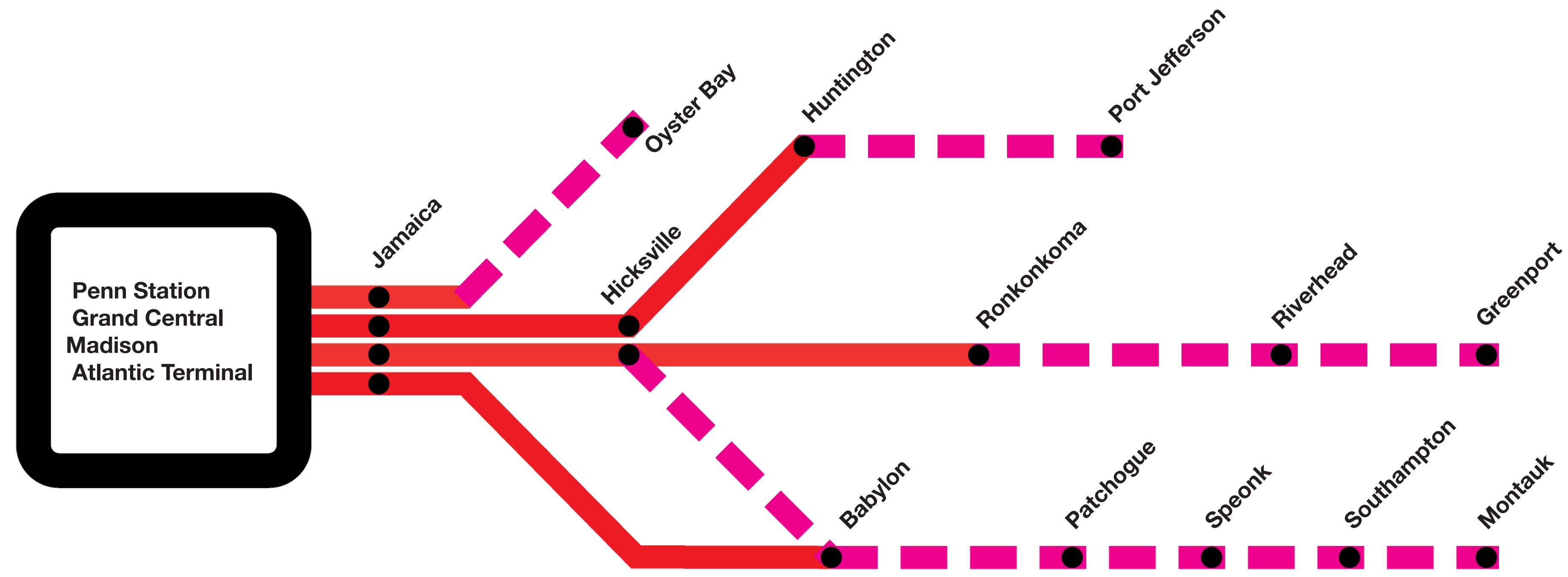
Network East — the Long Island Rail Road — is one of the oldest and most commented-upon rail systems in the country. Plans for near-universal electrification of the LIRR system date back to the 1940s, but only little progress has been made over the years. The railroad had been electrified as far as Babylon and East Williston via Mineola by the time of the state takeover in the 1960s. State bonds in the 1960s and MTA bonds in the 1980s financed expansions of electrification to Huntington and to Ronkonkoma. But, further expansions have stalled due to high costs. That hasn't lessened the public pressure on the agency to expand electrification, leaving MTA planners stuck between a rock and a hard place.

This report has identified the MTA/LIRR's decision to pursue expansion of its third rail power system as a major contributor of these high costs. Adopting overhead catenary systems commonly found elsewhere in the U.S., U.K., Australia, France and elsewhere would slash the costs of extending electrification from $49-$62 million per double-track mile (third rail) to between $11-$27 million (overhead). The trains would run on the overhead wires until reaching the third rail network and then switch over, just as every train on the New Haven Line does every day. This paper explores how this would work utilizing the currently proposed Port Jefferson Capacity Project in Section 6 and calculates it would reduce the price tag by $700 million. The debate between overhead catenary power and third rail is fully examined in Section 10, including an in-depth look at the economics and performance of both systems.

Improvements in trip times would be just as dramatic on the LIRR's Network East services as they are for Network West. The direct service between Penn Station and Oyster Bay, the end of the line, would take just 58 minutes, 20 minutes quicker than today. Port Jefferson into New York-Penn would become a 90-minute trip, which is 19 minutes quicker than the current time. Trip times into New York City from Patchogue would be cut from the current 87 minutes down to potentially 71 minutes.[43] Overall, the average trip between Manhattan and

43 Service speeds leading into the Port Jefferson Branch's diesel territory appear to be far slower than those leading into to the Montauk Branch territory. For instance, the Port Jefferson diesel trains are allotted 18 minutes to go between Hicksville and Huntington,

Network East



the stops on the Inner Montauk Branch would be 16% quicker, while the average trip length between Manhattan and stops on the Outer Montauk would drop by 23%. Additionally, the capacity improvement program proposed alongside would add double-tracking as far to the east as Southampton, allowing the MTA to dramatically expand service offered on the South Shore. Currently, the route is only single-tracked and offers only see two direct trains during the peak into Manhattan in the off-season.[44] The Port Jefferson Branch would also receive a similar package of upgrades.

A concerted program to fully build out New York's Network East and Network West rail systems would be an expensive endeavor, but one that has clear and obvious benefits for the Empire State. Fast and frequent rail service between New York City and upstate communities — Hudson Valley, Central New York and Western New York — would provide a massive shot-in-the-arm for efforts to bolster their post-manufacturing economies. The Network East expansion of electrification on Long Island would speed commutes, battle traffic on the congestion-clogged island and alleviate the parking crunch at LIRR Main Line stations. It would make it easier for

which is just 10 miles. However, differing routings make direct comparison using the schedules difficult.

44 LIRR trains #5 and #41

Electric 'Empire' Costs and Funds

Network East (LIRR):

Oyster Bay: $1.1-$1.2 billion
Port Jefferson: $2.2-$2.4 billion
Inner Montauk: $3.2-$3.5 billion
Central Branch: $600-$700 million
Outer Montauk: $2.8 billion
Ronkonkoma: $2-$2.2 billion

$11.9-$12.9 billion

- Packages designed to fit future MTA Capital plans

Network West:

To Pougkeepsie: 1.3-$1.5 billion
Poughkeepsie to Albany: $2.1-$2.4b
Albany to Saratoga Springs via Schenectady: $2.7-$3 billion
Schenectady to Syracuse: $13.1-$13.9 billion
To Buffalo: $14.1-$14.8 billion

$33-$35.6 billion

- Funded by MTA Capital: $2.7-$3.1 billion
- Funding need: $30.3-$32.5 billion ($1b/yr)

suburbanites to visit Broadway, museums and other major attractions; and for city residents visit their families, explore the parks and make trips to the famous beaches of the East End and the barrier islands.

Momentum designed its program to be package-based. Additionally, the packages covering the MTA's commuter railroads were structured to fit within the authority's future capital programs, provided that those remain roughly the same size as at present — approximately $65 billion, after adjusting for inflation. Each MTA railroad package would cost about $3 billion, which is roughly the amount spent on commuter railroad modernization and expansion in a typical capital program.[45] This would build a rolling and iterative electrification and modernization effort that upgrades one or two major line segments at a time.

For example, a first package could fund the Upper Hudson Line project, which would cost between $1.3-$1.5 billion; leaving $1.5 billion available to begin the important structural work on the Port Jefferson Branch. The second package would fund the remaining $1 billion of Port Jefferson Branch project and use the other $2 billion to tackle the structural work on the Inner Montauk Branch. The third package would complete the electrification of the Inner Montauk Branch and fund the overhaul of the Central Branch; and so forth. Each package would stand alone and deliver substantial value to riders and taxpayers — all while building towards a cohesive, all-electric future for the MTA. The authority has already begun to take steps in this direction, including $800 million for electrification expansion its proposed 2025-2029 Capital Program.[46] That would be sufficient to jump-start the electrification of either the Upper Hudson Line or the Port Jefferson Branch; see Section 5 and Section 6.

Overall, the cost of upgrading the MTA's portions of the network is projected to run between $14.6-$16 billion, which would be divvied up across five or six successive capital plans under this scenario. These costs exclude the $2.8 billion likely required to expand the fleet to provide the new service. The bulk of the MTA's commitment would go toward the Network East upgrades for the LIRR. The complete electrification of the LIRR system, plus an extensive double-tracking and grade separation program for the Port Jefferson Branch and Montauk Branch would cost $12-$13 billion. Two portions of the MTA's Metro-North system would be included in the Network West upgrade program: The Hudson Line through to Poughkeepsie; and the Wassaic segment of the Harlem Line. The upgrades for these two lines would cost approximately $2.7-$3.1 billion.

Funding the upgrades beyond the MTA's existing territory would require the governor and state lawmakers to provide non-MTA funding. There are a litany of ways to provide this funding, including a new state bond, a value-capture program based on increased revenues from existing taxes or a new levy.

Extension of the Network West upgrades from Poughkeepsie to Albany would cost $2.1-$2.6 billion. Expanding the network further to Saratoga Springs via Schenectady, delivering rapid and electric service throughout the entire Hudson Valley and Capital Region, would cost $2.7-$3 billion. The most expensive portions of the program would be the extensions to Syracuse and then onward to Buffalo. Those two projects, each roughly 130-miles long or more, would cost $13-$15 billion, apiece. In total, it would cost $30-$32 billion (in 2027$) to modernize and electrify from Albany to Saratoga Springs via Schenectady and then from Schenectady onward to Syracuse and Buffalo. The bulk of the money would

LIRR riders change to a diesel train at Babylon, which is the current end of the electric service area on the South Shore.

Credit: Nolan Hicks

45 Capital programs come every 5 years. The MTA attempts to dedicate about 70-80% of spending to New York City Transit and 20-30% to the commuter railroads. Those funds are then divided again, with about 80% flowing to maintenance and replacement projects and about 20% to expansion and modernization projects. Using these rules, a $65 billion MTA capital program would result in about $16 billion being dedicated to the commuter railroads, of which $3 billion would go to expansion and modernization. This is how we arrived at the proposed $3 billion package size.

46 US. NY. MTA. "2025-2029 Capital Plan: The Future Rides With Us." 2024. Pgs 167, 201, 223.

be spent on restoring two tracks to the corridor between Schenectady and Buffalo for passenger service. Despite the price tag, this remains far cheaper than a traditional high-speed rail build out, which would cost more than $70 billion.[47] It ensures that smaller communities like Amsterdam, Schenectady, Utica and Rome would benefit from the improved service and connections to New York City.

The costs for the Network East and Network West programs are well within the realm of other major public works in New York State. The reconstructions of LaGuardia and John F. Kennedy airports are expected to cost a combined $27 billion.[48] The new Port Authority Bus Terminal in Midtown carries a $10 billion price tag. Furthermore, the Network East and Network West programs will provide substantial additional value for money, as they will significantly expand and accelerate the transportation available throughout the state. The typical commuter train can carry 1,000 people; intercity trains average about 500. That means every fast electric train on a Momentum-equipped route is the equivalent of adding three or four flights a day to New York City. Twelve trains a day between New York City and Syracuse would be worth 36 new flights a day between the cities; ten trains a day between Buffalo and New York would be worth roughly 30 new flights. This is especially important because neither New York City airport has the space to add new runways or flights in the peak hours. This dramatic expansion of capacity will deliver significant return on investment by speeding commutes and making it easier and quicker than ever for millions of New Yorkers to travel across the state without having to worry about a car.

Decades of research from the United Kingdom show that speeding up service is one of the most effective ways to get commuters and travelers to pick passenger rail. Transport for London, the agency that runs the British capital's transit systems and roads, found a strong link between reduced trip times and boosted ridership — the core goal of any electrification program — after opening the Elizabeth Line.

Momentum developed a basic model, based on these findings, to project which MTA commuter rail lines would see the biggest ridership gains from electrification.[49] The projected time savings were then cross-referenced with those

47 California High-Speed Rail Phase 1 costs applied to 296-mile route length of Albany-Rensselaer to Buffalo-Exchange in 2027 dollars.

48 McGeehan, Patrick. "Why Tugboats Are Key to the $19 Billion Overhaul of Kennedy Airport." *The New York Times.* Oct. 10, 2023. https://www.nytimes.com/2023/10/10/nyregion/jfk-airport-reconstruction-barges.html

49 There was granular ridership data available for the LIRR, so this analysis inputted the average travel times for each stop on an LIRR diesel branch using a sample service pattern and tickets sold for each stop. Ticket sales data was only publicly available for each line segment on Metro-North, so we calculated the time savings from a mid-point on the line to ensure a conservative estimate.

achieved by two substantial and recent rail electrifications in the U.S. and the U.K. to confirm feasibility.[50,51]

This analysis found that the greatest jump in ridership would come from the electrification and acceleration of Metro-North's Upper Hudson Line, the first leg of the Network West program. The Port Jefferson Branch would yield the largest number of total riders on a per-segment basis for the LIRR and the second-largest increase on the railroad's network. The Inner Montauk and Outer Montauk branches combine for the largest overall increase in ridership, but separately would generate the third and fourth largest increases. The Oyster Bay Branch is an excellent candidate for electrification, as the short distances between stations mean it would benefit massively from the improved performance of electric service and see the largest percentage increase in ridership. However, its low ridership baseline means it would be the fourth-most used line in overall. There is a sizable drop-off in potential ridership before arriving at the Wassaic segment of the Harlem Line. The Ronkonkoma Branch's diesel territory placed dead last for potential short-term ridership growth.

Figure 1: Projected initial ridership gains from modernization of diesel lines, ranked by total ridership:

- Hudson (Croton-Poughkeepsie): 519,000 new trips annually (156,000 induced or mode-shifted)
  - +14% overall, 4.3 million annual trips total
- Port Jefferson (Huntington-PJ): 218,000 new trips annually (65,000 induced or mode-shifted)
  - 13% overall; 1.9 million annual trips total
- Montauk (Babylon-Speonk): 199,000 new trips (60,000 induced or mode-shifted)
  - +14% overall; 1.6 million annual trips total
- Oyster Bay: 232,000 new trips annually (70,000 induced or mode-shifted)
  - +21%; 1.3 million annual trips total
- Montauk (Speonk-Montauk): 173,000 new trips (52,000 induced or mode-shifted)
  - +20%; 1 million annual trips total
- Harlem (Southeast-Wassaic): 37,000 trips (11,000 induced or mode-shifted)
  - +13%; 317,000 annual trips total
- Ronkonkoma (Ronkonkoma-Riverhead): 5,000 new trips
  - +11%; 54,000 annual trips total
- Ronkonkoma (Riverhead-Greenport): 11,000 new trips
  - +13%-14%; 85,000 annual trips total

50 Caltrain and the UK Network Rail's Great Western Electrification

51 United Kingdom. Department for Transport. "Great Western Route Modernisation: First Post-Opening Evaluation – Final Report." 2022. Pg 36. https://www.documentcloud.org/documents/25450539-great-western-route-modernisation-first-post-opening-evaluation-final-report/

5 Network West

5 Network West

Gov. Kathy Hochul has made improving commutes on the Upper Hudson Line and reinvigorating communities in the Capital Region and Mohawk Valley two key priorities in her 2025 state budget proposal. The program proposed $400 million to help downtown Albany alone with millions more for towns beyond it. The MTA, which Hochul controls, responded with plans to expand the number of express trains running between Poughkeepsie and Grand Central. The Network West program unifies and builds upon both of these priorities by dramatically improving and expanding access to these regions by offering fast electric train service, which makes day trips or quick weekend getaways possible.

Gov. Hochul and MTA chairman Janno Lieber, in December 2024, ride an Upper Hudson Line train (top-most) and hold a press conference (above) to announce an expansion of express service to Manhattan.

Source: The Metropolitan Transportation Authority; the New York Governor's Office

Electrification would give every New Yorker commuting from every stop on the Upper Hudson express-like trip times into the city, potentially putting a half-hour or more back in their day, every day. Shrinking trip times between New York City and Albany to just two hours would make it far easier for state agencies to recruit employees. The proposed extension to Saratoga Springs would tackle the traffic that swamps the region during the famed summer horse races, making it much easier and much more relaxing for New Yorkers to attend. Extensions to Syracuse and then onward to Buffalo would deliver an order-of-magnitude increase in transportation capacity and substantially increase travel speeds, knitting together Buffalo, Syracuse, Albany, the Hudson Valley and New York City like never before.

5.1 The Upper Hudson Line

The Upper Hudson Line already has much of the infrastructure in place to deliver high frequency service thanks to a diesel schedule that runs as many as five trains per hour in the peak direction. It is double-tracked, almost entirely grade-separated and its rated speed of 80 mph is largely a product of the poor performance of diesel locomotives, not the geometry of the right-of-way. Improvements here would lay in the infrastructure and framework to provide the backbone for an expansion of rapid electrified service northward to Albany — and, potentially, beyond.

Each of the major stopping patterns on the Upper Hudson would see travel time reductions from electrification. The improved train acceleration from electrification would also open the door to increasing the top speed on the line, compounding the performance gains from the project. The end of the line, Poughkeepsie, would see trip times into New York City cut to about to 88 minutes for the regular peak service, a 23-minute time savings from the current 111 minutes. Commutes in from Beacon would take about 75 minutes, which is a 11-15 minute savings on the current 86-90 minute run-time.[52]

Speeding up Metro-North would also benefit Amtrak's services between New York City, Albany and points beyond. Faster commuter rail service will reduce congestion between Croton-Harmon and Poughkeepsie, which would in turn allow Amtrak to speed up its trains. For example, Amtrak's Empire Service #239 is scheduled to take 50 minutes to run between Croton-Harmon and Poughkeepsie, an average of just 48 mph despite making no stops. It arrives at Poughkeepsie at 7:22 pm, which slots it in just behind Metro-North #855 that currently arrives four minutes earlier at 7:18 pm. The Network West electrification and speed boost program would bring #855 into Poughkeepsie as soon as 6:55 pm. That 23 minutes savings would allow Amtrak #239 to operate at higher speeds.

It does not appear that electrification of the corridor beyond Peekskill has ever been studied[53] — and the most recent of those efforts dates to the 1970s.[54] A feasibility study should be commissioned as soon as possible; the designers and engineers assigned to it should be instructed to develop a best-possible system that would fit inside the expected cost envelope to prevent scope creep. The expected overall cost is approximately $1.3-$1.5 billion, in 2027 dollars; exclusive of expected fleet costs, which would run another $410 million.

52 Momentum analysis

53 United States. Metropolitan Transportation Authority. "1968-1973: The Ten-Year Program at the Halfway Mark." 1973. Pg. 31. https://babel.hathitrust.org/cgi/pt?id=ien.35556021272109&seq=33; https://www.documentcloud.org/documents/25471469-peek-skill-electrification-mta-1973-document/

54 Burks, Edward C. "$60 Million Planned for Rails." The New York Times. Nov. 19, 1978. https://www.nytimes.com/1978/11/19/archives/westchester-weekly-60-million-planned-for-rails-60-million-planned.html

Upper Hudson Line

Electrification (Croton-Harmon to Poughkeepsie): $900m-$1.1 billion

Poughkeepsie Yard replacement: $375 million

Fleet: $410 million (80 M8s)

$1.3-$1.5 billion

- Exclusive fleet costs

A catenary power system poses no risk to beloved Hudson River views. Europe has proven time and again that the lines do not disrupt the character of its coasts or its centuries-old towns and cities.

Counterclockwise: The Italian coast (top left), the French Mediterranean coast (middle) and the Portuguese coast (bottom left).

Credits: Marco Chitti (top left); Flickr: @Enzojz (center left); Flickr: Richard Hagues (bottom left)

5.2 Electrification to Albany

Electrification beyond Poughkeepsie to Albany offers an opportunity to dramatically speed service and expand capacity on the route. Gov. Hochul has asked for $400 million from state lawmakers to help revitalize downtown Albany.[55] The speed gains and frequency improvements offered by electrification would help to maximize and build upon those investments by making it easier than ever for New York City and Hudson Valley residents to visit the state capital.

This portion of the line is currently exclusively operated by Amtrak and is one of the rail carrier's busiest rail segments off the Northeast Corridor. Electrification would speed service in two major ways. First, it would replace slow-accelerating diesel trains with electric trains that can get up to speed much more quickly. Second, electric trainsets have a higher potential top speed that would allow New York to boost the speed limit on the corridor from the current maximum of 110mph to at least 125 mph,[56] which was hit on portions of the route before during in the late 1990s.[57] Electrification — combined with the higher top speeds — would slash travel times between the state capitol and Manhattan by 20-36 minutes, to just 2h5m.[58]

There are opportunities to cut trip times further by constructing additional improvements down the line. Bolstering or replacing the third-rail power system between Riverdale and Croton-Harmon to increase the top speed on this segment from 75 mph to 90-100 mph operation would bring Albany travel times down to the magic two-hour mark.

The power system upgrades for the Lower Hudson provide a good example of the gains that come from the Network West concept of treating the entire corridor like an integrated entity. The higher speeds and improved acceleration provided by a more powerful overhead electrical system

55 Churchill Chris; Kiessling Katherine "Hochul proposes massive state investment in downtown Albany." *Albany Times-Union.* Jan. 13, 2025. https://www.timesunion.com/news/article/hochul-proposes-massive-state-investment-downtown-20031451.php

56 Analysis done by NYU-Marron researcher Alon Levy

57 United States. New York. Governor's Office. "Governor Announces Successful 125 MPH Run of NY's High Speed Train." February 23, 2001. https://www.document-cloud.org/documents/25471441-hudson-line-125/

58 Assumes the following increases in top speed: Between Croton-Harmon and Poughkeepsie from 80mph to 100mph; Poughkeepsie to Rhinecliff to 110mph; and Rhinecliff to Albany-Rensselaer to 125mph.

Poughkeepsie to Albany

Phase 1:

ROW Purchase: $200 million

Electrification (Poughkeepsie to Rensselaer): $1.5-1.8 billion

Electrification of Rensselaer Yard: $375 million

Rolling stock (100 M8s): $513 million

$2.1-$2.4 billion

- Exclusive fleet costs

Phase 2:

Power system replacement: $900 million - $1.1 billion

$900m-$1.1 billion

would speed up Metro-North service along the corridor. An early analysis suggests it could shave several additional minutes off the Upper Hudson's typical peak direction service. The effect on Lower Hudson service between Riverdale and Croton-Harmon was not studied but it makes sense that, too, would see significant benefits. This upgrade would also have the benefit of elevating much of the line's electrical power system above the tracks and, thus, above any potential flooding from the Hudson (see Section 10). The cost of replacing the power system between Riverside and Croton is likely $900 million-$1.1 billion, which is treated here as an optional Phase 2 investment.

At first glance, the challenges confronting any Albany electrification program are political in nature — not engineering. The route already has high-level platforms as far north as Poughkeepsie and at Albany-Rensselaer. The biggest impediment to electrification and full modernization is that this segment of the Hudson Line is owned by a freight carrier, CSX. CSX, in turn, leases the track to the State of New York, which in turn pays Amtrak for maintenance and operation. That agreement bars the usage of the CSX-owned segment for "commuter service."[59] It also contains vertical clearance requirements of 22 feet — and no less than 20'6" during maintenance.[60] This would likely block the installation of catenary at the heights commonly found in the Northeast, where the wires sit 20-22 feet above the tracks.[61]

However, there is little practical rationale for this rule. A review of design documents shows that as little as eight inches of separation is required between the top of a train and the bottom of the contact wire for an overhead catenary system. Freight trains running on the Hudson Line are allowed to be no taller than 19'1",[62] which means that 19'9" would be sufficient clearance. In Philadelphia, this arrangement already exists on the Manayunk/Norristown Line. There, the wires are strung at a height of 21'3"- 22'5", engineering schematics show.[63] And Norfolk-Southern freight trains carrying cars with double-stacked containers aboard steam beneath them every day. Those are the tallest of the standardized American freight operations at 20'3" tall.[64] That means the clearance gap between the wires and the top of the containers is sometimes no larger than 12 inches.

Even if CSX were to continue to insist upon the restriction, the recent electrification of a commuter rail line in the San Francisco Bay Area, Caltrain, installed its wires at a height of 23 feet in unconstrained spaces.[65] (Objections from freight railroads are examined in further depth in Section 11). The first step to electrifying and improving the corridor then would be negotiating an amended lease or purchasing the tracks outright. Subsequently, management, maintenance and operation should be turned over to the MTA, which would then provide access to Amtrak for its intercity services.

To help facilitate these discussions and interest, a high-level estimate of the likely costs associated with the extension of electrification from Poughkeepsie to Albany is included.

5.3 An Electric Empire Corridor

These improvements through Albany would lay in a high-throughput railroad backbone to deliver substantially more and faster service along the Empire Corridor to western New York. However, expanding the modernization program westward will face challenges beyond those presented by the Poughkeepsie-Albany program. Much of the current 322-mile route is both owned and heavily used by CSX. The existing scheduling conflicts between CSX and Amtrak mean that passenger service was on-time just 69% of the time in 2023.[66]

A potential solution can be found in the 'Water Line' route's history. Much of the right of way is currently unused. It was originally constructed by the New York Central Railroad with four tracks along the route. The NY Central design allowed freight and passenger service to be able to operate largely independent of each other: passenger service on the southern two tracks and freight service on the northern two tracks. In the late 1950s, NY Central removed the freight

59 United States. Surface Transportation Board. "National Railroad Passenger Corporation and CSX Transportation Inc. — Petition for Declaratory Order." Lease Agreement. Pg. 30 (PDF pg. 66). Sept. 12. 2012. Finance Docket No. 35675. https://www.documentcloud.org/documents/25497272-csx-nysdot-amtrak-lease-for-hudson-river-line/

60 US. STB. Lease Agreement. 2012. Pg. 31 (PDF pg. 67). https://www.documentcloud.org/documents/25497272-csx-nysdot-amtrak-lease-for-hudson-river-line/

61 United States. Department of Transportation. Federal Railroad Administration. "Final Environmental Impact Statement/Report and4(f) Statement. Volume I: Northeast Corridor Improvement Project Electrification: New Haven to Boston." Pg.

62 CSX Corporation. "Albany Division Timetable No. 6" 2010. Pg. 58. https://www.documentcloud.org/documents/25471620-csx-albany-division-2010/

63 United States. Pennsylvania. Southeast Pennsylvania Transportation Authority. "Conshohocken to Ford: Norristown Line: Phase 2 – O.C.S. Replacement Project." https://www.documentcloud.org/documents/25497243-septa-ford-interlocking-to-kalb-interlocking-ocs-wire-heights/

64 Norfolk Southern Railway. "Harrisburg Division: Northern Region. Timetable No. 1." 2008. Pg. 23. https://www.documentcloud.org/documents/25471623-ns-norristown-restrictions/

65 United States. California. Caltrain/Peninsula Corridor Joint Powers Board. "Peninsula Corridor Electrification Project: Final Environmental Impact Report". 2015. Pg 3.8-30. https://www.documentcloud.org/documents/25497266-caltrain-vol-i-revised-deir-040615/

66 United States. Amtrak. "CY 2023 Host Railroad Report Card & Route On-Time Performance." April 2024. https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/HostRailroadReports/Amtrak-2023-Host-Railroad-Report-Card.pdf

Electric Empire Corridor Costs

Saratoga Springs via Schenectady:

Distance: ~40 miles
ROW purchase: $300-$400 million
Electrification: $600-$700 million
Track, signal, station improvements: $1.4-$1.6 billion
Yard: $375 million

$2.7-$3 billion

Schenectady to Syracuse:

Distance: ~140 miles
ROW purchase: $1.7 billion
Electrification: $1.9-$2.2 billion
Track, signal, station improvements: $9.5-$9.7 billion
Yard: $375 million

$13.5-$14 billion

Syracuse to Buffalo:

Distance: ~150 miles
ROW purchase: $1.8 billion
Electrification: $2.0-$2.2 billion
Track, signal, station improvements: $10.4-10.5 billion
Yard: $375 million

$14.6-$14.9 billion

tracks and consolidated operations onto the passenger tracks to save money.[67]

Restoration of those two tracks is an obvious solution. However, CSX imposed onerous restrictions on the most recent New York State Department of Transportation effort to examine ways to improve passenger service in the corridor. One of those requirements stated there must be at least 30 feet of separation between the still-existing tracks and any new track for passenger service if the new tracks are rated for a top speed above 90 mph.[68] That means that the right-of-way can only fit three tracks, crimping future service. Passenger rail and transit planners interviewed said there was little rationale for this rule.[69] Documents examined for this report support their assertion. A report from the 1970s-era Northeast Corridor Improvement Project show that tracks only need to be spaced more than 14 feet apart when speeds exceed 120 mph.[70] Additionally, documents show that freight railroads have agreed to smaller buffer rules in recent years. In the Chicago area, CSX itself agreed to a spacing of just 20 feet in a recent project to double track the electrified South Shore Line commuter railroad.[71] Conrail and NJ Transit have agreed to spacing of 25 feet between the passenger and freight tracks on the Lehigh Valley Line.[72]

CSX may be more willing to negotiate than it has been in the past. The industry is under immense pressure from Wall Street investors to deliver payouts and the major operators have been willing to part with other rights-of-way recently. A favorable agreement with CSX would allow New York State to reconstruct four tracks in the existing old New York Central right-of-way, adding back the two freight tracks that were removed. This would give passenger service two dedicated tracks once again and provide freight service with two tracks as well, reducing conflicts and improving capacity. New York State (via the State Department of Transportation, MTA, Amtrak or another entity) would be allowed to construct and install the Momentum upgrades on the two passenger tracks. In trade, CSX would likely be allowed to lease back or pay access charges for the two northern tracks at reduced rates.

5.3.1 The 'Water Level' Route is Capable

The 'High Speed Rail: Empire Corridor' study — the New York State DOT review hamstrung by CSX — found that portions of the existing right-of-way between Schenectady and Buffalo is actually quite capable. In places, it can support speeds of 125mph. However, the authors wrote that they ruled out upgrading the existing corridor early in the process because the entire length of the route could not be upgraded to 125mph. Instead, the report put forward the notion of constructing an entire new right-of-way on the other side of the river. This idea has several major disadvantages, including that the improved rail service would miss the downtowns of Amsterdam, Utica and Rome. Furthermore, the report's analysis of the capabilities of the Water Level route was incomplete. It did not study how much electrification could improve the performance of the existing line. "The incremental approach will never achieve trip times close to a new corridor, although this does not include the purported acceleration improvements of electric traction equipment," the authors wrote.[73] This should be re-examined and fully developed as a planning alternative for the Empire Corridor, particularly between Schenectady and Syracuse. Fully developing a program to restore the Water Level Route would likely require reaching an agreement with CSX. That deal would likely eventually involve the state buying the route. State ownership would make it vastly easier to plan, design and construct the upgrades. The size of the project would likely necessitate it being split into parts. This paper envisioned three likely segments: Albany to Saratoga Springs via Schenectady; Schenectady to Syracuse; and Syracuse to Buffalo. The Schenectady-Syracuse segment could likely be subdivided between Schenectady-Utica and Utica-Syracuse.

5.3.2 Phase 1 - Albany to Saratoga Springs via Schenectady

The first leg would run across the Hudson River and to Schenectady, before turning north and heading to Saratoga Springs, which provides a natural terminus for service. Additionally, expansion of high-capacity electric service would allow for New York State to dramatically ease

67 United States. New York. State Department of Transportation. "Empire Corridor Tier 1 Draft EIS [Environmental Impact Statement]." Executive Summary. Pg ES-4. https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/

68 United States. New York. State Department of Transportation. "Empire Corridor Tier 1 Draft EIS [Environmental Impact Statement]." Appendix J. Pg J-10. https://railroads.dot.gov/elibrary/empire-corridor-tier-1-draft-eis-volume-4-appendices-i-j; https://www.documentcloud.org/documents/25473215-nysdot-csx-agreement/

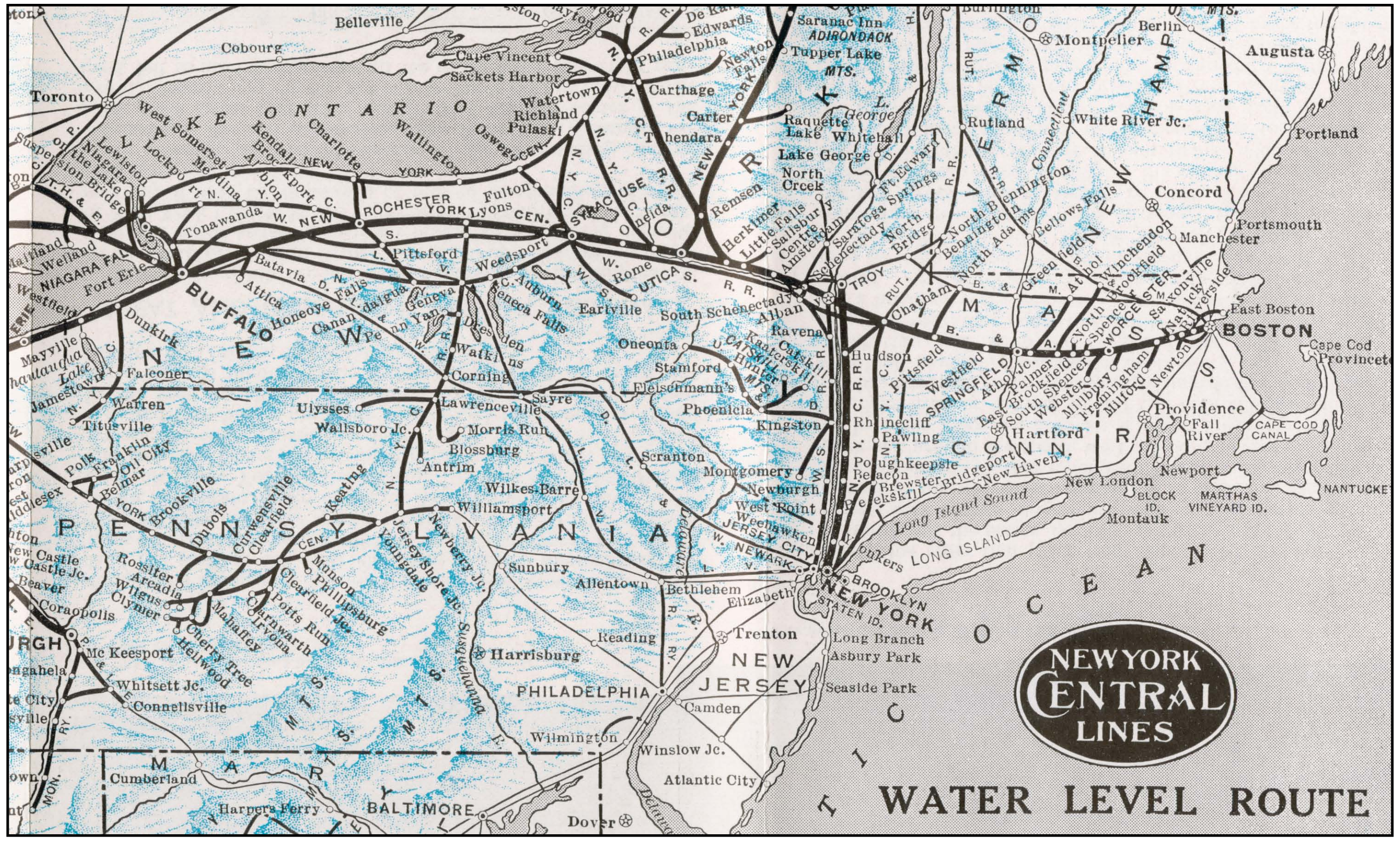
69 Interviewees D, E

70 United States. US Department of Transportation. Federal Railroad Administration. "TWO-YEAR REPORT ON THE NORTHEAST CORRIDOR." 1978. Pg 95. https://www.documentcloud.org/documents/25504735-1978-freight-passenger-separations/

71 United States. Indiana. Northern Indiana Commuter Transportation District. "Environmental Assessment and Section 4(f) Evaluation for the Double Track NWI Project." 2017. Pg 2-7, 2-10. https://www.documentcloud.org/documents/25473218-2017-09-18-south-shore-eis/

72 United States. New Jersey. New Jersey Transit. "Capital Plan Project Sheets." PDF pg 179. 2022. https://www.documentcloud.org/documents/25473216-nj-transit-capital-plan-2022-update-appendix-b-project-sheets-7-24-23/

73 New York. State DOT. "High Speed Rail: Empire Corridor". 2014. Pg 3-10. https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/



A map of the famed New York Central's 'Water Level Route' as featured in a railroad marketing brochure, circa 1933.

Source: The University of Chicago

congestion and expand transportation options to and from Saratoga during the summer horse races, which are one of the biggest events in the Capital Region. The proposal would add a second dedicated passenger track between Albany and Schenectady to lay in the groundwork for both the additional service to Saratoga and the continued western expansion to Utica, Syracuse, Rochester and Buffalo. This portion of the route is owned by CSX and sees very light freight usage.[74] Additionally, it would restore the historical double-tracking from Schenectady to Saratoga Springs, which was removed in the 1950s by freight lines to save costs amid the shift away from rail travel.[75] The portion from Schenectady to Saratoga Springs is largely owned by Canadian Pacific and is little used. CP indicated years ago it was interested in off-loading the line.[76] It has maintained ownership but Amtrak data blames CP for a disproportionate number of delays on the Ethan Allen Express, which runs over the trackage.[77] A state buyout of the line would help address this problem. The end result of this project would create a regional and inter-city transportation system that links together New York City and the entirety of the Hudson Valley. Trip times to Schenectady would be cut to 2h25m, while Saratoga Springs would be reachable in about three hours. It would provide capacity for potentially 20,000 seats in the peak direction on race days between New York City and Saratoga.[78] Day trips could even be possible. This dramatic increase in seat capacity and substantial improvements in trip time will provide a massive boon for the Capital Region and one of the state's longest-running attractions.

5.3.3 Phase 2 - Schenectady to Syracuse

The second leg would continue westward and deliver electrified service to Amsterdam, Utica, Rome and Syracuse, reinvigorating the regional economy by providing a fast, reliable and high-capacity link to New York City's job engine and cultural institutions. Amsterdam would be just a 2h37m train ride away, Utica would be just a little over three hours at 3h18m, Rome would be approximately 3h30m. Syracuse would be under the magic four-hour mark, taking 3h56m. That's two hours faster than current service.[79] Each of those trip times is markedly faster than driving. For Syracuse, it means New York City by train would be just as fast as flying and with far more seats available for travel. Weekend trips to Manhattan to see a show and visit museums would be a breeze. New York City residents, many of whom don't have cars, would now be easily able to visit and bolster local shops and businesses, go see a basketball game at Syracuse University or visit the state fair. Trip times are short enough some workers who only go into the office one or two days a week could even commute to New York City.

This is a busy corridor for freight trains, which turn south to head towards the ports of New York and New Jersey at the Hoffman's junction, which lies between Amsterdam and Schenectady.[80] Momentum proposes providing capacity for the expanded passenger service by reinstalling the two tracks that were removed on the Water Level Route right-of-way from Hoffman's to points westward to Syracuse and onward.[81] This would restore the Water Level to its

74 US. New York. State Senate. "Connecting New York's Future: New York State Senate High Speed Rail Task Force Action Program." 2006. Pg 13. https://www.documentcloud.org/documents/25559565-nys-senate-empire-corridor-hsr-task-force-study-2006/

75 US. New York. State Department of Transportation. "I-87 Multimodal Corridor Study - High-Speed Rail Pre-Feasibility Study: New York to Montreal." 2004. Pg 7. https://www.documentcloud.org/documents/25559667-finalhighspeedrailfeasibilitystudyreport05-18-04/

76 US. NYS. DOT. "I-87 Multimodal Corridor Study - High-Speed Rail Pre-Feasibility Study: New York to Montreal." 2004. Pg 5-6. https://www.documentcloud.org/documents/25559667-finalhighspeedrailfeasibilitystudyreport05-18-04/

77 US. Amtrak. "Host Railroad Report." 2024. Pg 8. https://www.documentcloud.org/documents/25559665-may-2024-amtrak-host-railroad-report/

78 Momentum analysis.

79 Momentum analysis.

80 New York. State Senate. "Connecting New York's Future: New York State Senate High Speed Rail Task Force Action Program." 2006. Pg 13. https://www.documentcloud.org/documents/25559565-nys-senate-empire-corridor-hsr-task-force-study-2006/

81 New York. State DOT. "High Speed Rail: Empire Corridor". 2014. Pg 1-4. https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/

original configuration by providing two dedicated tracks for passenger service and two tracks for freight service.

A similar proposal in Chicago for its portion of the old New York Central main line estimated that reinstalling the trackage, upgrading signals and reconfiguring the right of way would cost $70 million per mile adjusted for inflation and projected forward.[82] This should be considered the upper cost-bound for the project as urban Chicago is likely a far more difficult building environment than much of the route between Schenectady and Syracuse. Electrification and construction of stations push the costs upward to a little more than $90 million per mile (see Section 7 for cost models; and Section 10 for electrification economics). However, this is still less than half the cost of California's high-speed rail system, which is averaging more than $200 million per mile. The end result would be a system that provides many of the key benefits of high-speed rail service — trip times that are equal to flying and faster than driving, alongside frequent and convenient schedules — for substantially less money and reduced regulatory risk.

5.3.4 Phase 3 - Syracuse to Buffalo

The proposed Network West program for the western-most leg would extend the re-installation of the two tracks between Syracuse and Buffalo, restoring four-track service to the entire length of the corridor. Impressively, considering the distances involved and the geographic inefficiency of the routing — heading north to Albany and then west across the Mohawk Valley — the improvements would make train travel to Buffalo nearly two hours quicker than driving at 5h38-5h46m. A person would be able to step on a train in Buffalo at 7am and be in New York City for lunch and meetings, which is not possible today by either train or car. Flying would still maintain a small trip time advantage of approximately an hour, but rail would potentially provide thousands of new seats linking New York State's two largest cities with rapid and reliable service. Trips between New York and Rochester would be slashed to under five hours, at 4h49m-4h56m. That means person could leave Rochester at 3pm and be in New York City with plenty of time to make an 8pm curtain. Upstate travel would benefit with frequent service making it possible to go from Buffalo to Albany in just three hours.

The cost projections for this segment, like the Schenectady to Syracuse leg, were computed using the Chicago proposal as the baseline. As before, this segment sees reinstallation of trackage, upgrading signals and reconfiguring the railroad right-of-way, all at $70 million per route mile,[83] an upper cost-bound for the project due to the differences in built environments. (See Section 7 for more on cost modeling).

Additionally, there is an alternative to the reinstallation of the two tracks that should be considered: a 165mph-plus link between Syracuse, Rochester and Buffalo. The New York State DOT's 2014 report examining the potential for high-speed rail on the Empire Corridor floated the possibility of constructing a new right-of-way that would run from Albany to Buffalo parallel to the existing Water Level route. This report does not believe that idea makes sense between Albany and Syracuse because it would result in several key cities and towns — Amsterdam, Utica and Rome — missing out on the enormous benefits of electric service. However, a new high-speed or higher-speed route on the last leg between Syracuse and Buffalo warrants exploration.[84] There

Electrified trains work in any climate, including places where there is substantial snowfall every year, like Buffalo.

Above: An Italian high speed rail train passes through the snowy Swiss Alps near Bern.

Credit: Yann Sonzogni, via Flickr

82 US. DOT/FRA. "Chicago - Detroit/Pontiac Passenger Rail Corridor Program." 2014. Ch 2. Pg 43. https://www.documentcloud.org/documents/25482939-chi-det-chapter-2-alternatives-considered/

83 US. DOT/FRA. Ibid. https://www.documentcloud.org/documents/25482939-chi-det-chapter-2-alternatives-considered/

84 NY. State DOT. "New York. State DOT. "High Speed Rail: Empire Corridor" 2014. Pg 3-50 – 3-60. https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/

are no intermediate stops between Syracuse-Rochester and Rochester-Buffalo that would be bypassed. Furthermore, California High-Speed Rail and the Northeast Corridor have both developed operating models where trains running at speeds of 150-220mph can take advantage of the existing rail infrastructure in the urban cores of cities, like stations and routes, by running at lower speeds where the route is shared. This reduces or eliminates the need for eminent domain.[85] A high-speed rail line linking Buffalo-Rochester-Syracuse would build upon Momentum's gains and further reduce trip times. Buffalo to New York City would hit five hours, at 5h4m; Rochester to New York would take fall to 4h14m. Trip times between upstate destinations like Buffalo or Rochester to Albany, for example, would also see corresponding improvements. Such a project would knit the state even more closely together. Rochester functionally would be as far from New York City as Boston. However, the price tag for this bypass would likely be significantly more than the restoration of the two tracks, potentially as much $33 billion.[86] The cost-time trade-off debate is beyond the scope of this paper, but it should be developed for policy makers to consider.

5.3.5 Optional Croton-Harmon to Albany track capacity projects

Additionally, Momentum updated the costs for two oft-proposed plans to add additional track capacity to the Upper Hudson Line corridor.[87, 88] Both proposals would use existing right-of-way to construct the third track, which would allow for Amtrak trains to pass Metro-North trains. The underlying rationale for the capacity projects — the substantial mismatch in speed between Amtrak and Metro-North service — would be allayed, at least in part, by electrification. Still, both track capacity projects have been included in this review for the sake of completeness.

The first proposal would construct about 10 miles of a third track from just north of Cold Spring to just south of New Hamburg, through Beacon.[89] The second triple-track would run through Poughkeepsie, where Metro-North commuter trains currently turn around to return to Manhattan.[90]

85 California High-Speed Rail calls this 'blended' operation.
86 Calculated based upon California High-Speed Rail costs on its first segment.
87 Based on average cost, $142 million/mile, for proposed triple track of Harlem Line included in the MTA 20-Year Needs Assessment.
88 United States. New York. Metropolitan Transportation Authority. "20-Year Needs Assessment." 2024. Pg A-381. https://pub-81af28a3136344ffa26f094c671584ac.r2.dev/20-YearNeedsAssessment_ReportandAppendix.pdf; https://www.documentcloud.org/documents/25499092-mta-20-year-needs-assessment-report-and-appendix/
89 United States. New York. State Department of Transportation. "Hudson Line Railroad Corridor Transportation Plan." 2005. Pg 20, 34-36. https://www.documentcloud.org/documents/25499074-2005-hudson-river-line-plan/
90 NY State DOT. "Hudson Line Railroad Corridor Transportation Plan." 2005. Pg 20, 37-39. https://www.documentcloud.org/documents/25499074-2005-hudson-river-line-plan/

Both the Beacon and Poughkeepsie Triple Track proposals were detailed in the 2004 'Hudson Line Corridor Transportation Plan' and were included in the New York State Senate's 'Connecting New York's Future' report.[91] Subsequently, the Beacon Triple Track proposal was included in the 2013 'High Speed Rail: Empire Corridor' study.[92]

Additionally, there is approximately eight miles of existing third and fourth track between Croton-Harmon and Peekskill, if additional capacity is deemed necessary to relieve congestion on approach into the terminal station for the Lower Hudson Line segment. Such a proposal does not appear to have been studied, though extension of the third-rail electrification system to Peekskill was proposed in the 1970s.

Hudson Line track capacity expansions:

- Peekskill Third Track (MP 33-42): $1.3 billion
- Beacon Third Track (MP 53-63): $1.4 billion
- Poughkeepsie Third Track (CP72-75): $426 million

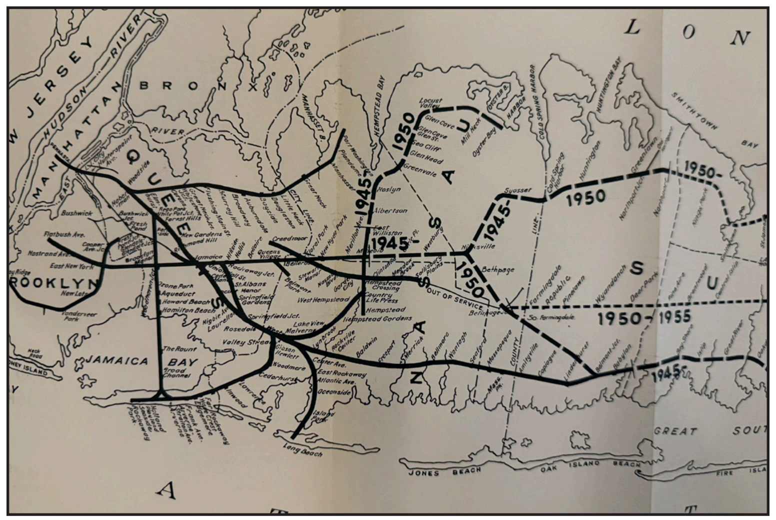
91 United States. New York. State Senate. "Connecting New York's Future." 2006. Pg 2-28, 2-30.
92 NY State DOT. "High Speed Rail: Empire Corridor". 2014. Pg 3-24. https://www.documentcloud.org/documents/25473638-empire-corridor-tier-1-draft-eis-volume-1/

6 Network East

Credit: Nolan Hicks

6 Network East (The LIRR)

Communities throughout Long Island have been pushing for electrification since the 1920s.[93,94] The fight for electric trains on the Oyster Bay Branch dates all the way back to at least 1922. However, despite extensive pushing from the 1920s to the 1940s, electrified service had only made it to East Williston.[95] By 1941, the public and politicians were running out of patience. The LIRR's state regulator, the Public Service Commission, held hearings to try and force the issue; a local Assemblyman sponsored legislation that would have required electrifying the route. Not even the outbreak of World War Two could put a lid on the push. A massive white paper and modernization program commissioned by the LIRR's owner, the Pennsylvania Railroad, that was released in 1942 suggested that Oyster Bay should be first up for electrification upon the end of World War Two.[96] "The public demand for this improvement is well authenticated," the report, authored by the then-prominent engineering firm, J.G. White, stated.



In 1942, The 'White' Paper proposed an expansive electrification effort to reinvigorate the LIRR in the coming post-war era. Most of the proposal, as outlined in this map, remains unbuilt. The report has yet to be digitalized.

Source: The Brooklyn Public Library system's Othmer Library archives

The proposal called for winning back customers to the railroad — and charging higher fares — by accelerating and improving service through a massive 20-year campaign to electrify most of the network. Electrification would be extended all the way to Port Jefferson on what was then the Wading River Branch; the Ronkonkoma Branch would be electrified all the way to Manorville; the Montauk Branch would be electrified, too, out to Speonk. The Central Branch cutover, which connects the Montauk branch to the Main Line near Farmingdale, would have been electrified too.[97] The plan was shelved as the railroad's finances continued to deteriorate after the war.

It reemerged two decades later when New York State bought and bailed out the railroad in 1965. Gov. Nelson Rockefeller proposed electrifying the Oyster Bay Branch as part of a $200 million effort to modernize the railroad.[98] Rockefeller's 1965 program differed in one key way: Rocky proposed extending electrification to Ronkonkoma while the J. G. White plan went all the way to Manorville. Today, only the Ronkonkoma extension promised by Rockefeller has been fully built. Port Jefferson electrification was only extended to Huntington. No progress has been made on the Montauk or Oyster Bay lines in a century.

93 "Long Island to Improve and Extend Electric Service." Railway Electrical Engineer. Volume 13. Page 366-367. 1922. https://www.google.com/books/edition/Railway_Electrical_Engineer/hRU6AQAAMAAJ?hl=en&gbpv=1&dq=%22oyster%20bay%22%20AND%20electrification%20%22long%20island%22&pg=PA366&printsec=-frontcover

94 "Position of LI on Oyster Bay Electrification." Railway Age. Volume 85. Pg 1203. 1928. https://www.documentcloud.org/documents/25508726-1928-railway-mag/

95 "Long Island Railroad Rejects as 'Unwise' Plea to Electrify Its Oyster Bay Branch." The New York Times. 1941. https://www.documentcloud.org/documents/25508729-nyt-1-15-1941/

96 J. G. White Engineering Corporation. "Report on the Long Island Rail Road Company." Volume 4. Pg. VII-9. 1942.

97 J. G. White. Volume 4. 1942. Map. https://www.documentcloud.org/documents/25508745-map-of-1942-lirr-electrification-plan/

Port Jefferson Branch

Electrification (Huntington to Port Jefferson): $500-$620 million

Double-tracking and ROW improvements: $1.3-$1.4 billion

Port Jefferson Yard: $375 million

Fleet (60 M8s): $308 million

$2.2-2.4 billion

- Exclusive fleet costs

6.1 The Port Jefferson Branch

Port Jefferson electrification has been repeatedly studied, most recently in 2020, has extensive local political support and is likely the readiest MTA electrification project to go into design and environmental review.[99] Completion of the environmental review process is likely necessary to qualify for federal support despite this project being almost entirely within right-of-way already owned by the MTA.[100]

Electrification would speed service and induce ridership. The current direct service between Port Jefferson and Penn Station (Train #619) would be 18% quicker from end to end. Overall, trip times across the branch would fall by 14% on average. The simple ridership model built for this study based on work done by Transport for London suggests that electrification's quicker service would result in up to a 13% gain in ridership over the short run, potentially 218,000 new trips annually.

The Port Jefferson electrification would be the most heavily used of the LIRR's diesel lines on a per-mile basis. Across the MTA system, it the second-highest increase in per-mile initial ridership after the electrification of the Upper Hudson Line. Electrification of the line would also bolster Stony Brook University by speeding and expanding service to the campus. Gov. Hochul has named Stony Brook a flagship campus of the State University of New York system and improved transit would only help attract students, staff and researchers.[101]

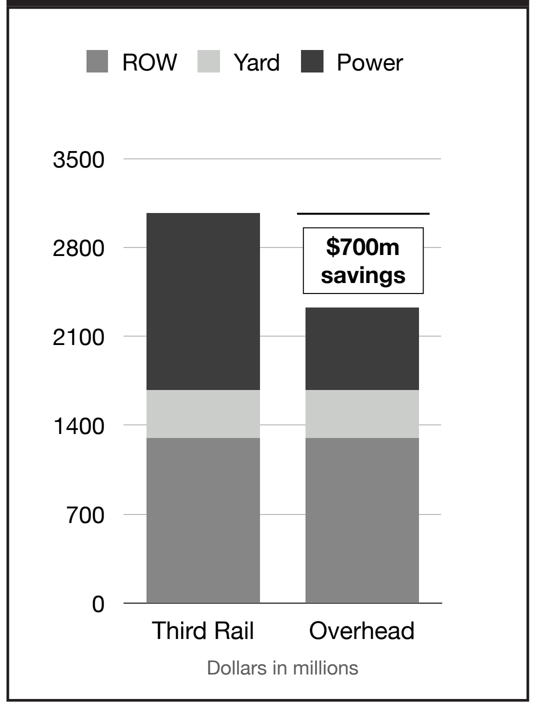
98 Grutzner, Charles. "Rockefeller Urges State Buy L.I.R.R. and Modernize It." The New York Times. February 26, 1965. https://www.documentcloud.org/documents/25508728-nyt-rocky-buys-lirr-electrification-promised/

99 United States. New York. Metropolitan Transportation Authority. "Port Jefferson Branch Electrification and Feasibility Study & Conceptual Planning/Design." 2020. https://www.documentcloud.org/documents/25450463-port-jeff-wsp-feasibility-study/

100 The Federal Railroad Administration can grant a reprieve from the usual environmental review requirements, under the the categorical exclusion provision of the National Environmental Policy Act.

101 United States. New York. State University of New York. Stony Brook University. "A Joint Statement from The University at Buffalo and Stony Brook University On Being Designated as New York State's Flagship Public Universities". 2022. https://news.stonybrook.edu/university/a-joint-statement-from-the-university-at-buffalo-and-stony-brook-university-on-being-designated-as-new-york-states-flagship-public-universities/

Overhead vs. third rail



The most recently proposed version of the Port Jefferson Capacity Project pitched by the MTA includes reworking or replacing the structures along the right of way to ensure clearances of at least 22 feet, which is sufficient for catenary. This portion would cost $2.2-2.4 billion when electrified using overhead catenary power. This price tag excludes the rolling stock costs, which are estimated at $308 million.

6.1.1 Third Rail vs. Overhead

Opting for overhead catenary power offers an opportunity for dramatic reductions in capital outlays for the Port Jefferson Capacity Project. The project, as currently proposed by the MTA/LIRR, calls for extension of the existing third rail power system from its current terminus at Huntington to Port Jefferson. It carries a $3.1 billion price tag, excluding the cost of new rolling stock.[102]

Momentum would extend electrification using overhead catenary power and marry together with the existing third-rail power networks by purchasing trains capable of running on both, like the M8s currently used for the New Haven Line. This type of setup is known as dual electrification. It would reduce the capital outlay from $3.1 billion to $2.2-$2.4 billion. The economic and engineering advantages of overhead catenary systems and how to take advantage of them while incorporating legacy third-rail systems is discussed in depth in Section 10.

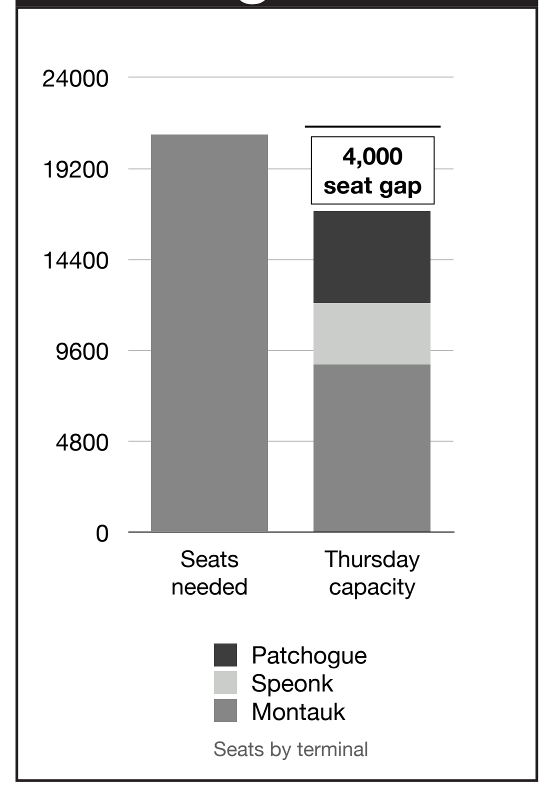
6.2 The Montauk Branch

The Montauk Branch is the longest in the system, stretching for nearly 120 miles from New York Penn Station to Montauk. The route is functionally divided into two parts: the innermost segment, the Babylon Branch, which is fully electrified and grade separated; and the 80-mile outer segment, the Montauk Branch, which is unelectrified, almost entirely at grade and single-tracked beyond Sayville.

There have been few improvements to the line since the Babylon Branch portion was grade separated and elevated onto a berm in the 1960s and 1970s. Dual mode diesels allow for some service directly into Penn Station and high-level platforms mean that accessibility has been improved. But, schedules have not seen a substantial increase in service in years and the infrastructure — from a shortage of locomotives and passenger cars to the 66 miles of single-tracking

102 NY-MTA. "20-Year Needs Assessment." 2024. Pg A-395. https://pub-81af28a3136344ffa26f094c671584ac.r2.dev/20-YearNeedsAssessment_ReportandAppendix.pdf; https://www.documentcloud.org/documents/25499092-mta-20-year-needs-assessment-report-and-appendix/

Summer Seat Shortage



— severely limits the amount of service that can be run.

The limited infrastructure has not been able to keep up with exploding demand for service along the South Shore, particularly during the summertime on trains bound for the Hamptons. The combination has resulted in a highly visible capacity crunch and frequent reported reliability problems. Overpacked trains run massively behind schedule, the single-tracked territory limits the number of trains that can run in each direction — and both issues are exacerbated by frequent breakdowns.

An analysis of ticket sales from July 2023, the peak of the summer season, shows that the crux of the issue is too many people trying to fit onto too few trains. The LIRR sold 309,000 tickets that month — averaging 10,000 per day — with an origin or destination between Bay Shore and Montauk.[103] The entire fleet of diesel passenger cars has approximately 18,000 seats.[104] The long distances and single tracking make it difficult to increase capacity by increasing frequency. The ticket sales data did not include a day-by-day breakdown, but observation suggests that passenger loads are concentrated on particular days, and, in a particular direction. For example, heading east on Thursdays and Fridays heading east, while returning to New York City on Sundays-Tuesdays.[105]

If the summer surge on Thursdays and Fridays is 50% above the rolling daily average, the MTA would need 21,000-plus seats of capacity heading east to meet demand.[106,107] That would consume the bulk of the LIRR's diesel fleet, while the railroad must still run its regular service on the Port Jefferson and Oyster Bay branches. Hitting those figures likely requires doubling — or more — the service between New York City and the East End. Furthermore, the ticket data shows that demand for service continues year-round in the post-pandemic world as many people appeared to have turned what were once second homes into primary residences. Ticket sales between

103 NYU-Marron analysis of MTA/LIRR ticket data. It was obtained under Freedom of Information Law request from the LIRR rider advocate website 'The Long Island Rail Road Today' and generously provided to NYU-Marron.

104 Kawasaki. "LONG ISLAND RAIL ROAD COMMUTER BI-LEVEL." 2014. https://web.archive.org/web/20140604175056/http://www.kawasakirailcar.com/lirr.htm

105 The LIRR's summer 2024 schedule included 5 trains between New York City and Montauk on typical Wednesdays, 7 on Thursdays and 9 on Fridays. The pattern repeats inbound, there are 9 trains on a typical Sunday but 5 on Mondays)

106 Ridership between Westhampton and Montauk had exceeded pre-pandemic levels by July 2023. However, ridership between Bay Shore and Patchogue was still at just 66% of pre-pandemic levels that month; the segment between Bellport and Speonk was also lower. As such, this analysis included the July 2019 ridership figures for Bay Shore to Speonk; and 2023 figures for Westhampton to Montauk. That totals 376,550 rides for July, for a daily average of 12,147 — and an expected peak of 18,220.

107 A margin of 15% was applied to the peak figure, generating a total of approximately 21,000 seats needed to meet peak capacity demand.

East End service has faced a years-long capacity crunch

Crowding on summertime Montauk trains as captured across three years

Credits: The New York Times (left); Dan's Papers (center); and Twitter/X user @Andrew Puschel (right)

Speonk and Southampton were up 39% in 2023 compared to 2019; east of Southampton, they were up another 16%. Electrification and other modernizations (like double-tracking, sidings and full signalization beyond Speonk) would not only speed up service, it would give the MTA the infrastructure to tackle the new year-round demand and the summer surges. The goal would be a system capable of doubling to tripling the amount of service along the South Shore east of Babylon — potentially 30 trains per day in the peak direction. The upgraded line would be well-equipped to meet these demands and put a dent in the traffic crisis along the South Shore.

Electrification would speed up service substantially on both the inner and outer portions of the Montauk Branch. (The model assumes the MTA takes advantage of the M8's performance and uprates the speed on the branch from the current diesel-imposed limit of 65 mph to 80 mph). The time savings could boost ridership from east of Speonk to Montauk to 47% above its pre-pandemic levels, year-round. Meanwhile, ridership from stations between Bay Shore and Speonk would rise to 14% above baseline, the Momentum analysis found.

6.2.1 Babylon to Speonk and the Central Branch

The Montauk Branch from east of Babylon to Patchogue is mostly double-tracked to Sayville, but still needs substantial upgrades in order to provide reliable, fast and frequent service. There are 21 grade crossings between Babylon and Patchogue that will need to be separated, closed or be upgraded. The double-track would need to be extended from Sayville to the east and likely installed on the Central Branch, too. Both segments need to be electrified.

The density of station stops along the Inner Montauk, particularly between Babylon and Patchogue, means this segment will heavily benefit from the improved acceleration and deceleration offered by electrified service. The ridership model shows that the Inner Montauk would see the third largest gains in initial ridership and would become the third-most traveled portion of the MTA's electrification program. Additionally, the Inner Montauk offers the greatest opportunity for additional medium-term ridership growth thanks to as-of-right infill development. Electrifying this portion of the route is essential to expanding the network to the Outer Montauk.

This project would have several major components, beyond electrification. It would separate many of the roughly 21-grade crossings between Babylon and Speonk, reducing the risk of crashes between trains and automobiles and the amount of horn-blowing trains must do by law.

Inner Montauk

Electrification (Babylon to Speonk): $800 million-$1 billion

Grade separations (Babylon Yard to Sayville): $800 million

Double-track, station and ROW upgrades (Sayville to Speonk): $1.2-$1.3 billion

Yard (Speonk): $375 million

Fleet (80 M8s): $410 million

$3.2-$3.5 billion

- Exclusive fleet costs

Central Branch

Electrification: $220-$260 million

Double-track, two stations and ROW upgrades: $390-$420 million

$610-680 million

Additionally, it would build a second track between Sayville and Speonk, which will allow trains to run in both directions simultaneously. And it would rebuild the Patchogue, Bellport, Mastic-Shirley and Speonk stations so they can handle inbound and outbound trains at the same time.

Furthermore, electrification of the Central Branch would alleviate congestion along the Babylon Branch by providing a second electrified route from the South Shore to Jamaica. It would also open the door for new stops and additional service. There is substantial population density clustered along the northern and southern portions of the Central Branch, which could be served by two infill stations: downtown North Lindenhurst, which would help relieve pressure at Babylon; and Fulton/Main Streets south of Farmingdale. These new stops would allow the LIRR to fully utilize this existing right-of-way and bring service to a part of Long Island where a car would otherwise be needed to easily access transit. The total expected cost for both the Inner Montauk and Central Branch improvements would be $3.8-$4.2 billion.

Outer Montauk

Electrification (Speonk to Montauk): $1-$1.2 billion

Double Track, Stations, ROW upgrades (Speonk to S. Hampton): $1 billion

Stations, Sidings, ROW upgrades (B'hampton to Montauk): $400 million

Yard (Montauk): $375 million

Rolling stock (80 M8s): $410 million

$2.8-$3 billion

- Exclusive fleet costs

6.2.2 Speonk to Montauk

The proposed Outer Montauk upgrades would deliver electrification, full double-tracking and rebuilt stations from Speonk and Southampton. Further east, the package proposes electrification, full signalization and stations rebuilt to handle inbound and outbound trains simultaneously, improving speeds and slashing delays. The end result would be an entirely electric Montauk line offers reliable and rapid service for commuters to Manhattan — and, potentially Brooklyn — and that has the necessary infrastructure to handle the summer crush. Most grade crossings in the towns and hamlets would be grade separated, which improves safety and reduces the chances for a service-disrupting collision. Combined, the Inner Montauk and Outer Montauk programs would cut the single-track territory on the Montauk Branch from 66 miles to 26 miles. This would dramatically increase capacity across the line and make it possible to run dependable hourly service between New York City and the East End, in combination with an expanded LIRR South Fork Commuter Service.

Altogether, this upgraded service would be far quicker and more comfortable than driving to and from the city. That will help take a bite out of the crippling traffic on the South Shore and East End, improving quality of life and boosting the local economies. The local service on the Montauk Branch (LIRR #20) would be 36 minutes faster in each direction, turning the current 195-minutes journey into a 159-minute trip. Additionally, the right-of-way upgrades likely will provide the LIRR with the opportunity to increase the top speed on the 60-65 mph top speeds on the line to 75-80mph to take fuller advantage of the electric trainsets. Those improvements would further reduce trip times to about 157 minutes (2h37m). That's a 40 minutes faster than current service — and nearly as quick as the Cannonball.[108] This electric LIRR Train #20 service would reach Babylon in 52 minutes, Patchogue in 72 minutes and Southampton in 119 minutes (1h59m).

Oyster Bay Branch

Electrification (East Williston-Oyster Bay): $290-350 million

New stations (East Williston-Locust Valley): $330 million[1]

Double tracking (Locust Valley-Oyster Bay), Oyster Bay station: $230 million

Yard (Oyster Bay): $375 million

Rolling Stock (32 M8s): $165 million

$1.1-1.2 billion

- Exclusive fleet costs

1 Average of $36 million per station generated from NJ Transit high-level platform station package overall as contained in its most recent capital plan.

6.3 The Oyster Bay Branch

The close station spacings on the Oyster Bay Branch — 10 stops over 13 miles — mean that diesel locomotives are uniquely ill-fit for the route. Electrification would slash travel times from Oyster Bay to Penn Station by an average of 24% when factoring in a transfer — a figure that grows to 29% at the end of the line.[109] The 78-minute commute from the end of the line at Oyster Bay would be cut to just 58 minutes. The trip in from Glen Head would be slashed from 53 minutes to 42 minutes. Additionally, the better acceleration of electric trains means that Oyster Bay services would be able to clear the Mineola pinch point more quickly, reducing Main Line congestion and allowing for potential increases to service.

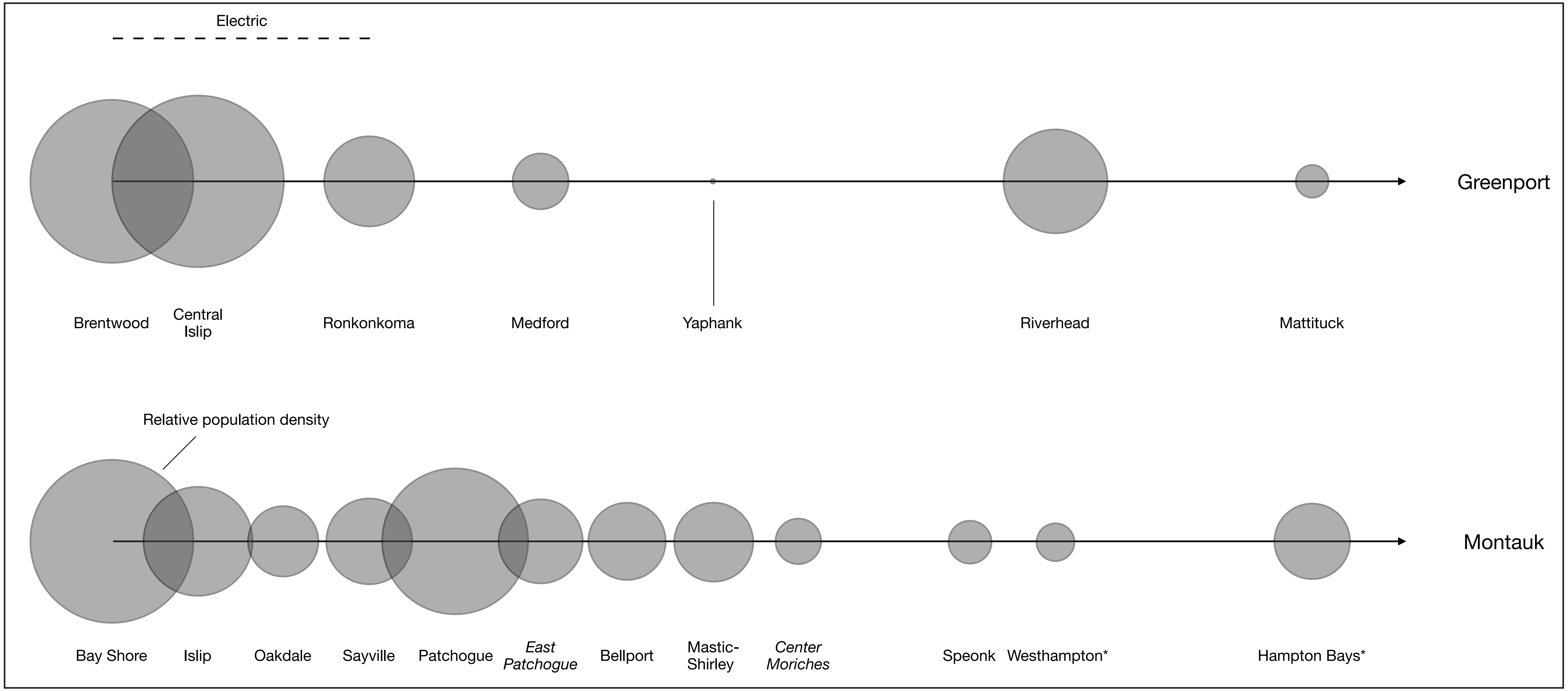
The ridership model shows that the speed gains could result in 232,000 new trips, a 21% gain. The trip time reductions are especially conducive to the TfL model, which shows that Oyster Bay electrification would generate the largest percentage gain in ridership of any diesel branch and the second-largest increase in the number of trips. These findings are buttressed by data that shows there are dense communities clustered along the line, which should be conducive to ridership. It suggests that the current low usage of the line is a product of the present levels of service. The current anemic ridership is a big reason the Oyster Bay Branch would only become the fourth-most ridden electrification project.

The infrastructure is mostly there already. The Oyster Bay Branch is already double-tracked and is largely grade separated. Full electrification and modernization would cost approximately $1.1-$1.2 billion, exclusive of the fleet costs.

108 The official Cannonball, which runs on Fridays, takes 2h31m; the same stopping pattern on Thursdays is scheduled to take 2h21m.

109 The direct service between Oyster Bay and Penn Station takes 78 minutes. There is just one direct train on weekdays and none on weekends.

The Montauk Branch is the central line for eastern L.I.



Factbox

This is a comparison of the population densities between the South Shore's Montauk Branch and the center island's Ronkonkoma Branch.

The population density is taken from the immediate half-mile surrounding the station.

The larger the circle, the denser the population surrounding the station.

Bay Shore (7,600 people per square mile) has roughly the twice the population density of Sayville (3,900 people per square mile) and so its circle is twice the size.

A full table is included at Figure 2.

Source: The City University of New York - Graduate Center's Mapping Service

6.4 Beyond the 'Main Line'

The LIRR's planning philosophy since the early 1980s[110] — and codified in a 1994 system review[111] — was built around economizing its high costs for electrification and construction by focusing on delivering improvements along a central island corridor, the Main Line and one of its feeders, the Ronkonkoma Branch. Secondly, it called for parking garages and park and rides to allow riders from the non-electrified branches or lightly served electric branches to drive to a Main Line station and use the frequent service.

However, this strategy has reached a point of diminishing returns for a litany of compounding reasons. Research into rider behavior from Britain shows that commuters respond sharply to improvements in trip time — which is fully discussed in Section 9.2. Bringing electric, modern service to stations closer to riders' homes would make taking LIRR trains more attractive for commutes and intra-island trips by reducing the amount of time it takes to get to the train, a concept known as out-of-vehicle time. These reductions would build upon time savings already provided by electrification to the actual service.

There's a second major knock-on cost to this strategy. Requiring Long Islanders to drive to Main Line stations for quality service has resulted in the construction of expensive parking garages and large surface lots, which are often full at peak times. The parking shortage limits the ability of Long Islanders to access transit and has led to towns requiring permits for parking. Expanding the reach of fast electric service on low frequency diesel routes (and low frequency electric branches) is one way the MTA can use its existing tracks and capital program to relieve the Main Line parking crunch. These large parking garages and surface lots also take a toll on com-

110 Barron, James. "L.I.R.R. Plans 25 More Miles of Electric Rail." The New York Times. Pg. 25-26. March 12, 1983. https://www.nytimes.com/1983/03/12/nyregion/lirr-plans-25-more-miles-of-electric-rail.html

111 United States. New York. Metropolitan Transportation Authority. "Long Island Rail Road Network Strategy Study." 1994. https://www.documentcloud.org/documents/25499143-1994-lirr-network-strategy-study/

munities. They produce little tax revenue for local governments and are often a significant barrier to efforts to revive downtown districts. Furthermore, large parking lots next to train stations present an obvious opportunity to place new housing as Long Island — and New York State, writ large — to continue to combat an excruciating shortage of homes.

The Babylon station provides a compelling example of how this could play out. The proposed North Babylon infill station would reduce the number of people needing to drive to the current Babylon station from the north; while expanding electrification would reduce the number of drivers coming into Babylon from the east. The cumulative effect should lessen the parking crunch at Babylon. For the Oyster Bay Branch, faster trains and turning trains that currently terminate at Jamaica into direct rides to Manhattan would reduce the need for residents along the route to drive to the Main Line to get good and fast service.

Then there's the matter of where the population densities are located on Long Island. As the graphic and table show, by about 40 miles east of Manhattan, Long Island's population is no longer equidistantly spread along the central Main Line. Instead, riders — and potential riders — are clustered in towns that line the South Shore north and south of the Montauk Branch. This, ironically, means that the South Shore line is functionally central to the population, even though the Ronkonkoma Branch is central geographically. For example, Sayville is just as dense as Ronkonkoma; Patchogue is far denser than anything to its north. Further east, there is not a substantial population pocket along the Ronkonkoma Branch for the 20 miles until reaching Riverhead. Comparatively, there are four communities along the Montauk Branch: Bellport, Mastic-Shirley, Speonk and Westhampton. Furthermore, there are opportunities for new infill stations along this stretch of the Montauk, potentially in East Patchogue and Center Moriches. That would bring the number of stops between Bay Shore and Westhampton to 11; while there would only be six between Brentwood and Riverhead. Ultimately, this analysis shows it makes much more sense to drive limited capital dollars toward these well-established communities, which receive comparatively little service, before spending billions to run wires and track through miles of parks and pine barrens.

Figure 2: Comparing the average population density within a half-mile of a LIRR station between the Montauk and Ronkonkoma branches.

Mile	Montauk	Density	Infill Score	Ronkonkoma	Density	Infill Score
40	Bay Shore	7,604	31	Brentwood	7,449	Electric
43	Islip	5,124	10	Central Islip	7,959	Electric
46	Oakdale	3,301	1			
49	Sayville	3,981	23	Ronkonkoma	4,159	Electric
52	Patchogue	6,832	24			
55	*East Patchogue**	3,898	NA	Medford	2,617	0
58	Bellport	3,592	11			
61	Mastic-Shirley	3,722	21	Yaphank	140	5
64	*Center Moriches**	2,103	NA			
67						
70	Speonk	2,046	10			
73	Westhampton	1,772^	5	Riverhead	4,878	30
76						
79						
82	Hampton Bays	3,538^	5	Mattituck	1,477	10

**Italics are possible infill stations*

^Likely affected by 2020 Census being conducted mid-pandemic

Courtesy: City University of New York – Graduate Center's Mapping Service

7 Modeling Costs

7 Modeling costs

Momentum's infrastructure design involves five major components: the overhead catenary system, stations, grade separations between tracks and roads, signals and control systems, and the tracks themselves. This analysis has sought to identify real world examples and documentation for each type of project to ensure the cost models included in this paper reflect construction premiums that major infrastructure projects in North America and the United Kingdom have faced in recent years. This is not to excuse the high costs or to dismiss the crucially important work being done to improve designs and find efficiencies. It is to show that even in the current environment, with current designs, Momentum's framework delivers significant value for money and should be pursued.

This section provides models and guidance to project expected costs. Some component prices — like track, electrification and signals — are specified on route miles constructed; while grade crossings and stations are priced per facility built. This analysis grouped these components into scenarios that passenger rail planners may encounter on their systems: one model contemplates a service running through a dense urban environment with frequent stops; while another examines what a more suburban-exurban project would entail, where stops are spaced further apart but there is a need for grade separations; and there is a hypothetical inter-city route connecting two cities that runs through a series of towns, its stations are spaced far apart and grade separations are relatively simple.

The component cost analysis shows that the bulk of the expense typically comes from stations and grade separations, which require the heaviest civil works. Electrification is a significant cost, but it accounts for approximately a third of the overall expense. The physical tracks and signal systems are a fraction of the cost of the electrification, the stations or the grade separations. (Again, rolling stock purchases are generally considered separately from the cost of the infrastructure improvements.)

Component cost breakdown:

- Electrification: $6.6-$44 million/mi
- Stations: $31-$59 million per station[112]

112 This assumes 900-foot high-level platforms, which would be sufficient to fit a 10-car EMU train or an eight-car train with two locomotives

- Grade Crossings: $31-$69 million per separation[113, 114]
- Signals/controls: $7-$8 million/mi
- Second track: $4 million/mi[115,116,117]

Additionally, the analysis has identified specific proposals and projects that included several of these elements grouped together in existing built environments, providing real-world examples as another potential cost metric. These packages typically required a substantial reworking of the existing right-of-way to fit a second track on a line that was previously built as a single-tracked; or if double-tracked, to reworked to fit a third or fourth track. These packages included the associated upgrades to stations, grade separations and other major components. All of these costs have been equalized for inflation and pushed forward to 2027$.

Package costs:

- South Shore Second Track: $52m/mi [118]
- Ronkonkoma Second Track: $57m/mi [119]
- LIRR Main Line Third Track: $381m/mi[120]
- Metro-North Harlem Line Third Track: $143m/mi[121]
- Chicago/NY Central Third + Fourth Tracks: $71m/mi[122]
- NJ Transit Raritan Valley Third + Fourth Tracks: $167m/mi[123]

113 The US DOT guide cited below suggests a range of grade separation costs of $7.5-$52 million when adjusted for inflation. However, a review of the grants awarded from the Federal Railroad Administration's 'Railroad Crossing Elimination Grant Program' shows the lower-end appears to be overly optimistic. A more realistic lower-end cost band appears to be $31-$40 million. The upper bound is set against the MTA/LIRR Third Track project, which was a complicated project but was not a record-setter for grade separation costs.

114 United States. US Department of Transportation. "APPENDIX D. Costs and Benefits of Various Crossing Improvements." Accessed Jan. 31, 2024. https://highways.dot.gov/safety/hsip/xings/highway-railway-grade-crossing-action-plan-and-project-prioritization-7

115 Combines the cost of two Michigan projects: One to reinstall a second track along a portion of the route between Chicago and Detroit, near Niles; the other is to improve the infracture of a single-track segment to support 110mph.

116 US. Michigan. House Fiscal Agency. "Memorandum: Michigan's High Speed Intercity Passenger Rail Projects." 2011. Pg 5. https://www.house.mi.gov/hfa/Archives/PDF/FederalARRA_Archives/Capital%20grants_supplementalrequest_update.pdf

117 Johnston, Bob. "Amtrak unveils infrastructure plan to transform Chicago operations." *Trains*. June 10, 2022. https://www.trains.com/trn/news-reviews/news-wire/amtrak-unveils-infrastructure-plan-to-transform-chicago-operations/

118 US. Indiana. Northern Indiana Commuter Transportation District. "Environmental Assessment and Section 4(f) Evaluation for the Double Track NWI Project." 2017. https://www.documentcloud.org/documents/25473218-2017-09-18-south-shore-eis/

119 US. NY. MTA. "Capital Program Dashboard." Was divided into two phases. Phase 2: http://web.mta.info/capitaldashboard/allframenew_head.html?PROJNUM=I-70304wx&PLTYPE=1&DISPLAYALL=Y; Phase 1: http://web.mta.info/capitaldashboard/allframenew_head.html?PROJNUM=I60304tx&PLTYPE=1&DISPLAYALL=Y

120 US. NY. MTA. "LIRR Main Line Expansion." https://www.mta.info/project/lirr-main-line-expansion

121 US. NY. MTA. "The Future Rides with Us: MTA 20-Year Needs Assessment (2025-2044)." 2024. Pg A-381. https://pub-81af28a3136344ffa26f094c671584ac.r2.dev/20-YearNeedsAssessment_ReportandAppendix.pdf

122 US. Department of Transportation. Federal Railroad Administration. "Chicago - Detroit/Pontiac Passenger Rail Corridor Program." 2014. Ch 2. Pgs 64-67. https://www.documentcloud.org/documents/25482939-chi-det-chapter-2-alternatives-considered/

123 US. New Jersey. New Jersey Transit. "Capital Plan Project Sheets: Rail Infrastructure." Pg 114-115. https://content.njtransit.com/sites/default/files/njtplans/Rail%20Infrastructure%20-%20Project%20Sheets.pdf

7.1 Minimum package for electric routes

This hypothetical minimum case for an already-electric route focuses on the installation of high-level platforms. This 30-mile route already is grade-separated and has overhead power. The last component that needs to be installed is high-level platforms, which cuts dwells, improve accessibility and allow for the adoption of more optimized rolling stock. The sample route has 10 stations that need high-level platforms that would potentially save 30 seconds per stop — 5 minutes in total. Upgrading from electric locomotives to high-performance electric EMUs with optimized door designs could shave another 60 seconds off per stop, increasing the total time saved to 15 minutes per trip.

The commuter rail systems on the Northeast Corridor segments between Washington D.C. and Trenton,[124,125] and Providence and Boston[126] provide real world examples of this test case. These station costs are higher than normal because it is very difficult to arrange the necessary service outages to do construction work on the NEC.[127] NJ Transit's busy Morris and Essex Lines are also another prime candidate these upgrades, which would likely be less expensive because it is off the main NEC.

Components:

- Stations: 10 at $85 million each - $850 million

Total cost: $850 million

Cost per mile: $28 million/mi

7.1.1 Minimum package for diesel routes

The hypothetical minimum case for a diesel route also focuses on a single infrastructure item, electrification. Our sample 40-mile route is already double-tracked and grade separated and stations have already been upgraded with high-level platforms. The one major component it needs is electrification, plus a new or upgraded yard to house the electric trains. The Upper Hudson Line and the Hartford line are two real-world examples of this scenario.

Components:

124 Operated by MARC between Maryland and Washington and SEPTA between Wilmington and Philadelphia and Trenton and Philadelphia.

125 The NJ Transit Jersey Ave.stop still has low platforms, too.

126 The MTBA currently runs diesel locomotives beneath Amtrak's catenary power system. It is grouped here because the wires have already been installed.

127 Model stations are the NJ Transit's proposed reconstruction of the Elizabeth station and the reconstruction of SEPTA's Cornwells Heights station, which is underway. The cost of Cornwells Heights was increased by 20% to match increase in platform lengths from 600 to 720 feet to fit an eight-car train.

A SEPTA train bound for Temple University. The agency has not received enough funding from the state or federal authorities to upgrade all of its stations to high-level platforms, like the one seen here.

- Electrification: 40 miles at $22-$27 million/mi - $880-$1100 million
- Yard: $375 million

Total cost: $1.3-$1.5 billion

Cost per mile: $32-37 million/mi

7.2 Moderate package for electric routes

This sample route is 30 miles long and has already been electrified. However, key pieces of the Momentum infrastructure package still need to be installed: there are 10 stations that need high-level platforms and 15 grade crossings that need to be separated or closed. This analysis assumes that both the station and grade crossing costs come in at the high end of the range because of the dense surrounding environment. However, the stations are somewhat less expensive than the Northeast Corridor stations because being off the NEC should make it easier to schedule outages to do the construction work. The ex-Reading Railroad lines in the SEPTA system provide a real-world example of this scenario.[128]

128 US. Pennsylvania. Southeastern Pennsylvania Transportation Authority. "Reimagining Regional Rail: State of the System" 2024. Pg 80-84https://www.documentcloud.org/documents/25544328-septa-rrmp-02-state-of-the-system-v8/

The benefits from this package are the shortened dwells and improved accessibility offered by high-level platforms, saving 30 seconds off of every stop. These gains can be further built upon by adopting fully-optimized rolling stock like the MTA's Metropolitan fleet. Rolling stock with wide corner-point doors can shave another 30 seconds off of every stop by speeding up boarding and disembarking. These two components would combine to cut up to 10 minutes off each trip on this route. Additionally, the grade separations boost safety and improve service reliability by reducing the odds of crashes with cars.

Components:

- Stations: 10 at $59 million each - $600 million
- Grade crossings: 15 at $60 million each - $900 million

Total cost: $1.5 billion

Cost per mile: $50 million/mi

7.2.1 Moderate package for diesel routes

Our hypothetical moderate package assumes a double-tracked, signaled line that already has an extensive amount of service. The current operator runs diesel service, so electrification will be needed. This 50-mile route has 20 low-platform station stops that will need to be upgraded. There are 5 crossings that need to be re-engineered and separated. This analysis assumes that both the station and grade crossing costs come in at the high end of the range because of the dense surrounding environment. NJ Transit's Main/Bergen Line and Caltrain pre-electrification are comparable to our hypothetical line.

The time savings generated for riders from this upgrade package would be substantial — potentially yielding 40 minutes in savings for trains making all stops from the end of the line. Switching from diesel locomotion to high-performance EMU trainsets could save 60 seconds per stop; upgrading from low-level platforms to high-level platforms should shave off another 30 seconds per stop; adding the optimized door designs would increase the time savings even more. These combine to save 90-120 seconds per stop.

Components:

- Stations: 20 at $59 million each - $1.2 billion
- Grade crossings: 5 at $60 million each - $300 million
- Electrification: $22-27 million/mi - $1.1-$1.4 billion
- Yard: $375 million

Total cost: $3-$3.3 billion

Cost per mile: $60-$66 million/mile

7.3 Maximum package

Our hypothetical suburban package assumes a line that currently has limited to moderate amounts of passenger service. It is single-tracked with passing sidings and has rudimentary signals. The current operator runs diesel service, so electrification will be needed. This 25-mile route has 10 low-platform station stops that will need to be upgraded. There are a few grade crossings, but the structures — like bridges, overpasses and underpasses — along the route need to be re-engineered or replaced to support a second track. The right-of-way work is similar to the improvements proposed by the Port Jefferson Capacity Project and the recently completed second track project for Chicago's South Shore commuter service, which runs to South Bend, Ind.

Components:

- Stations/ROW improvements/signals ($52-$57 million/mi): $1.3 billion-$1.4 billion
- Electrification ($22-27 million/mi): $525-$725 million

Total cost: $1.8-$2.1 billion

Cost per mile: $72-$84 million/mi

7.4 Intercity: Lightly used freight line package

Our first hypothetical inter-city package is for rights-of-way purchased from freight railroads that were infrequently used for freight purposes (fewer than five trains per day, give or take). These lines are typically single tracked, perhaps with some sidings. Originally, though, it had two tracks and the space for the second track remains, allowing for easy restoration. This is similar to the portion of the route between Chicago and Detroit, once east of Michigan City, Indiana.[129,130] This package of upgrades would improve the first track, install a second track, add signals that allow for frequent service and high-level station platforms, and electrify the route.

This package is designed to be able to turn any underutilized or disused freight corridor into a route capable of delivering frequent intercity and commuter service. Our sample line is approximately 100 miles long. It has seven stations spaced over the first 25 miles, followed by five more stations over the subsequent 75 miles. The route has already been grade separated through the denser portions of the city. There are only a few grade crossings in rural areas because the rail line preceded much of what was built around it. There will be two yards built to support both inner and outer service zones.

Electrification in smaller towns and rural areas should be easier than in denser cities. It should be possible to achieve Amtrak's costs for the New Haven-Boston electrification, which averaged out to about $11 million per mile, adjusted for inflation.

Components:

- Stations (urban/suburban): 7 at $59 million each - $600 million
- Stations (rural/towns): 5 at $36 million each - $180 million
- Grade crossings: 5 at $60 million each - $300 million
- Track: 100 miles at $4 million/mi - $400 million
- Electrification (urban/suburban): $22-27 million/mi - $600-$700 million
- Electrification (rural/town): $11-12 million/mi - $825-$900 million
- Signals: $7 million/mi - $700 million
- Yards: 2 at $375 million - $750 million

Total cost: $4.5 billion

Cost per mile: $45 million/mi

7.5 Intercity: Heavily used freight line package

This package is for rights-of-way purchased from freight railroads that remain heavily used (twenty or more trains per day), but that lie along routes important for passenger service. These rights-of-way in the Northeast and Midwest were often built with four tracks or more but were downsized to two tracks by budget cuts between the 1950s and 1970s. One such example is the old New York Central Water Level route, now called the Empire Corridor. It links together Albany and Buffalo and once had four tracks, which were cut to two. The space remains to restore the original configuration (see Section 5).

Our sample route is roughly 150 miles long. It is currently an active two-track right of way carrying both freight and passenger service, with space to add two more tracks. Our proposal restores the two tracks and, broadly speaking, reseg-

129 "Timetable: MCRR - Main Line Michigan Division - Town Line to Niles." Accessed February 2025. https://www.michiganrailroads.com/timetables-routes/333-michigan-central-railroad-timetables/4994-time-table-mcrr-main-line-michigan-division

130 Michigan Central Railroad track map at Porter, IN. 1918. https://www.documentcloud.org/documents/25544429-michigancentralrr-track-map/

regates freight and passenger services. This eliminates scheduling conflicts and resulting delays. Electrification means trains can achieve higher speeds and accelerate up to those speeds far more quickly. There are seven stops that need to be upgraded to high level platforms, cutting dwells and improving accessibility. Installation of higher capacity signaling and motorized switches means that this route will be capable of supporting both intercity service as well as commuter services near both ends of the line (e.g. Syracuse and Albany-Rensselaer), should local communities be willing to support it.

The most expensive portion of this project is the re-configuration of the right-of-way back to four tracks. This cost was modeled off of a similar proposal through Chicago, which planned to restore two tracks to a heavily trafficked portion of the freight network.[131,132,133] It would make sense that constructing such improvements in more rural areas would cost less, but it is unclear how much less it would cost as there are no specific case studies available. This analysis assumed the Chicago costs for the full length of the route, despite the project likely costing less.

Components:

- Re-installation of track, re-configuration of ROW and signals (150 miles at $71m/mi) - $10.6 billion
- Stations (urban/suburban): 2 at $59 million each - $120 million
- Stations (rural/towns): 5 at $36 million each - $180 million
- Electrification (urban/suburban): $22-27 million per mile - $1.1-$1.4 billion
- Electrification (rural/town): $11-12 million per mile - $1.1-$1.2 billion
- Yards: 2 at $375 million - $750 million

Total cost: $13.8-$14.3 billion

Cost per mile: $92-$95 million/mile

131 This proposal called for the restoration of two tracks along the old New York Central right-of-way into Chicago. It included signaling, but did not include electrification.

132 The proposed project would cost $1.65 billion in 2013 dollars, which was escalated to $2.47 billion in 2027 dollars to account for inflation past and future.

133 US. DOT/FRA. “Chicago - Detroit/Pontiac Passenger Rail Corridor Program.” 2014. Pgs 64-67. https://www.documentcloud.org/documents/25482939-chi-det-chapter-2-alternatives-considered/

8

Reforms & Recommendations

8 Recommendations

Momentum set out to explore why American passenger rail service has fallen behind its contemporaries in Europe and to develop a framework that would allow intercity and commuter railroads to make the most out of existing routes. Through the course of this investigation, I was struck by how similar its infrastructure designs are to those that were developed during a brief period of aggressive U.S. investment that spanned from the mid-1960s to the late-1970s, which were then subsequently downsized or shelved and forgotten about. In a way, this helped. I used this work to help validate the models and designs that this paper developed. In another way, it was absolutely maddening to effectively be reinventing the wheel — and to be able to draw a line between the collapse in American investment in research, planning and design for transit and our ability to develop and build the sorts of game-changing transit and rail programs that this country regularly delivered in the first half of the 20th Century.

America's spend-thrift approach to trains and transit has cost taxpayers in a litany of ways, big and small. Our Acela I case study is just one example (see Section 9). These recommendations come in two halves: First, a package of ideas that aims to rebuild the public sector's knowledge and expertise, empowering elected officials and policy makers to ask the right questions; second, suggestions for top-level specifications to help guide project development, so that transit agencies can get better and more consistent results from the engineering and design consultancies.

There has been significant commentary on regulatory and permitting reforms by other authors and researchers, which I will leave to them except where it directly involves electrification. California recently enacted legislation that exempts railroad electrification projects from its onerous environmental review process. New York should follow suit and designate projects that provide or enhance service on existing railroad and transit rights-of-way as Type II projects under the State Environmental Quality Review Act and City Environmental Quality Review Act, which would exempt them from city and state reviews beyond the already required federal impact analysis. Transit and passenger rail improvements mean less pollution and less traffic, which improves the environment and quality of life. No New Yorker is served by tying them up in red tape.

8.1 Bolstering Planning and Research:

8.1.1 MTA Labs

The MTA should expand its Construction and Development (MTA C&D) arm to bring in-house both its long-term planning and the first stage of individual project development, which typically results in a feasibility study. This new department, C&D Labs, would give the MTA firm command of its expansion and modernization plans; and, just as importantly, the early phases of individual project designs, which is where the most expensive decisions are made. This would require expanding the MTA C&D staff by approximately 500 people to match the staffing levels for long-term planning and megaprojects at Transport for London.[134]

8.1.2 CUNY: Dept. of Transit Planning and Engineering

Manpower shortages have hampered efforts to expand and improve rail service in the U.S., interviewees told us. There are not enough planners, designers and engineers interested in transit to meet the needs of the public sector. It's a problem that has been repeatedly identified by NYU-Marron.[135] Lawmakers should task the state's public university systems with fixing this shortage. Momentum proposes two programs that would tackle the MTA's biggest capital program challenges head-on: Expanding and modernizing the system; and developing the next generation of subway and regional rail trains. One of the programs would be housed in the City University system, while the other would be based out of the State University system. The CUNY program would focus on the structural half of this mandate, focusing on what we build and how we build. This program's responsibilities would include comparing our designs — for stations, tunnels, power systems and more — to those used by other major transit agencies globally and using those findings to develop best practices as part of the effort to attack our high construction costs.

SUNY: Dept. of Rolling Stock Innovation

This report envisions the State University program focusing on the mechanical and moving portions of transit, particularly rolling stock design, manufacturing and quality

134 Hicks, Nolan. "MTA's backward design process puts consultants in charge, adds millions of dollars in costs, insiders say." The New York Post. Sept. 17, 2023. https://nypost.com/2023/09/17/mtas-backward-design-process-puts-consultants-in-charge-adds-millions-of-dollars-in-costs/

135 Goldwyn, Eric; et al. "How to Improve Domestic High-Speed Rail Project Delivery." New York University. Marron Institute. Transit Costs Project. 2024. Pgs 25-28. https://transitcosts.com/wp-content/uploads/HSR_Final_Report.pdf

control. The ability of the U.S. to advance designs and engineering for passenger rolling stock effectively disappeared with the collapse of Budd Industries and the St. Louis Car Company. New federal regulations, known as alternative compliance, offer a chance to better harmonize the U.S. and European rail markets. New York — with its rolling stock plants like Alstom in Hornell, Siemens Mobility in Horseheads, CAF in Elmira and Kawasaki in Yonkers — should be an active participant in this market. This requires us to invest in rolling stock research and development, including a workforce with the necessary expertise to design, engineer and build the trains. Binghamton and Buffalo are both home to extensive railroad infrastructure, which could make either SUNY campus a natural home for this program.

8.1.3 Library of Transit Planning & Engineering

There is no central repository in New York (or, really, anywhere) that collects, organizes, digitizes and makes searchable the documents from past projects and proposals for transit and passenger rail improvements. This scattering of materials means planners often have to spend time reassembling documents from various sources or are forced to start from scratch, even though the resulting project will look a great deal like the work that preceded it. This is a crazy way to do business and is easily remedied by the establishment of a transit and passenger rail library and research center. It would rebuild our knowledge of proposals past and present, beginning with New York State and then growing to include New Jersey and Connecticut. It should then expand its collection to include key documents and reports from other major transit and passenger rail projects across the Americas, Europe and Asia. The documents from nations that do not speak English — likely French, Italian, German, Spanish and Japanese, to start — should be translated to allow U.S. researchers to easily utilize them. The repository could be housed at the New York State Library, one of the state's research universities or one of New York City's research library systems, like the New York Public Library or the Brooklyn Public Library.

8.2 Momentum Technical Design Guidelines

8.2.1 Electrification

Guidelines for catenary power system:

- Type: Overhead catenary
- Voltage: 25,000V at 60 Hertz (50Hz in western Europe)
- Wiring type: Constant tension
- Substations: Every 36-49 miles
- Switching stations: Every 18-24.5 miles (halfway between substations)
- Paralleling stations: Every 6-9 miles
- Catenary pole spacing: Minimum of 200 feet in straightaways

8.2.2 Stations

Guidelines for stations:

- Lengths: 720 feet (8-car length) or more
- Platform height: 4 feet (48 inches)
- Distance from platform edge to track center line: 5'7" (67 inches)

8.2.3 Rolling stock

These rolling stock recommendations take into account the potential weight savings for the MTA's third rail-powered rolling stock discussed in Section 11. This analysis suggests putting the rolling stock efforts on two tracks. The first track would be to investigate and implement improvements and weight savings to the existing designs. This weight savings program should also explore additional ways to modernize the MTA's rolling stock, including pilots to test 2x2 seating arrangements, switching from two-car trainsets to four-car or five-car trainsets (like how the New York City subway already operates) and open gangways. The second track would further those lessons and apply them to trains built with more extensive use of lightweight materials, like aluminum.

Design and performance goals for Metropolitan M11 (Mercury pilot):

- Maintains traditional steel-body construction
- Weight (A-Car): 107,000-114,000 lbs.
- Doors: At the corner-points of cars (e.g. the M7/M8/M9)
- Door width: 50 inches
- Configuration pilots:
    - Four/five-car sets: A-C-C-B; A-C-C-C-B
    - Open gangways between cars
- Interior layout pilots:
    - 2x2 throughout
    - Subway-style bench layout from doors to car ends; 3x2 in central core section

Design and performance goals for Alternative Compliance pilot (Apollo pilot):[136]

136 The performance specification suggestions for the Alternative Compliance trains were developed from the RFP performance guidelines for the Silverliner V. The Effective Transit Alliance came up with similar figures in a piece they recently wrote. They named the hypothetical train the M10. https://www.etany.org/not-so-capital-plan-the-

- Integrate results of multi-car trainset, interior design and M11 weight reduction pilots (as applicable)
- Adopt Tier 3/alternative compliance construction and safety standards for weight savings
- Vertical height: 13'3" (159 inches)
    - Fits within East Side Access/63rd Street tunnel
- Multi-power system compatibility:
    - AC: 25kV/60Hz
    - AC: 12kV/60Hz
    - AC: 12kV/25Hz
    - DC: Over-running
    - DC: Under-running
- Performance targets:
    - 0-50mph: 25 seconds (AW1 weight)
    - 0-80mph: 55 seconds (AW1 weight)
    - Top speed: 110-125mph

8.2.4 ROWs and Clearances

Guidelines for clearances:

- Distance between track centers (up to 125mph): 12'6" in straightaways
- Distance between track centers (125-160mph): 14 feet in straightaways
- Minimum clearance between contact wire and train: 8 inches (passing)
- Minimum clearance between contact wire and overhead structure: 7 inches (passing)
- Minimum total clearance between train and structure: 15 inches (passing)

A LIRR train departs Atlantic Terminal

Credit: Nolan Hicks

future-is-electric

Discussions of:

Doctrine & History, Designs, Specs, & Freight

9 Doctrine & History

Credit: The National Archives via Wikipedia

9 Planning Philosophy of Momentum

Momentum's infrastructure framework is underpinned by a "trip-time first" planning philosophy, which offers several benefits when compared to the traditional American preference for redundancy and a focus on the expansion of rail infrastructure. The trip-time first philosophy focuses on delivering the highest possible average speeds and shortest possible trip times on existing routes. This helps to minimize project risk and price-tags when compared to the construction of brand-new systems. It means that existing riders feel the benefits of the project on the first day of service, whereas more traditional capacity and redundancy projects sometimes take years to be put to full use. Additionally, these improvements also immediately yield improved revenues for transit agencies, as shorter trip times have been shown to induce new trips from new riders and mode-shift from cars thanks to the improved convenience

The philosophy is underpinned by decades of academic research from Britain, which shows that commuter and intercity rail passengers respond in a sharp and positive manner to improvements in trip time. The research shows that quicker trip times improve both rider satisfaction with transit and help to attract new demand to existing services. American academic research conducted during the brief period of rail nationalization and significant federal funding for passenger service from the 1960s through the 1970s echoed these findings. However, much of that body of knowledge in American rail planning was lost amid the diminution of federal transportation research agencies during the 1980s. Those funding cuts mean that there has been little formal academic research in the U.S. into the service factors that drive ridership over the last four decades. What research has been funded in the U.S. has primarily focused on bus ridership. This, on a certain level, is understandable considering both the limited resources for research and national applicability of bus ridership. Every community has some type of bus service, while subways, metros, and passenger rail services are not commonly found outside of the Northeast, Chicago and a few other locales.

However, Momentum's literature review found that this has resulted in compounding series of faulty assumptions, which has pushed American transit planning and capital development in a diametrically different direction from Europe. This review explores these factors in-depth in the following sections.

American planning does acknowledge that trip times are an important factor in selecting which mode a new transit line should take and in computing future ridership projections. However, in the U.S., trip times post-completion of the line are treated as a fixed constant and not as a variable that can be improved. This appears to stem from the fact that almost all of the available literature focuses on traditional bus services, which can move no quicker than the flow of traffic. Furthermore, the reliance on bus-based research — caused by the lack of study of other transit modes — has forced U.S. academics and planners to use bus service and bus ridership behaviors as a proxy for all transit ridership. This has flattened the distinctions between passenger modes — passenger rail, subways, and buses — into just 'transit.'

This stands in stark contrast to Britain, where extensive research shows transit ridership and behaviors vary significantly by mode used. Commuter and intercity rail passengers respond sharply and positively to reductions in travel time, while bus riders are far more focused on reliability — both real and perceived — of the service. Additionally, the lack of study means that American planners have a very different view of how riders consider trip time and reliability than their British counterparts. British research shows that rail riders are far more concerned about trip time and keeping to schedule than incremental improvements in frequency, because rail services operate — and are thought of as operating — on a 'timetable.' The American approach, driven by the flattening of the various transit modes into a bus-centric paradigm, believes that riders view a lack of frequency as a lack of reliability — and that the provision of infrastructure for future frequency increases is paramount, even if the service boost is not immediately warranted. The cumulative effect of this research deficit — plus the balkanized nature of the U.S. rail network — helps explain why U.S. transit and passenger rail operators favor projects that riders are less likely to appreciate.

Federal regulators' failure to maintain and further develop research and expertise for transit agencies has led to other costly errors which have undermined confidence in American rail and transit services. For example, lessons learned in the 1970s about domestic struggles to develop high speed passenger rail equipment were not absorbed. Two decades later, many of those same problems plagued Amtrak's Acela I program. The agency that conducted that research saw its staff slashed from 1,600 to 600 during the Reagan administration, which bragged about 'privatizing' research into the future development of passenger rail and transit services, which effectively killed it.

Intentionally or not, the gutting of transit research and development by a hostile administration in the 1980s has taken a long-lasting and under-appreciated toll on passenger rail service in the U.S. The resulting loss of knowledge and insularity has contributed to an American planning doctrine that prizes projects with massive costs and long construction timelines, while providing little immediate benefit to riders upon completion. The combination is the worst of both worlds for transit agencies and passenger railroads, whose spending receives more scrutiny than perhaps any other single function of government even as they receive comparative scraps when it comes to taxpayer support.

The trip-time first philosophy takes American transit planning 'back to the future,' tackling both the value-for-cost crisis in transit *and* the public and political cynicism about supporting passenger rail service head-on. It aims to do this by making tangible improvements to existing service — namely, markedly faster journeys — a key criterion in how projects are shaped and pitched for capital programs. The goal is the development and delivery of projects that improve lives, provide immediately evident value-for-money and transform the existing ridership into a powerful constituency for further modernization and broader support for transit. Success begets success. Momentum for transit is essential to its survival and potential expansion in our current politically perilous moment, where projects will once again have to overcome frequent, intense and ideologically-driven opposition.

9.1 The Cost of Lost History

The railroad modernization launched by the U.K. in the 1950s and the U.S. in the 1960s was in response to major business and geopolitical challenges. These major projects may have differed in details but shared these traits: Electrification, high-performance trains and, in the U.S., level boarding. British Rail was already nationalized and the U.S. industry was headed toward the same fate. Growing competition from automobiles and airlines — both of which benefited from extensive government support — siphoned away passengers and freight, endangering the industry's bottom line.

The British, desperate to upgrade a system that was still almost entirely powered by steam, looked across the English Channel and imported the power system developed by in France.[137] The French system was an advanced, higher-voltage and higher-frequency version of the catenary power systems built by the New Haven & Hartford and Pennsylvania Railroads before World War II. This would become the system that powers the famed French TGV trains. Slightly tweaked, that system was supposed to provide Amtrak its replacement for the aforementioned Northeast Corridor power system[138] that it inherited from the Pennsylvania Railroad's collapse.

The concepts behind level boarding also have history in railroading. The Pennsylvania Railroad financed the construction of high-level platforms at key stations, like New York's Pennsylvania Station, to boost throughput by speeding alighting.[139] But the level-boarding design was not widely applied, even in the Northeast, until the government takeover.

Riders rewarded widespread application of these components as part of modernization efforts, giving passenger rail service important wins in the U.S. and Britain amid the post-war explosion in automobile demand. British Rail's electrification of the West Coast Main Line, a key link that runs from London to Scotland, slashed travel times and spurred ridership gains of as much as 80%.[140] The MTA in New York opted to install universal high-level platforms and extend electrification, albeit using its inherited third rail systems.[141] Today, the Long Island Rail Road and Metro-North are two of the most used commuter railroads in the country. Level boarding, expansion of electrification and high-performance EMUs were all included in the federal government's Metroliner and Electrak programs for the Northeast Corridor during the 1960s and 1970s. (However, the federal effort only targeted infrastructure used by Amtrak, often leaving the commuter services along the route unimproved. And the proposed expansion of electrification from New Haven to Boston would not be funded by Congress until the 1990s).

The designers and engineers who crafted the U.S. modernization sometimes remarked on the knowledge and

137 United Kingdom. British Rail. 'Your New Railway; London – Midlands Electrification.' 1966. Pg. 10. https://www.documentcloud.org/documents/25453279-liverpool-london-launch/?mode=document&q=french#document/p10

138 United States. Department of Transportation, Federal Railroad Administration. 'Northeast Corridor High Speed Rail Passenger Service Improvement Project. Task 16 – Electrification Systems and Standards.' 1976. https://www.documentcloud.org/documents/24788751-1970s-60-cycle-report/

139 Hamlin, George. 'Almost, but Not Quite.' Trains Magazine. August 4, 2019. https://cs.trains.com/trn/b/observation-tower/archive/2019/08/04/almost-but-not-quite.aspx

140 United Kingdom. British Rail. 'Electric all the way: London to Glasgow'. 1974. https://www.documentcloud.org/documents/25453280-brlm-elec002/

141 United States, New York. Metropolitan Commuter Transportation Authority. 'Metropolitan Transportation — a program for action. Report to Nelson Rockefeller, Governor of New York.' 1968. https://ia600208.us.archive.org/1/items/metropolitantran00newy/metropolitantran00newy.pdf

skill lost in American railroading during the disinvestment — roughly World War II to the mid-1960s — before nationalization. And it was particularly pointed at times. A 1977 U.S. Department of Transportation report examining potential strategies, standards and needs for electrification expansion was unsparing.[142] "In the absence of recent electrification projects in this country, one looks to the wealth of experience accrued in Europe in electrified passenger and manifest freight service." In another section, it stated: "The amount of catenary installed in the United States in the last forty years has not been sufficient to preserve and update the installation techniques and skills developed in the first quarter of the century."

The U.S.'s attempts to develop locomotives that could perform at high speeds were similarly hobbled by the loss of expertise. "The lapse in interest in intercity passenger trains in the U.S. during the 1950's and 1960's has restricted development of rail passenger equipment to transit and commuter trains," a blistering assessment delivered to the U.S. DOT in 1981 concluded.[143] "Passenger locomotives with reasonably high speed capability are not new in the U.S. but the lessons of history in the development of locomotives in the U.S. at times seem to have been forgotten," it added. "The patterns of passenger equipment development in Europe and Japan, when contrasted with most U.S. practice, confirm this point."

At that point, the U.S. and U.K. were a decade or so behind the French, who were on the verge of launching the TGV. In a bid to catch up, there were extensive plans drafted to expand electrification on the Northeast Corridor and beyond. The British were experimenting with tilting train technology that they hoped would allow them to deliver French and Japanese speeds, running at 160 mph, over the country's existing twisty tracks.

9.1.1 Research and development gutted

But the economic forces — inflation and energy shortages — that led the U.S. and U.K. administrations to invest in rail also contributed to their political defeats. In both countries, they were succeeded by administrations hostile to rail investments. In the U.K., the Thatcher government axed the tilting train program and sold the patents for a pittance to the Italians, who ironically would sell trains with the technology back to the U.K. two decades later.[144,145] (The tilting train technology also underpins both generations of Amtrak's Acela trains.) In the U.S., most of the attention over the transit funding battles between the Reagan administration and Congress was focused on the White House's repeated attempts to slash funds for expansions, new lines and other projects. Many of those programs survived because of robust support from lawmakers.

However, the research arms at the U.S. DOT faced a virtual dismantling. The Federal Railroad Administration saw its staff cut by two-thirds, from 1,686 in 1979 to 640 by 1986.[146,147] The DOT annual report for 1981, the Reagan administration's first year in office, bragged that all non-safety-related research was being phased out or shifted to the private sector.[148] Left unsaid was that improving pas-

Mocked in its time, British Rail's Advanced Passenger Train (APT) pioneered the tilting technology that underpins Amtrak's Acela.

Credit: The Norwich Guardian (UK)

142 United States. U.S. Department of Transportation/Federal Railroad Administration. 'Cost Effectiveness of Research and Development Related to Railroad Electrification in the United States.' December 1977. https://www.documentcloud.org/documents/25454684-cost-effectiveness-of-research-and-development-related-to-railroad-electrification-in-the-united-states-dec-1977/

143 United States. US-DOT/FRA. 'Passenger Train Equipment Review Report'. 1981. Pg. 1-1, 1-2, 2-42. https://www.documentcloud.org/documents/25454741-1981-passenger-train-equipment-review-report-volume-2/

144 Parkinson, Justin. "APT tilting train: The laughing stock that changed the world." BBC News. https://www.bbc.com/news/magazine-35061511

145 Smith, Roger. "Pendolino: 250 million miles and still going strong." Modern Railways. Nov 21, 2019. https://www.modernrailways.com/article/pendolino-250-million-miles-and-still-going-strong

146 United States. Department of Transportation. 'Thirteenth Annual Report, Fiscal Year 1979.' https://www.documentcloud.org/documents/25471920-1979-us-dot-annual-report/

147 United States. US DOT. 'Twentieth Annual Report, Fiscal Year 1986.' https://www.documentcloud.org/documents/25471919-1986-usdot-twentieth-annual-report-fiscal-year-1986/

148 United States. US DOT. 'Fifteenth Annual Report, Fiscal Year 1981.' https://

senger service was a key focus of federal research and that the private sector — that is, the freight railroads — would have little interest in continuing it. After all, the government had allowed them to exit the passenger business by creating Amtrak in the 1970s.

The story repeats at the DOT's city-focused arm, the Urban Mass Transportation Administration. UMTA's research budget was slashed from $94 million annually in the 1970s to $22 million in 1987, a 77% decline.[149,150] Like at the FRA, research into non-safety-related matters was curtailed. The staff cuts were brutal: 210 of the 375 staff at headquarters were either laid off or reassigned. The method with which the cuts were executed further crushed morale. "UMTA's chief was in Florida on official business when the layoffs were announced. But several employees said that one of the bosses' more light-hearted aides handed out "gag" (as in choke) pink slips to some people NOT on the hit list," a Washington Post columnist reported.[151]

With little funding or political support, the FRA and UMTA work was filed away and forgotten. The people responsible for it were either laid off, reassigned or retired. But the problems that their work sought to solve remained — and have reared their head each time Congress has awarded funding for passenger rail, often through one-time appropriations which make it difficult to rebuild the knowledge base.

9.1.2 Acela Problems Foretold

Fifteen years after that 1981 FRA report that zeroed in on how the weight of American locomotives was hampering the U.S.'s ability to develop a high-speed rail program, Amtrak awarded the contract to develop its first true high-speed train set, the Acela, after testing European designs along the Northeast Corridor. However, the FRA — the agency that commissioned the weight report, then had its staff slashed and research filed away — imposed safety requirements that so substantially increased the Acela's weight that the French nicknamed it 'the pig'.[152] All of those extra pounds took a toll.

www.documentcloud.org/documents/25471917-1981-usdot-fifteenth-annual-report-fiscal-year-1981/

149 United States. National Academies of Sciences - Transportation Research Board. 'The State Role in Technical Assistance and Research.' Transportation Research Circular, No. 343. December 1988. https://www.documentcloud.org/documents/25454774-review-of-reduced-planning-support-trb/

150 The 77% reduction figure was calculated by adjusting $60 million in 1979 for inflation to equate it with 1987 dollars, which would be $94 million.

151 Causey, Mike. 'All Those RIF Notes Haven't Been Final'. The Washington Post. February 17, 1982. https://www.washingtonpost.com/archive/local/1982/02/18/all-those-rif-notes-havent-been-final/e99f38ac-a23e-4dab-9171-4fbaea572344/

152 Dao, James; Wald, Matthew L.; Phillips, Don. "Acela, Built to Be Rail's Savior, Bedevils Amtrak at Every Turn". The New York Times. April 24, 2005. https://www.nytimes.com/2005/04/24/us/acela-built-to-be-rails-savior-bedevils-amtrak-at-every-turn.html

They were blamed for the frequent breakdowns that plagued the trains during their early years of service.[153] Amtrak was planning for their replacement by 2012 after just a decade of service, a fraction of a train set's usual 30-to-40-year life span.[154]

The Acela breakdowns generated so many headlines that Congress held a hearing where the train's weight came up.[155] However, a review of the transcript shows no awareness that the problem of weight and high-speed trainsets had been warned about more than 30 years before. The 1981 report had been so thoroughly lost to history that not even the investigators briefing the panel brought it up.[156] For the Acela II, the FRA reversed course and adopted safety standards that are virtually identical to those found in Europe.[157] This allowed the replacement trainsets to be 30% lighter, correcting a major mistake that crippled the first program. Crucially, this process began just a few years after the weight problem became astonishing clear and during a period of relative stability in the federal bureaucracy, which meant that lessons learned were still immediately at hand. The Acela fiasco provides a case study in the high cost and embarrassment that come from slashing research and gutting an agency's staff and memory.

9.2 A 'trip-time first' planning mindset

The disconnect in American railroad capital planning between tangible service improvements, particularly improving trip times, and project development is a significant liability for garnering political and public support for improvements. Momentum addresses this by borrowing from the British and putting trip time at the center of the program. Linking tangible improvements to capital programs is essential, as the skepticism over spending on public transportation runs deep, even in transit-dependent New York.[158] Delivering improvements to speed and frequency of

153 United States. U.S. House of Representatives. Committee on Transportation and Infrastructure. Subcommittee on Railroads. Hearing Transcript. 'Getting the Acela back on Track'. 2005. https://www.govinfo.gov/content/pkg/CHRG-109hhrg22496/pdf/CHRG-109hhrg22496.pdf

154 By comparison, Amtrak's Amfleet passenger cars were built between 1975-1981 and are only now being replaced

155 Wald, Matthew L. "Amtrak Official Outlines Roots of Acela Problems." *The New York Times.* May 12, 2005. https://www.nytimes.com/2005/05/12/us/amtrak-official-outlines-roots-of-acela-problems.html

156 U.S. House of Representatives. 2005. https://www.govinfo.gov/content/pkg/CHRG-109hhrg22496/pdf/CHRG-109hhrg22496.pdf

157 United States. Department of Transportation. Federal Railroad Administration. 'Passenger Equipment Safety Standards; Standards for Alternative Compliance and High-Speed Trainsets.' 2016. https://railroads.dot.gov/elibrary/passenger-equipment-safety-standards-standards-alternative-compliance-and-high-speed

158 Hicks, Nolan. "Congestion Pricing's Promises Never Reached East Harlem." Curbed - New York (Magazine). June 26, 2024. https://www.curbed.com/article/congestion-pricing-second-avenue-subway-east-harlem-polls.html

existing service can only help build an important constituency for projects among current riders who will benefit — and the lawmakers who represent them.

The 'trip-time first' focus emerged in the U.K. from the success of the West Coast Main Line electrification in the 1960s and is backed by decades of further research following subsequent electrification projects. The studies showed that trip time was often the most important consideration for riders utilizing inter-city and longer distance commuter services. Those findings were mirrored in research that was funded by the U.S. government during the short period of rail nationalization in the 1970s.

But, like the lessons on train weight, it was forgotten amid the massive cuts to the DOT's research arms.[159] This moved the burden of improving passenger service to two groups, one ill-equipped to continue it and the other disinterested: publicly-funded transport agencies and freight railroads. Transit agencies cannot easily fund research because they are usually strapped for cash, their spending comes under intense scrutiny from the press and politicians and funding studies is easily attacked.[160] The second group, freight railroads, has no incentive to fund it. They have adopted business models that focus on moving enormous quantities of goods at the lowest possible costs, which means minimizing investment.[161] Spending on research and maintaining infrastructure capable of higher-speed operations does not fit the business plan.[162]

9.2.1 U.K. Underpinnings of 'Trip-Time First'

The completion of the U.K.'s two major projects to electrify the entire West Coast Main Line — stretching northward from London and branching off to Manchester, Liverpool and Glasgow — in the 1960s and 1970s slashed trip times across the line by as much as 25%. It prompted what appears to be the first attempt to study what effect speedier service had on ridership.[163] The authors of the research at the time pointed out the rarity of infrastructure or design improvements facilitating trip-time savings of this magnitude.

159 Sections 5.1, 5.1.1

160 The New York Post, the conservative New York City tabloid, mocked on its front page an MTA proposal to use up to $1 million in federal grant money to study fare evasion, which the authority estimates costs more than $600 million annually. "Fare-ly Stupid." The New York Post. Dec. 14, 2024. https://nypost.com/cover/december-14-2024/

161 Chokshi, Niraj; Eavis, Peter. "Railroads' Strategy Thrilled Wall Street, but Not Customers and Workers." The New York Times. Sept. 19, 2022. https://www.nytimes.com/2022/09/19/business/freight-rail.html

162 Interviewees D, E, F, G, H, I, J, K, N, O

163 Evans, Andrew. "Intercity Travel and the London Midland Electrification." Journal of Transport Economics and Policy. Vol. 3, No. 1. January 1969. https://www.jstor.org/stable/20052126; https://www.documentcloud.org/documents/25462883-evans-intercity-travellondon-1969/

The early literature suggests a strong correlation, though the lack of computerized traffic monitoring or ticketing systems in those days meant that both traffic and rail passengers had to be hand-counted, which limited the review.[164] The first count was launched after the first major phase of the electrification, stretching north from London and covering the separate spurs for service to Manchester and Liverpool. It found that ridership increased by 1.3% for each 1% reduction in travel time for shorter intercity trips and as much as 1.4% per 1% reduction in journey time for longer trips.[165] The electrified lines saw patronage increase by 27-58%, while the non-electrified services saw it drop by 8%.

A 1983 study examining travel patterns across the U.K., including for inter-city rail in eight markets, found a somewhat weaker but still substantial relationship between trip times and ridership.[166] The results produced two different groupings. In three markets the correlation between trip time reduction and ridership was strong, at approximately .8%-1% ridership gain per percentage point reduction of travel time. Two of the three markets (Glasgow and Preston) in this group had received electric service as part of the West Coast Main Line upgrades. The remaining five markets showed a weaker correlation of .3%-.5% boost in ridership per 1% reduction in travel time. However, four of those five markets received diesel service, not electric.[167] "The estimated elasticities of demand with respect to rail journey time are all negative and (typically) highly significant," the authors wrote. It found that fares, and -- to a lesser extent -- the amount of service offered by air and bus competition, can also drive inter-city demand. Surprisingly, the authors wrote, the response to both trip times and fares was far larger than the response to increasing frequency on service at the same speed.[168]

The American literature of the era was less developed, but the findings largely align with those from the United Kingdom. A 1973 examination of an experiment run by the Massachusetts Bay Transportation Authority (commonly called the 'T') found that the biggest driver of new demand for passenger service was shrinking or inverting the travel

164 Evans, 1969

165 Evans, 1969, pg. 77

166 Jones, Ian S; Nichols, Alan J. "The Demand for Inter-City Rail Travel in the United Kingdom: Some Evidence." Journal of Transport Economics and Policy. Vol. 17. No. 2. May 1983. https://www.jstor.org/stable/20052678; https://www.documentcloud.org/documents/25463195-jones-demandintercityrail-1983/

167 NYU Marron analysis of traction source for rail markets identified by Jones and Nichols (1983). Carlisle, Glasgow and Preston are served by the West Coast Main Line, which was electrified to Glasgow by 1974.

168 Jones and Nichols. 1983. Pgs. 150-151

time gap between rail service and car travel.[169] The study described the relative differential in trip time as “the most highly significant variable, suggesting that choice of mode is particularly sensitive to relative travel time.” It added: “The strong significance of the income and relative travel time variables suggests that rail demand is most sensitive to changes in time cost, whether these changes result from changes in travel time or in the opportunity cost of this time.”[170] However, the study did not quantify the direct relationship between trip time reductions and ridership, unlike many of the British studies.

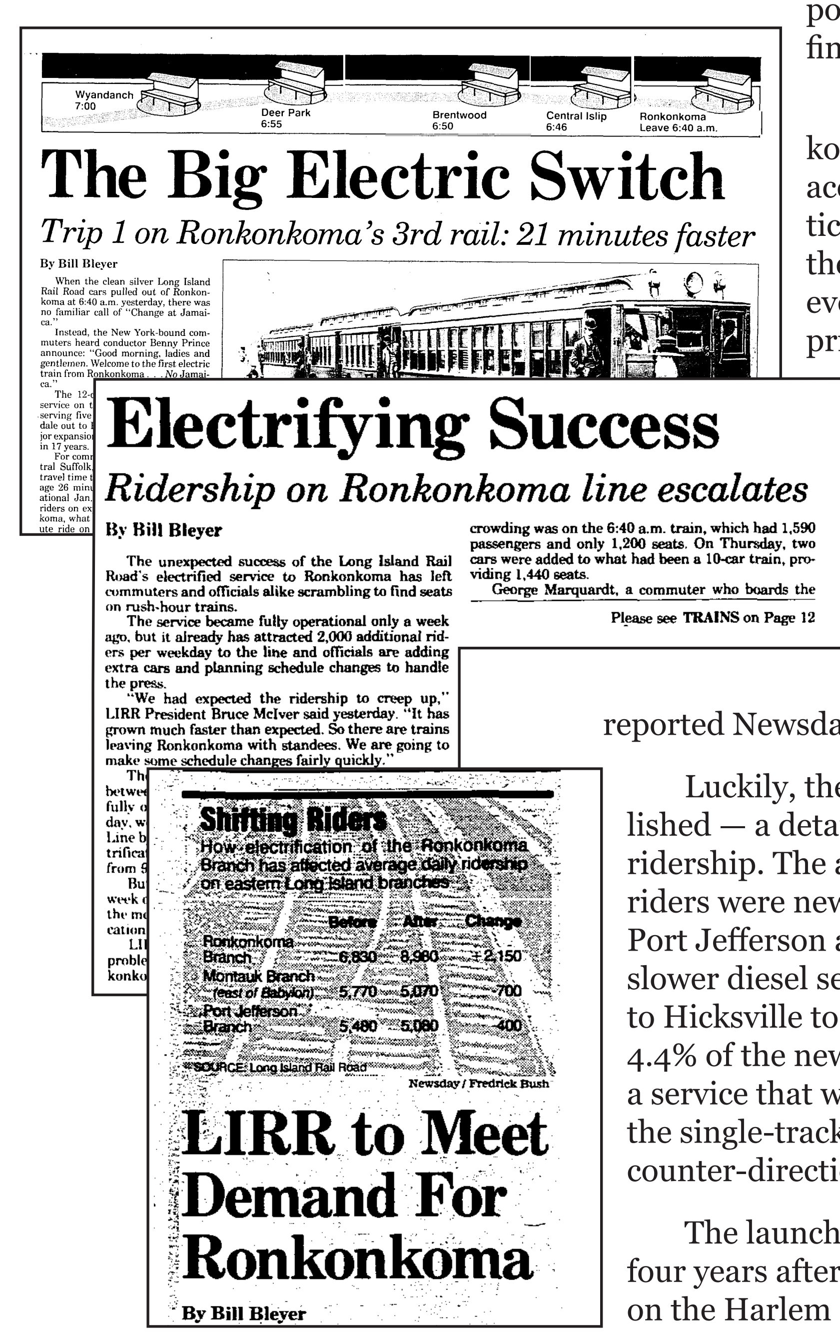
A subsequent UMTA report, released in 1980, directly commented on the scant nature of research into the relationship between quicker transit service and ridership in the U.S. “Perhaps the most important factor that affects public transportation ridership is travel time. Unfortunately, measuring ridership response to total travel-time changes as well as to changes in trip time components is a difficult task. In contrast to the previous sections on service elasticities, there has been scant experimentation with travel-time variations.” Most of the study was focused on buses, which are the predominant mode of mass transit in the U.S. outside the Northeast and select older cities, like Chicago. The paper included only a summary of reports previously compiled about services in London.[171] The London results showed that longer commuter rail services, over 25 miles in length, saw a .86% bump in ridership per 1% reduction in trip time; shorter routes saw a gain of .49% per 1% time saved.[172]

The UMTA study appears to have been one of the last federally sponsored examinations of how rail service speed and ridership interrelate. Shortly after it was released, the Carter Administration was replaced by the Reagan Administration, which ordered the staffing and funding cuts.

9.2.2 Anecdotal US Validation from the 1980s (LIRR, Metro-North, NJ Transit)

Amid the brief period of federal support, UMTA in the late 1970s helped underwrite what is still the largest expansion of American commuter rail electrification since the 1930s. This paper could locate no formal academic reviews of the effect on ridership, likely as a consequence of the Reagan-era cuts to staff and funding at the U.S. DOT. But, the success of the electrifications was often documented in contemporaneous accounts published by newspapers and magazines. A review of that record paints an anecdotal portrait that aligns with the British research findings.

Newsday’s coverage touted the success of the Ronkonkoma electrification project


Wyandanch 7:00 | Deer Park 6:55 | Brentwood 6:50 | Central Islip 6:46 | Ronkonkoma Leave 6:40 a.m.

The Big Electric Switch

Trip 1 on Ronkonkoma’s 3rd rail: 21 minutes faster

By Bill Bleyer

When the clean silver Long Island Rail Road cars pulled out of Ronkonkoma at 6:40 a.m. yesterday, there was no familiar call of “Change at Jamaica.”

Instead, the New York-bound commuters heard conductor Benny Prince announce: “Good morning, ladies and gentlemen. Welcome to the first electric train from Ronkonkoma . . . *No Jamaica.*”

Electrifying Success

Ridership on Ronkonkoma line escalates

By Bill Bleyer

The unexpected success of the Long Island Rail Road’s electrified service to Ronkonkoma has left commuters and officials alike scrambling to find seats on rush-hour trains.

The service became fully operational only a week ago, but it already has attracted 2,000 additional riders per weekday to the line and officials are adding extra cars and planning schedule changes to handle the press.

“We had expected the ridership to creep up,” LIRR President Bruce McIver said yesterday. “It has grown much faster than expected. So there are trains leaving Ronkonkoma with standees. We are going to make some schedule changes fairly quickly.”

crowding was on the 6:40 a.m. train, which had 1,590 passengers and only 1,200 seats. On Thursday, two cars were added to what had been a 10-car train, providing 1,440 seats.

George Marquardt, a commuter who boards the

Please see TRAINS on Page 12

Shifting Riders

How electrification of the Ronkonkoma Branch has affected average daily ridership on eastern Long Island branches

	Before	After	Change
Ronkonkoma Branch	6,830	8,980	2,150
Montauk Branch (east of Babylon)	5,770	5,070	700
Port Jefferson Branch	5,480	5,080	400

SOURCE: Long Island Rail Road

Newsday / Fredrick Bush

LIRR to Meet Demand For Ronkonkoma

By Bill Bleyer

The MTA’s electrification of the Ronkonkoma Branch received the most detailed accounting of its costs and ridership. News articles show that riders flocked to the line when the project was completed in January 1988, even though the single track meant that the primary benefit was reduced journey times. Average trip times fell by 27%, from 97 to 71 minutes.[173] Confirming the trip time thesis, ridership on the Ronkonkoma Branch surged by 31%, growing from 6,830 to 8,950 in the first week.[174] “The unexpected success of the Long Island Rail Road’s electrified service to Ronkonkoma has left commuters and officials alike scrambling to find seats,” reported Newsday, the major daily paper for Long Island.

Luckily, the LIRR conducted — and Newsday published — a detailed breakdown of the sources of the new ridership. The analysis revealed that 400 of the additional riders were new to the LIRR, while 1,100 came from the Port Jefferson and Montauk branches that were served by slower diesel service. The remaining 650 had been driving to Hicksville to catch a quicker electric train.[175] In total, 4.4% of the new riders were induced to park their cars for a service that was predominantly aimed at commuters, as the single-track setup made it virtually impossible to run counter-directional service during peak hours.

The launch of the Ronkonkoma electrification came four years after Metro-North expanded electrification on the Harlem Line from its longtime terminus at North

169 McDonough, Carol C. “The Demand for Commuter Rail Transport.” Journal of Transport Economics and Policy. Vol. 7, No. 2. May 1973. https://www.jstor.org/stable/20052317; https://www.documentcloud.org/documents/25463144-mcdonough-demandcommuterrail-1973/

170 McDonough. 1973. Pg. 142

171 United States. Department of Transportation. Urban Mass Transportation Administration. “Patronage Impacts Of Changes In Transit Fares And Services.” 1980. https://libraryarchives.metro.net/dpgtl/usdot/1980-patronage-impacts-of-changes-in-transit-fares-and-services-september.pdf; https://www.documentcloud.org/documents/25463459-1980-patronage-impacts-of-changes-in-transit-fares-and-services-september/

172 UMTA. 1980. Pg. 70

173 Bleyer, Bill. “Saving Minutes From Rush Hour: LIRR expands electric service on Main Line.” Newsday. Jan. 17, 1988. https://www.documentcloud.org/documents/25469843-shaving-minutes-from-rush-hour/

174 Bleyer, Bill. “Electrifying Success: Ridership on Ronkonkoma line escalates.” Newsday. Jan. 23, 1988. https://www.documentcloud.org/documents/25469564-electrifying-success-ridershi/

175 Bleyer, Bill. “LIRR to Meet Demand for Ronkonkoma.” Newsday. March 11, 1988. https://www.documentcloud.org/documents/25471663-lirr-to-meet-demand-for-ronkon-1/

White Plains to Brewster North, now called Southeast.

Unfortunately, two factors make it difficult to establish a pre-electrification baseline. A month-long strike in 1983 crippled Metro-North service. In addition, before 1983, Conrail owned and operated the Harlem Line and counted its ridership together with the Hudson Line, records from the era show. This means that ridership reports from 1981 and 1982 do not contain enough detail to provide a baseline either.

However, ridership reports from the late 1980s, following the MTA takeover, and news coverage that could be located in the archives of now-defunct local Westchester news outlets suggests the project had a significant and positive effect. In 1985, a local newspaper, The Reporter-Dispatch, wrote about the struggle to find parking spots around stations that had received electrified service after its first year. The story reported that ridership on the Upper Harlem Line grew by 17%, but it did not contain the raw figures.[176]

That report is buttressed by the findings of a 1989 report from the MTA Inspector General that evaluated the performance of both of the authority's commuter railroad agencies from 1984 to 1988. The IG report stated that the Upper Harlem electrification shaved 10-21 minutes off of trips into Grand Central. Statistics collected by the IG showed the Harlem Line — both Upper and Lower segments — saw its ridership jump from 15.4 million in 1984 to 19 million in 1988, a 23% increase. That outpaced the 11% increase on the New Haven Line over the same period of time.[177] Additionally, the IG report said that the number of trains run across the Metro-North system remained virtually unchanged over the four-year period, growing from 511 to 516, meaning that frequency increases should be eliminated as a potential source of the ridership jumps, leaving trip times as the major remaining variable.

Unlike the MTA projects, NJ Transit's electrification on the North Jersey Coast Line from South Amboy to Matawan and then to Long Branch was troubled. NJ Transit's locomotives were beset by breakdowns that left riders stranded throughout the summer. Only 63% of trains ran on-time during the first weeks of operation, which was 10 percentage

176 Tagliaferri, Ed. "Parking for Commuters Can Be Frustrating Affair." Reporter-Dispatch (Gannett). March 31, 1985. A1: https://www.documentcloud.org/documents/25471666-the-reporter-dispatch-1985-03-31-1/; Jump: https://www.documentcloud.org/documents/25471667-the-reporter-dispatch-1985-03-31-12/

177 US. NY. MTA. Office of the Inspector General. "A Review of LIRR and Metro-North Service and Performance, 1984-1988." 1989. MTA/IG No. 89-13. https://www.documentcloud.org/documents/25471668-mnr-ridership-1984-1988/

points worse than pre-electrification.[178] (The E60 locomotives were so notoriously unreliable[179] that their other major operator, Amtrak, retired or sold off its fleet within just a few years of their arrival — including to NJ Transit for use on the North Jersey Coast Line, with predictable results.) The first ridership assessments, via local press coverage, are underwhelming in the context of the MTA's success, potentially because of the chronic locomotive breakdowns. Still, the line outperformed the rest of the NJ Transit commuter rail network. Ridership fell by 1.5% over the first four months of expanded electric service, but that was half of the 3% drop seen systemwide.[180]

9.2.3 Modern Validation of 'Trip-Time First' (Elizabeth Line and Caltrain)

Modern validation can be found across the Atlantic. Transport for London has used its Oyster Card fare payment system to calculate growth in ridership against reductions in travel time by comparing the tap-in and tap-out data collected for each destination pair on the new Elizabeth Line — formerly Crossrail — and the modes of travel used before its commissioning. Crossrail had two objectives: Provide suburban commuters with timetabled, rapid electric service into central London; and merge the branches through central London together to form a high-frequency service that relieves overcrowded metro lines (this operational concept underlies NYCT's express services and the LIRR's Main Line).

TfL's analysis found a significant correlation between trip time savings and ridership gains, with the strongest relationship on trips originating from the Elizabeth Line's outer branches. The 40-mile-long Reading Branch, which was electrified as part of Crossrail, saw a jump of 9.2% in ridership for every 10% reduction in trip time, a nearly 1:1 correlation. The eastern branch, which was already electrified, but stopped short of the London core at Liverpool Street (the New York equivalent of transferring to an inbound subway at Atlantic Terminal) saw a 9% boost for every 10% reduction in trip time. This corresponds with the earlier British academic studies correlating ridership gains

178 Baehr, Guy T. "Shore Commuters Declare Train Emergency." The Star-Ledger (Newark). July 26, 1988. https://www.documentcloud.org/documents/25471755-the-star-ledger-1988-07-26-19/

179 United States. U.S. Congress. General Accounting Office. "How Much Federal Subsidy will Amtrak Need?". Pgs 30-35. 1976. https://www.documentcloud.org/documents/25471756-gao-report-on-nj-amtrak-locomotives/

180 De Gray, Joyce. "Train Ridership Down." The Asbury Park-Press. Feb. 2, 1989. A1: https://www.documentcloud.org/documents/25471757-asbury-park-press-1989-02-02-page-1/; Jump: https://www.documentcloud.org/documents/25471758-asbury-park-press-1989-02-02-page-3/

One of Caltrain's new electric trains pulls into the station at Palo Alto, on the San Francisco peninsula.

Source: Walter Heinrich via Flickr

and trip time. The inducement was strongest on the farther out branches, which also corresponds with the earlier work that shows that longer trips are more sensitive to trip time reduction. The ridership gains inside central London were less significant — .6% per 1% reduction in travel time.[181]

This suggests that riders responded in a sharply positive manner to faster service and other important reductions in travel time, like the elimination of transfers. Overall, TfL found that an astonishing 38% of trips made using the Elizabeth Line by the end of its first year had either mode-shifted or would not have previously occurred (that is the project induced trips that would not have otherwise happened). "Research shows that journey time is the most important driver of travel demand and the customer experience of passengers," it noted.

Caltrain, the commuter railroad linking San Jose and San Francisco, launched its electrified service in mid-September 2024, and the early results have been promising. The new schedules reduced run times for all service patterns, but especially for local services, which make 21 stops over the 51-mile route. The super express, dubbed the Baby Bullet, now takes 59 minutes, which is six minutes quicker than the old diesel service. The local service, which could take as long as 107 minutes, now takes just 83 minutes, a 22% improvement.[182,183]

Overall ridership in November 2024 — two months into the new electric service — was up 28% compared to the same month in 2023. Weekday ridership increased by 24% year-over-year post-electrification. That's double the 13% year-over-year gain seen on the line before electrification took effect.[184] More impressively, Saturday ridership shot up 63% and Sundays saw an astounding 74% jump.[185] Caltrain's weekday average ridership has exceeded 25,000 in every month following electrification, a mark not reached since before the coronavirus pandemic struck.

9.3 Different transit modes, different motivations

Following the major cuts in U.S. DOT support and funding for research, the work that has been done has focused primary on local buses and not subways, commuter rail or intercity passenger service. This has led American researchers — and the transit community, more broadly — to project bus rider behaviors to other modes of transit. Flattening these crucial distinctions between the modes means that important tools to induce ridership on railroads and subways has deemphasized proven interventions that grow ridership on railroads and subways. Mode is a critical factor that cannot be ignored in shaping both service expectations and capital programs.

As laid out in Section 9.2, research from Britain shows that commuter and intercity rail riders value trip time above virtually all other considerations. Subway riders are heavily influenced by both trip times and service frequency, which is often viewed by riders as a proxy for service reliability. Bus riders are the least responsive of the groups to trip time improvements — instead, riders are most acutely, and negatively responsive to the perceived unreliability of bus service,

181 United Kingdom. Transport for London. 'Travel in London 2023; Focus report: Elizabeth Line Travel Trends in the First Year of Operation' -- https://tfl.gov.uk/cdn/static/cms/documents/travel-in-london-2023-elizabeth-line-travel-trends-in-the-first-year-of-operation-acc.pdf

182 US. California. Caltrain. "Printer-Friendly Caltrain Schedule [EFFECTIVE September 25, 2023]." 2023. https://www.documentcloud.org/documents/25471794-cal-train-timetable/

183 US. CA. Caltrain. "Printer–Friendly WEEKDAY Caltrain Schedule [EFFECTIVE September 21, 2024]." 2024. https://www.documentcloud.org/documents/25471793-ct-printerfriendlyschedule-09-21-2024-final/

184 US. CA. Caltrain. "Total Ridership and Average Weekday Ridership – Nov. 2024." Nov. 2024. https://www.documentcloud.org/documents/25471766-caltrain-ridership-1/

185 US. CA. Caltrain. "Ridership Executive Summary – Nov. 2024." Nov. 2024. https://www.documentcloud.org/documents/25471765-caltrain-ridership-2/

the research shows. Bus riders do not respond as sharply as subway riders to headway improvements, but the increases in frequency may reduce the perception of unreliability that heavily discourages ridership. In the U.S., that means that frequency of service and network coverage take center stage in just about any conversation about service improvement and potential ridership gain in transit, while the speed of the service is treated as a secondary consideration. Furthermore, this literature review also found that this mistake is compounded by U.S. planning applying the wrong weights to the various components of calculating trip time — placing too much importance on the amount of time spent walking to stations and waiting for service, while undervaluing the amount of time spent on the train or bus. This means that even when U.S. planning thinks about trip time, it focuses too much attention on making the waits for trains and buses more pleasant (e.g. through massive investments in stations and headhouses) and underprioritizes investments that make service quicker.

9.3.1 Conflating modes of transit

The compounding effects of the diminution of federally supported research into subway and passenger rail passenger behaviors can be seen in a recent study, which foregrounded bus service and gave little consideration to trip time improvements. In the paper, Lyons et al. (2025) dove into the twin conflicting mandates transit agencies must meet: providing universal service across the geographic territory because they are the transportation of last resort for those who cannot afford automobiles; versus generating sufficient ridership, which typically comes from just a few higher-frequency routes, to limit or eliminate the need for government subsidy. Like its predecessors, the authors focused on "1) Transit service coverage, and 2) Transit service frequency," as ways to spur ridership.[186]

The study found that ridership was roughly 30% more responsive to improved frequency than network coverage. "Transit service planners who read this study can be somewhat confident that it is better, in terms of ridership, to focus resources on high-performing routes at the cost of sacrificing spatial coverage."[187] This matches British findings that suggest bus riders are sensitive to the perceived unreliability of the

186 Lyons, Torrey; Ewing, Reid; Tian, Guang. "Coverage vs frequency: Is spatial coverage or temporal frequency more impactful on transit ridership?." Journal of Transport Geography. Volume 122. 2025. https://www.sciencedirect.com/science/article/pii/S0966692324002679; https://www.documentcloud.org/documents/25477027-frequency-vs-coverage-ridership-study/

187 Lyons, et al. 2025. Pg 9. https://www.documentcloud.org/documents/25477027-frequency-vs-coverage-ridership-study/

local buses and that boosting service frequency is one way to attack those perceptions. However, the only consideration that Lyons et al (2025) gave trip times was to note that bus service becomes more competitive with driving during rush hours because congestion slows down all average speeds.[188]

Subways, commuter rail and intercity passenger services are different creatures because they are separated from traffic. This not only means they operate independently from the traffic congestion that slows everything else down, it also means that transit agencies can determine their own fate when it comes to the speed and reliability of the service delivered. (Transit agencies have attempted to bring some of these attributes to selected bus lines by giving them dedicated rights-of-way with Bus Rapid Transit projects).

The focus on traditional bus service and discounting of trip time are both threaded throughout the 2024 paper's literature review. It named two main influences, Taylor and Fink (2003), which was also largely a literature review;[189] and Taylor et al. (2009), which shared authors with the 2003 paper and built upon that initial work. Taylor et al. (2009) examined some three dozen variables that could influence ridership, including headways, fares and network coverage — but did not consider trip times.[190] Trip times are only mentioned as a function of the perceived 'disutility' of transit, minimizing its importance.

Taylor et al. (2009) explain this by dividing trip time into two components, in-vehicle trip time and out-of-vehicle time, based on their own literature review. "Numerous studies have found that travelers perceive out-of-vehicle time (walking to and from transit stops, transferring, and waiting at transit stops) as more onerous (and therefore more costly) than in-vehicle time," they wrote.[191] "Therefore, someone who lives and works near transit stops on a particular line will likely perceive lower costs for a peak-hour, peak-direction transit trip than will a person traveling between the same two stops, but who lives and works farther from the stops and/or who is traveling at night or weekends when service is less frequent."

188 Lyons, et al. 2025. Pg 8. https://www.documentcloud.org/documents/25477027-frequency-vs-coverage-ridership-study/

189 Taylor, Brian D.; and Fink, Camille N.Y. "The Factors Influencing Transit Ridership: A Review and Analysis of the Ridership Literature." University of California, Los Angeles.

190 Taylor, Brian D.; Miller, Douglas; Hiroyuki, Iseki; Fink, Camille N.Y. 'Nature and/or nurture? Analyzing the determinants of transit ridership across US urbanized areas'. Transportation Research Part A: Policy and Practice. Volume 43. Issue 1. 2009. Pg 67. https://www.sciencedirect.com/science/article/pii/S0965856408001274; https://www.documentcloud.org/documents/25477142-ucla-follow-up-2009/

191 Taylor; et al. 2009. Pg 62. https://www.sciencedirect.com/science/article/pii/S0965856408001274; https://www.documentcloud.org/documents/25477142-ucla-follow-up-2009/

Taylor et al. (2009) cite four different works on this subject. However, a review of those papers underscores the lack of research in the U.S. on this subject. The oldest citation, which dates to 1986, is not a study. Rather, it is a computer software manual produced by the Federal Transit Administration that lays out how to build a ridership model comparing bus and auto usage on microprocessor-based computers (i.e. a desktop computer).[192] The FTA manual includes sample weights for the variables that it says are based on either 'experience'[193] or 'assumptions'.[194] It hypothesizes that a planner building a model may want to disaggregate how the model divides trip time into time spent in transit (in vehicle) and time spent using transit but not on the bus (out-of-vehicle). In an uncited parenthetical, the manual states: "In fact, experience indicates that travelers consider out-of-vehicle travel time to be more burdensome than in-vehicle travel time, so a five minute increase in out-of-vehicle travel time does have a greater effect on mode choice than does a five minute increase in in-vehicle travel time." It then assigns weights that value out-of-vehicle time at three times that of in-vehicle time, with no citation or further justification.[195]

The second of the works was not readily available for review. The third cited paper — Small et al. (1999) — examined the behavior of drivers and freight truckers in response to congestion and the installation of high-occupancy vehicle lanes on Route 91, east of Los Angeles, Calif. The paper did not discuss transit service along the route, or indeed, at all.[196] Its literature review cites one study that comments on the value of out-of-vehicle time versus in-vehicle time, a 1979 book by Nils Bruzelius, 'The Value of Travel Time.' The study acknowledges that while Bruzelius "criticizes several studies as using poor data and suspect techniques and oversimplifying assumptions, he does offer some generalizations based on the literature." It adds that "[Bruzelius] states that walking and waiting time are valued from 2 to 3 times more than in-vehicle time," then offers a summary of his calculations pricing this time against wages. A review of Bruzelius' book shows that the figure of '2 to 3 times' comes with a large number of caveats and appears to be an assessment of bus rider behavior, not of those who ride trains.[197]

The fourth referenced paper, Wardman (2001), undercuts the claims about the outsized significance given to out-of-vehicle time elsewhere, though this caveat goes unmentioned in the 2009 paper.

Wardman (2001) was itself a review of previous literature, but it primarily focused on British academic work on this subject. This review was detailed and included a substantial analysis of prior studies on the effect on ridership of trip time improvements as compared to other factors, such as frequency improvements (headways) and service reliability. (It even includes an examination of differing rider behavior based on geography and population densities). It attempted to find the origin of the doctrinaire belief in transit planning, which had come to be frequently cited in American research, that time in-vehicle is of little consideration to riders. "One of the most widely adopted conventions in transport planning is that of valuing walk and wait time at twice in-vehicle time for non-business trips," the authors wrote. "The convention is widely adopted in many other countries, but its precise origins are not clear."[198]

Not only was the origin unclear, but the claim that riders value time spent walking to and waiting for transit two to three times more than the speed of service actually delivered appeared to miss the mark. "We have collected evidence on 290 valuations of walk time, wait time, access time and combined walk and wait time. The average values are all less than two and, with the exception of access time, the differences are statistically significant," Wardman wrote. He estimated the effect at approximately 1.6x.[199] That is 20%-50% less than the 2-3x weight typically ascribed. Furthermore, the study found that railroad users are more sensitive to time spent both in-transit and waiting for transit than Underground riders, who, in turn, were almost twice as sensitive to those factors as bus riders.[200] In short, mode is a critical factor that cannot be ignored in shaping both transit

192 United States. Department of Transportation. Federal Transit Administration (formerly UMTA). "A Self-Instructing Course in Disaggregate Mode Choice Modeling." 1986. https://www.documentcloud.org/documents/25477152-fta-1986-manual-on-computerized-modeling/

193 FTA. 1986. Pg 95. https://www.documentcloud.org/documents/25477152-fta-1986-manual-on-computerized-modeling/

194 FTA. 1986. Pg 4. https://www.documentcloud.org/documents/25477152-fta-1986-manual-on-computerized-modeling/

195 FTA. 1986. Pg 108. The manual, rather absurdly, also states that increasing headways on services with frequencies of less than every 8 minutes is less onerous than on services with shorter headways because "additional waiting time can be spent at home or the office, rather than at the transit stop."

196 Small, Kenneth A.; Noland, Robert; Chu, Xuehao; Lewis, David. "Valuation of Travel-Time Savings and Predictability in Congested Conditions for Highway User-Cost Estimation." National Academy Press. 1999. https://www.documentcloud.org/documents/25477183-1999-ca-highway-survey/

197 Bruzelius, Nils. "The value of travel time: theory and measurement". Croom Helm. London (UK). 1979. Pg 152. https://archive.org/details/valueoftraveltim0000bruz/page/152/

198 Wardman, Mark. 'A review of British evidence on time and service quality valuations'. Transportation Research Part E: Logistics and Transportation Review. Volume 37. Issues 2–3. 2001. Pg 110. https://www.sciencedirect.com/science/article/pii/S1366554500000120; https://www.documentcloud.org/documents/25479558-uk-study-on-ivt-vs-ovt/

199 Wardman. 2001. Pg 110. https://www.sciencedirect.com/science/article/pii/S1366554500000120; https://www.documentcloud.org/documents/25479558-uk-study-on-ivt-vs-ovt/

200 Wardman. 2001. Pg. 119. https://www.sciencedirect.com/science/article/pii/S1366554500000120; https://www.documentcloud.org/documents/25479558-uk-study-on-ivt-vs-ovt/

service expectations and the attendant capital programs, and American planning doctrine appears to have underestimated the value riders place on the time they spend traveling on trains.

9.3.2 The British 'Black Book' for Planning

A consortium of major British universities, in conjunction with the country's major transportation and transit agencies, has produced a guide for transit planning and ridership projections — 'The Demand for Public Transport,' known unofficially as the Black Book.[201] First published in 1981 and subsequently revised in 2004, it contains a well-sorted compendium of research into a wealth of topics, including what drives ridership, the differences in service expectations between transit modes and different ridership outcomes based on population density and mode of service. The usefulness of such a publication should be obvious, but there does not appear to be an American equivalent.[202]

The findings and analysis contained in the 'Black Book' show that a trip-time first focus for railroad service and capital investments would deliver the best value for money. The data on response to increased frequency is more limited, but riders appear to respond less to it. This suggests a logical approach is to speed service where possible and then boost frequency.[203] Further bolstering the case, data shows that the longer the distance of the trip, the more that riders value reductions in trip time.[204]

Riders on subways and other heavy rail systems value both increases in frequency and improvements in trip time. One of the studies cited in the guide, Wardman's 2001 paper, puts special emphasis on headways as a key feature for metro-style systems. "The high value of headway for underground [heavy rail] is not surprising. Underground users generally expect a high frequency service whilst changes in headway will lead to changes in relatively highly valued wait time given that random arrivals for underground trains tend to be more common than for buses and trains[,] which generally operate at lower frequencies."[205, 206]

201 United Kingdom. TRL Limited (Transport and Road Research Laboratory). "The Demand for Public Transport: A Practical Guide." 2004. https://www.documentcloud.org/documents/25479563-trl593-uk-planning-black-book-the-demand-for-public-transport/
202 This report recommends the funding and creation of one.
203 UK. TRL Limited. 2004. Pg 73. https://www.documentcloud.org/documents/25479563-trl593-uk-planning-black-book-the-demand-for-public-transport/
204 UK. TRL Limited. 2004. Pg 20. https://www.documentcloud.org/documents/25479563-trl593-uk-planning-black-book-the-demand-for-public-transport/
205 Wardman. 2001. Pg. 119.
206 Expectations for bus service headways as compared to delivered schedules should be a focus of further study. Riders in the UK seem to expect frequent service, but discount the likelihood it will be provided or operated. This, in turn, seems to fuel desire for the certainty of a timetable, which traffic and other conditions make extremely difficult to

Bus riders are not particularly sensitive to frequency or trip times, but are extremely averse to perceived unreliability and waiting. Overall, service frequency, as measured by headways, tends to be much more valued for shorter trips.[207] Of note, the 'Black Book' suggests that riders transition from thinking about transit in terms of timetables to expected headways when frequencies exceeded four to five trains per hour.[208]

9.4 Real-world Implications of Planning Philosophies

The diminution of research and corresponding loss of knowledge has warped how American commuter and intercity rail services develop and evaluate programs to improve or expand service, interviews and the literature review shows. The U.S. philosophy discounts smaller-bore projects and iterative improvements that aim to improve existing service. Instead, it prizes mega-projects, particularly those that build redundancy — especially adding tracks, terminal capacity and grand stations. The philosophy treats improving existing trip times as a secondary concern, a decision justified by pointing to the potential for hypothetical frequency increases. This philosophy holds even if there are no plans to increase service in the short or medium-term upon completion, meaning a project's benefits remain largely theoretical.

The sum effect is that significant and expensive civil structures — sometimes costing billions of dollars — are constructed, but the service riders receive does not see a commensurate level of tangible improvement. Commutes remain basically the same despite the large expense. "Nobody cares about travel times in transit to a surprising degree," said one planner.[209] "It's really weird." This planner darkly joked that the central theme to many of these projects seemed to be building as many tracks as possible so that railroads can put as little effort into schedule writing as possible.

This stands in stark contrast to the British philosophy, which prizes maximizing the speed of service and capacity of existing rights of way. The U.K.'s Network Rail — the infrastructure and capital agency — recently completed a £1.2 billion ($2 billion) program to upgrade one of the nation's two major north-south routes, the East Coast Main Line[210].

deliver. Anecdotally, this seems to mirror rider behavior in New York City.
207 UK. TRL Limited. 2004. Pg 78, 80-81. https://www.documentcloud.org/documents/25479563-trl593-uk-planning-black-book-the-demand-for-public-transport/
208 UK. TRL Limited. 2004. Pg 71. https://www.documentcloud.org/documents/25479563-trl593-uk-planning-black-book-the-demand-for-public-transport/
209 Interviewee O
210 Hellen, Nicholas. "They finished the fast train line 2 years ago. You still can't

The project included several elements, the largest of which were construction of a new freight bypass and reconfiguring the tracks at the route's southern terminal in London, King's Cross.[211] The project will speed up service, cutting trip times on the fast trains running between London and Edinburgh, Scotland by 15-30 minutes.[212,213]

The East Coast Main Line, like the Northeast Corridor, is heavily trafficked and hosts several commuter services that complicate operations. Both corridors are roughly the same length: the Northeast Corridor spans roughly 450 miles versus the 400-mile long ECML. Yet, a train running the length from London to Edinburgh makes the trip in 4h8m, averaging 96 mph.[214,215] That is more than 40% faster than the roughly 70mph the Acela averages going between Boston and Washington. Making the Acela as quick as the fast trains on the ECML would cut trip times from Washington to Boston to just 4h41m[216] — a savings of two hours. That would make train travel not only much faster than driving, but also as quick (if not quicker) than flying for every city pair on the corridor. "Reading this kind of thing, I just can't really imagine Amtrak announcing a low-billions project that would cut Boston-DC travel times by 20 minutes," said another planner.[217]

The mammoth upgrade program currently planned and partially underway for the Northeast Corridor provides a potent example of this. The Northeast Corridor Commission's 2035 investment program — which Amtrak helped shape — calls for spending at least $117 billion on a slew of projects along the entire corridor. It includes some time improvements but is predominantly focused on new capacity.[218] Most of the money — $96 billion — is focused on repairs, replacement and upgrades between Washington and the end of the Hell Gate Line in New Rochelle.[219] (It also includes NEC corridor branches like the Harrisburg service.) The program aims to shave 54 minutes off of the route between Washington and Boston — with 26 minutes coming from the New York to Washington segment. Upgrading the catenary system on the Northeast Corridor to constant tension is key to unlocking those potential new top speeds of up to 160mph. The current fixed tension system limits current top speeds to 125-135mph, the NEC Commission's report states.[220] "Acela service will benefit from curve speed improvements as well as a new constant tension catenary system that allow for speeds greater than the current maximum 135 mph in the [Mid-Atlantic North, which spans from north and east of Baltimore to Trenton] territory," it states.

However, wire replacement has become one of the first things that Amtrak has looked to scale back, potentially capping speeds for a century.[221] Documents filed with the NEC Commission for Amtrak's planned $630 million wire replacement from New Brunswick to Newark show the railroad intends to keep installing fixed tension catenary.[222] Worryingly, additional filings for the Amtrak catenary replacement program between Wilmington (Brill) and Philadelphia (Landlith) do not specify that the wires will be constantly tensioned.[223] Meanwhile, the railroad is continuing to pursue a potential $16.8 billion expansion at New York's Pennsylvania Station, despite the fact that a needed bridge to get trains into the station remains unfunded and unbuilt.[224] (New York Gov. Kathy Hochul only recently signaled her opposition to the Penn Expansion plans). Still, Amtrak's decisions on the Northeast Corridor provide a clear example of how the U.S. rail planning values theoretical capacity to the detriment of improving existing service. Reform appears to be afoot in one corner of U.S. passenger rail service. California's most recent rail plan, released in late 2024, developed the schedules the state wishes to run before beginning the planning for its infrastructure spending, which it calls 'service-led' planning.[225] This will help ensure each project builds towards the state's

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ride it." The Times of London. June 8, 2024. https://www.thetimes.com/uk/transport/article/they-finished-the-fast-train-line-years-ago-you-still-cant-ride-it-d6knpq8x3

211 Sherratt, Philip. "Pivotal moment for East Coast projects." Modern Railways. Feb. 23, 2021. https://www.documentcloud.org/documents/25507179-modern-railways-east-coast-upgrade/

212 United Kingdom. Parliament. House of Commons. "East Coast Main Line Timetable Changes." 2024. Pg. 8. https://www.documentcloud.org/documents/25507172-parliament-brief-on-east-coast-timetable/

213 UK. London Northeastern Railway. "New LNER Timetable: May 2022 Consultation." 2022. Pg. 20. https://www.documentcloud.org/documents/25507171-lner-may-2022-timetable-change-consultation-document-final-version-v5/

214 UK. Network Rail. East Coast Main Line. December 2025 Timetable. "Table 1 of 21: London Kings Cross to Lincoln, West Yorkshire, Humberside, Teesside, the North East and Scotland." Nov. 2024.

215 East Coast Main Line fast train is scheduled to cover the 397 miles between London and Edinburgh in 4 hours and 8 minutes, an average of 96mph.

216 Calculated by applying ECML fast train average of 96mph across the 457 miles between Washington D.C. and Boston

217 Interviewee G

218 US. Northeast Corridor Commission. "Northeast Corridor Commission Announces CONNECT NEC 2035." July 2021. https://www.documentcloud.org/documents/25472580-c35-press-release/

219 US. Northeast Corridor Commission. "Connect2035" fact sheets. 2021. https://www.documentcloud.org/documents/25472597-c35-territory-fact-sheet-all/

220 US. Northeast Corridor Commission. "Connect2035: A 15-Year Service Development Plan and Infrastructure Planning Process for the Northeast Corridor". Pg. 139. 2021. https://www.documentcloud.org/documents/25472768-connect-nec-2035-plan/

221 The current catenary system was installed by the Pennsylvania Railroad in the 1930s and has yet to be replaced. It is reasonable to expect that it could take as long to fund a second program to replace or modernize this system.

222 United States. Northeast Corridor Commission. "NEC Capital Investment Plan - Project Information Appendix." 2024. Pg 91. https://www.documentcloud.org/documents/25483296-nec-commision-project-inventory/

223 US. Northeast Corridor Commission. "NEC Capital Investment Plan - Project Information Appendix." 2024. Pg. 124. https://www.documentcloud.org/documents/25483296-nec-commision-project-inventory/

224 Hicks, Nolan. "Amtrak Wants to Sell Us a Very Expensive New Station." Curbed-New York Magazine. Aug. 23, 2024. https://www.curbed.com/article/amtrak-penn-station-expansion-through-running-gateway-tunnel.html

225 US. CA. Department of Transportation. "2024 California State Rail Plan." 2024. Pg 3. https://dot.ca.gov/-/media/dot-media/programs/rail-mass-transportation/documents/california-state-rail-plan/2024-ca-state-rail-plan-a11y.pdf

larger vision for its rail network.

An Amtrak Northeast Corridor train dashes through the Maryland snow in 1987. This 1970s-era locomotive, the AEM-7, was known for its light weight, high speeds and reliability.

Credit: Roger Puta, via Wikipedia

10 Electrification

Credit: UK Network Rail

10 Discussion: Electrification considerations

Electrification of routes is essential to delivering the time savings and improved service promised by a high-throughput framework, like Momentum. The dramatically improved acceleration allows passenger rail services to maximize the amount of time trains can spend at top speed, allowing them to take fuller advantage of a particular route's existing capabilities. Diesel trains can take 120-180 seconds to get up to 80mph, while EMU trainsets already found on commuter rail lines can hit that speed in about 60 seconds. That's potentially 60-120 seconds (one to two minutes) back per stop on a route without making additional modifications or improvements to the line to boost top speed. As for top speeds, once again, electric trains have the advantage. SEPTA's Silverliners can hit 100mph in regular service; Amtrak's Northeast Regional trains easily cruise at 125mph and its new Acela trainsets are capable of exceeding 160mph.

American passenger rail services have been slow to embrace electrification despite these apparent advantages. Planners and transit activists interviewed thought a comparative analysis aimed at demystifying electrification projects would be clarifying and useful. Ours focuses first on the form of electrification because two of the nation's largest commuter railroads, the LIRR and Metro-North, inherited third rail power networks and have considered expanding those systems. The MTA's size is such that its projects often become models and case studies for other transit projects across North America. For these reasons, this section cracks open the age-old question of third rail versus overhead power. This report concludes overhead catenary power systems (typically delivering 25 kilovolts at power grid frequency, typically 50-60Hz) offer better performance at much lower cost than third-rail. It recommends that legacy third-rail operators consider a dual-electrification strategy — already used on the New Haven Line — as a way to deliver the benefits of electrification at substantially lower costs.

This report then dives into the differing specifications between three recent major electrifications using overhead catenary power: Caltrain, Amtrak's New Haven-Boston electrification and common specifications used for U.K. projects. It identifies several key areas where the Caltrain project's specifications exceed Amtrak's New Haven-Boston system and British standards, likely contributing to unnecessary scope and to the cost overruns that plagued the project.

10.1 Economics of Third Rail vs. Overhead

Overhead catenary power has become the dominant form of electrification for commuter rail and intercity passenger service since the end of the Second World War. Our evaluation of both types of power systems crystallized why the rest of the world has opted for overhead power when constructing new systems. The cost to build an overhead power system is typically less than half the cost of expanding third rail — and 28% cheaper in the worst-case scenario. This substantially improves the economics of electrification. It provides better performance by delivering more power to trains more consistently, which means not only higher top speeds, but also improved acceleration (see Section 11). Furthermore, overhead catenary also lowers operating costs when compared to third rail because it is more energy efficient. And it speeds up track work because the third rail does not have to be disassembled and reassembled. The debate is so one-sided that in one of the few other places with a legacy third rail network, the United Kingdom, further large scale expansions have been banned in favor of catenary.

Only the MTA appears to have extended third-rail power systems for commuter rail purposes in recent decades. The best-case cost this analysis could identify for such a project was the LIRR electrification to Ronkonkoma in the 1980s, which averaged $49.2 million per mile. The MTA's costs have grown about 27% over that baseline. The authority currently projects that installing new third rail would cost $62.5 million per mile, a figure derived from an analysis of the Port Jefferson Capacity Project.[226] One of the biggest drivers of this cost is the number of substations required for third rail power. MTA specifications call for substations, which cost $30-40 million each, every 1.1-1.25 miles. That means substations alone account for half the cost, roughly $30 million per route mile.[227] This paper could identify no other sizable expansion of third-rail power for commuter or intercity networks since the Ronkonkoma expansion four decades ago, likely also contributing to the high costs the

226 We calculated the estimate by isolating the third-rail electrification component from the rest of the $3.1 billion proposed Port Jefferson modernization. The program calls for the construction of a new yard, which would cost between $360-$390 million, based on two comparable projects included in the 20-Year Needs Assessment. It would also build a second track to allow for bidirectional service, station improvements and upgrades to bridges and other structures on the right-of-way. This work costs approximately $1.3 billion, a figure derived from identifying and analyzing three other similar double-tracking programs from suburban or urban areas (LA Metrolink, Chicago's South Shore Line, MTA Double Track to Ronkonkoma). That leaves $1.4 billion for the electrification, or approximately $62.5 million per route mile.

227 The original price tag was confirmed by the MTA, then adjusted for inflation to $590 million in 2027 dollars, or $24.6 million per mile for a single-track route. These projects typically scale linearly, so a double-tracked version would likely have cost $1.1 billion, or $49.2 million per mile.

MTA faces.

The cost range of third-rail, $49.2-$62.5 million per mile, exceeds the worst case cost this study identified for overhead catenary power, the Caltrain electrification. At $44.5 million per mile, it may be the most expensive overhead catenary project ever. The project was plagued by delays, lawsuits and a botched upgrade to another key system, its train-control signals.

These factors helped push Caltrain's costs substantially above every other overhead electrification project examined by this paper. This analysis found that costs can typically be grouped into two universes: first wave projects with higher costs; and iterated projects with lower costs, providing real world evidence that these costs can be driven lower with experience. First wave systems typically cost between $22-$27 million per mile. Subsequent projects are typically far cheaper, with price tags that can be as low as $11-12 million per mile.

Figure 3: Overhead vs. Third Rail cost comparisons (Prices equalized for double-track and 2027$)

Third rail:

- MTA/LIRR Port Jefferson: $62 million per route mile[228]
- MTA/LIRR Ronkonkoma: $49.2 million

Catenary:

- Caltrain: $44.5 million per route mile
- UK Great Western: $29.7 million
- Adelaide (Australia) Gawler Central Line: $26.8 million
- Midlands Main Line – Phase 1 (UK): $26.2 million
- Toronto GO-RER: $21.6 million
- Midlands Main Line - Phase 2 (UK): $12 million[229]
- Manchester - Wigan to Bolton (UK): $10.7 million
- Amtrak NEC (New Haven to Boston): $10.7 million
- France SNCF (Gretz-Armainvilliers to Nogent-sur-Seine): $6.6 million per route mile

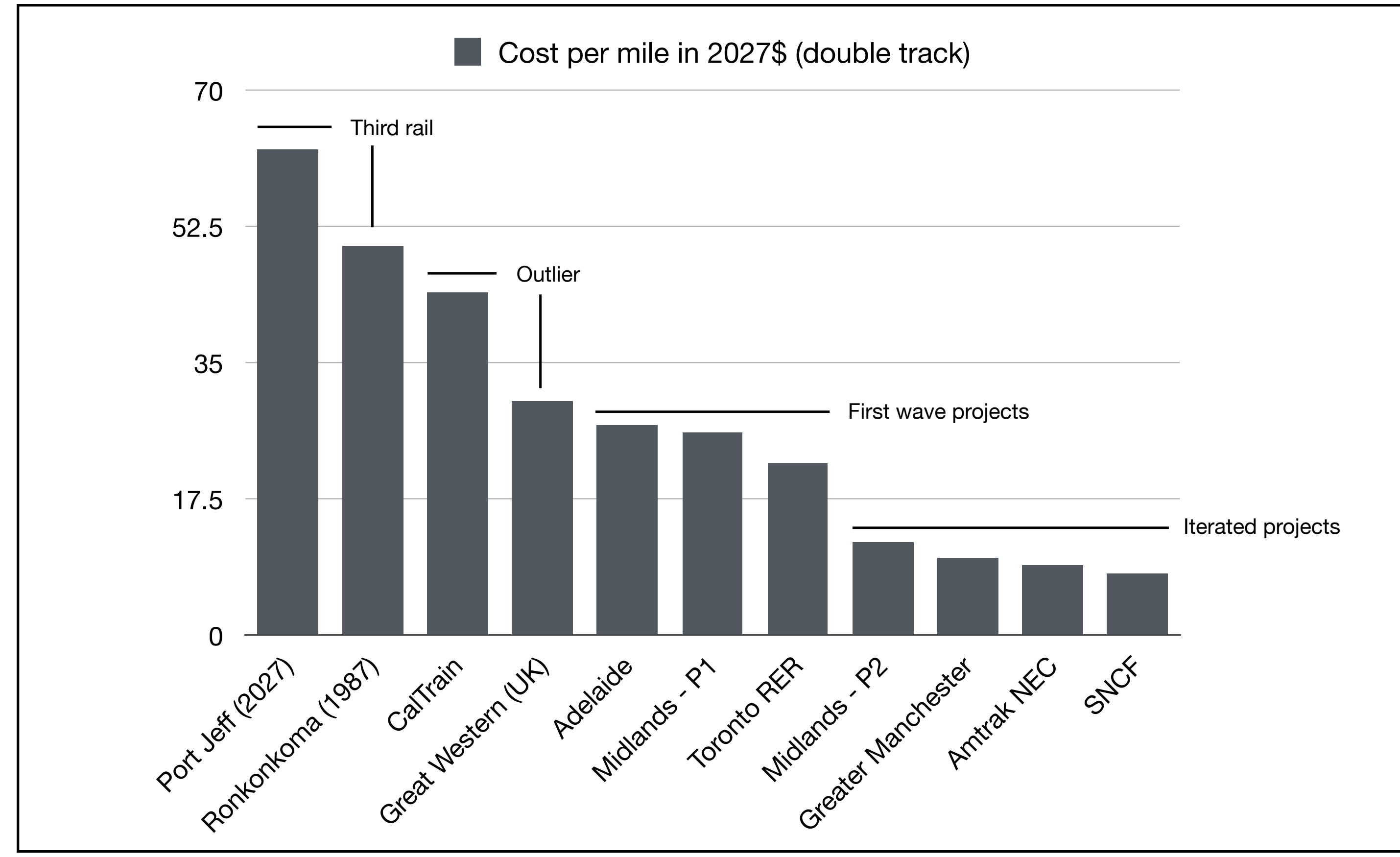
Figure 4: Overhead vs. Third Rail cost comparisons, grouped by project band (Prices equalized for double-track and in 2027$)

Overall: Catenary vs. third-rail cost (double-tracked)

- Third Rail:
  - Worst case: $62.5 million/mi
  - Best case: $49.2 million/mi
- Overhead:
  - Outlier projects: $29.7-44.5 million/mi
  - First wave: $21.6-$26.8 million/mi
  - Successive projects: $10.7-$12 million/mi
  - Best case: $6.6 million/mi

228 The Port Jefferson Capacity Project is unbuilt

229 The Midlands Main Line electrification is called Phase 3, but it is the second major electrification of the line.



This chart shows how overhead catenary systems are cheaper than expansions of third rail power even in the worst case scenario, and that the costs of overhead power systems come down with experience.

10.1.1 Third rail: Higher costs, worse performance

Third rail electrification also costs more to operate than catenary power because it loses far more energy during transmission and lengthens track maintenance timelines, documents show. An extensive report prepared by the UK's Rail Safety and Standards Board found that third rail systems require 16% more electricity than catenary because of transmission losses. The report also found that third rail power elongates track maintenance timelines by 20% due to the time spent dismantling and then reinstalling the third rail to get to the track beneath it. The study recommended that Network Rail further study replacing the third rail network with overhead power where possible because of the substantial operational and capital savings.[230]

On top of the higher costs, third rail limits the speeds that trains can hit. Trains running on wires routinely reach

230 United Kingdom. Rail Safety and Standards Board. 'Investigating the economics of the 3rd rail DC system compared to other electrification systems'. 2011. https://www.documentcloud.org/documents/25450536-rssb-investigating-the-economics-of-the-3rd-rail/

150mph on the Northeast Corridor and exceed 180mph in Europe. By comparison, the British have been able to push trains on their third rail networks up to 100 mph, but face significant energy loss and other performance issues.[231] The MTA's network is capped at 75-80mph. Trains powered by catenary also appear to accelerate more quickly than trains powered by the third rail, another advantage of overhead wires. For example, SEPTA's Silverliner V trains are heavier than the MTA's M7s, and both use Mitsubishi motors rated for the same horsepower. Yet, SEPTA's Silverliners can get up to 50mph in just 24 seconds and hit 80mph in about 60 seconds[232] whereas it takes the M7 60 seconds to reach 50mph and 120 seconds to hit 80mph.[233] (This paper examines the M7's performance in greater detail, particularly the extra penalty its excess weight imposes on performance because of the LIRR and Metro-North legacy third rail systems in Section 11).

10.1.2 Britain's near-ban on new third rail

British rail regulators in 2015 issued a memorandum that effectively banned construction of new third rail systems, with only a narrow carve out for small-scale expansions. "There is a presumption against the reasonable practicability of new-build or extended DC third rail in view of the safety requirements duty holders must satisfy in order to justify the use of third rail," reads the policy directive from the United Kingdom's Office of Rail Regulation.[234] "No significant geographic extension of third rail electrification has taken place on the mainline railway for many years," it states. "However, smaller third rail renewal and very minor extension schemes have been – and continue to be – proposed. For these small-scale projects, duty holders may be able to demonstrate that simple extension or replacement of the third rail is the only viable option in the circumstances."

However, the MTA's current planning tool for potential electrification projects, the Port Jefferson Capacity Project, would opt to expand the agency's existing third rail electrification network. The project's high costs have resulted in a freeze on the electrification hopes for this line for decades.[235] The decision to continue to opt for third rail is a significant contributor, our review shows. The design decisions leading to those high costs deserve reconsideration in the face of a potential alternative: Dual electrification.

231 UK. RSSB. 2011. Pg 41-42. https://www.documentcloud.org/documents/25450536-rssb-investigating-the-economics-of-the-3rd-rail/

232 United States. Pennsylvania. Southeast Pennsylvania Transportation Authority. "Actual Acceleration Rate Versus Time." 2005. https://www.documentcloud.org/documents/25506095-septa-silverliner-v-curves/

233 United States. New York. Metropolitan Transportation Authority. "Electrification Benefits Methodology." https://www.documentcloud.org/documents/25506094-mta-m7-curves/

234 United Kingdom, Office of Rail Regulation. 'ORR's Policy on Third Rail DC Electrification Systems'. Released: March 27, 2015. https://www.orr.gov.uk/sites/default/files/om/dc-electrification-policy-statement.pdf; https://www.documentcloud.org/documents/25450363-uk-limits-on-third-rail/

A M8 rolls into a snowy Harlem-125th Street station running on third rail power.

Credit: Julian Briggs

10.2 Dual electrification: Marrying overhead to existing third rail

The MTA's commuter railroads LIRR and Metro-North are not the first to wrestle with how best to utilize legacy third-rail networks while pursuing cost-effective expansion of electrification. Twice before, planners have solved this riddle by using rolling stock to marry together existing third rail electrification with catenary. This allowed them to claim the advantages of overhead power — lower costs, greater efficiency and higher speeds — while making the most of existing infrastructure. Both resulting projects are high throughput systems that serve as the backbone of their respective transportation networks: Metro-North's New Haven Line; and the Thameslink, which binds together northern and southern London.

235 'Will We Ever See Electrification of the LIRR Port Jefferson Branch?'. The Messenger Papers. June 13, 2024. https://messengerpapers.com/2024/06/will-we-ever-see-electrification-of-the-lirr-port-jefferson-branch/

A century ago, The New York, New Haven and Hartford Railroad — a forerunner to the MTA — opted for a then-experimental catenary that would directly feed power to trains. It picked catenary in part because it had lower costs and would be easier to expand. Its hand was also forced by the banning of third rail in Connecticut. The NH&H system would run trains via catenary to the New York State line, where they would change over to the third rail network that was already built to serve Grand Central. The NH&H's Connecticut system was revolutionary. The Pennsylvania Railroad's intercity power system was modeled after it.[236]

Many decades later, across the Atlantic, British Rail planners interested in boosting the efficiency of their commuter rail operations into London's core and operating under Thatcher-era budget controls opted to marry together the two different power systems as part of a through-running arrangement. They spent £4 million[237] to reactivate a disused tunnel under London that physically joined two separate commuter rail networks — one powered by overhead wires, and the other with third rail. They used their rolling stock renewal budget to purchase trains that could run on both. Every day, the Thameslink service runs subway levels of frequency — 20-24 trains per hour in each direction — across two tracks while making the power transition in the heart of London.

Revising the Port Jefferson Capacity Project to use overhead catenary power, instead of third rail, would cut its capital cost by as much as one-third, this analysis found. As proposed, the $3.1 billion project would construct a second track and electrify the 22.8 route miles from Huntington to Port Jefferson. Switching to catenary power would reduce the upfront costs to $2.2-2.4 billion.

Port Jefferson: Catenary vs. third-rail cost

- Catenary: $500-$620 million
    - Total cost: $2.2-$2.4 billion
- Third rail: $1.4 billion
    - Total cost: $3.1 billion

Overall, catenary would reduce the total cost of electrifying and modernizing the entire MTA network by $6.8-$9.3 billion, from approximately $21.4-$25.3 billion all-in to $14.6-$16 billion.

236 United States, The American Society of Mechanical Engineers - The Institute of Electrical and Electronics Engineers. 'Alternating-Current: Electrification of the New York, New Haven & Hartford Railroad – 1907'. 1982. https://www.asme.org/getmedia/6b0a5b95-c416-47e1-8115-7cb9e336d94f/76-ac-electrification-of-the-nynh-h-railroad-brochure.pdf; https://www.documentcloud.org/documents/25451232-new-haven-spark-history/

237 Lewis, Clive. "BR to reopen London rail tunnel." The Observer (London). June 24, 1984. https://www.documentcloud.org/documents/25463512-br-plans-to-reopen-snow-hill-tunnel-in-1984/

Figure 5: Electrification cost projection for MTA diesel network (estimated):

Overhead catenary program: $14.6-$16 billion

- Electrification cost: $5.2-$6.5 billion (240.5 route miles)
    - This is an average based on the first-wave cases
- Double track, sidings, signals, stations, grade separations: $6.8 billion (covering 172.8 route miles)
- Yards: $2.7 billion

Third rail network program: $21.4-$25.3 billion

- Electrification cost: $11.9-$15 billion (240.5 route miles)
- Double track, sidings, signals: $6.8 billion (covering 172.8 route miles)
- Yards: $2.7 billion

Furthermore, the difference in purchase price between a train that can handle both third-rail and overhead power and a train that just handles third-rail power is extremely small, just 6%. The M8, which can handle both, cost $5.4 million per car in the most recent order when adjusted for inflation; the M9, which can only take third-rail, cost $5.1 million.[238,239]

10.3 Smaller footprint, more resilient system

Overhead catenary systems require just a fraction of the substations needed for third rail. This not only saves substantial money, but also shrinks the size of the project's physical footprint and decreases the need for eminent domain. Overhead catenary power systems for double-tracked routes average just one substation every 25-49 miles, while third rail requires substations spaced no further apart than every two miles (the Port Jefferson Capacity Project specifications call for them every 1.1-1.25 miles). Over a 40-mile project — for example, Babylon to Speonk — an overhead power system would need to site and construct two substations; third rail would require at least 20 and potentially as many as 36 substations, using LIRR's Port Jefferson specifications.

Furthermore, catenary power is safer and more resilient than third rail electrification. First, the substantially longer distance between substations makes it easier to locate them on higher ground and reduce flooding risk. Second, the wires are typically 20 feet above the ground, keeping the bulk of the

238 US. NY. MTA. "Meeting of the Metro-North Railroad Committee." Nov. 2016. Pg. 42. https://www.documentcloud.org/documents/25747603-mnr-m8-procurement/

239 US. NY. MTA. "Capital Program Oversight Committee Meeting." June 2021. Pg 24. https://www.documentcloud.org/documents/25747604-m9-iec-report/

electrical infrastructure well above any water. This is particularly important for routes that run through low-lying land or immediately alongside lakes or rivers, like the Hudson Line. Furthermore, elevating the electrical infrastructure improves safety by substantially reducing the risk of electrocution.

10.4 Northend (New Haven-Boston) vs. Caltrain

A comparison between the two most recent major American electrification projects — Caltrain and Amtrak's Northend — reveals substantial differences in their specifications, despite supporting similar levels of service for the foreseeable future. This may partially explain why Caltrain's system ended up costing roughly four times as much as the Amtrak system when adjusted for inflation.

First, there is the infrastructure that brings the electricity to the wires over the tracks. Both Caltrain and Northend use alternating current systems that transmit 25,000 volts at 60 Hertz, which is commonly shorthanded as 25kV/60Hz (or 25/60). This is the modern U.S. standard, and it is functionally identical to the French and British standard. Both were built to support high-speed intercity and commuter rail services.[240,241] Both will have similar numbers of trains running beneath their wires for the foreseeable future — four commuter trains in the peak direction/hour and one-to-two intercity trains peak direction/hour.[242,243] (That adds up to about 10-12 trains per hour in both directions in the peak period.) Furthermore, planning documents suggest that the Northend system was designed to handle a schedule with more than 250 trains per day, which is 80 trains more than 170-train schedule projected for the CalTrain system.[244,245,246]

240 "Northeast Corridor Improvement Project: Electrification – New Haven, CT to Boston, MA: Final Environmental Impact Report Supplement." 1995. Pg I-2. https://www.documentcloud.org/documents/25449202-1995-northeast-corridor-improvement-project-electrifica/#document/p67

241 "[T]he Massachusetts Bay Transportation Authority (MBTA) plans, at some unspecified future date, to convert its commuter rail operations to electric operation... In recognition of these plans, Amtrak's designers are sizing and selecting locations for facilities to accommodate the future conversion of MBTA to electric operation."

242 United States. California. High Speed Rail Authority. "2024 Business Plan - Technical Supporting Document: Service Planning Methodology." 2024. Pg 10.

243 Amtrak and MBTA timetables

244 Amtrak's planning documents state the system was designed with MBTA's electrification in mind, but do not provide a specific figure for its capacity. However, tables contained in the noise abatement portion of the final environmental impact statement include the projected future schedules for both: Amtrak, 44 trains between Back Bay and South Station; MBTA, 213 trains between Back Bay and South Station. That totals 257 trains.

245 United States. Federal Railroad Administration. "Northeast Corridor Improvement Project Draft Environmental Impact Statement/Report for Electrification of Northeast Corridor, New Haven, CT to Boston, MA. Volume 3. Technical Appendices." 1993. Pgs 4-56 and 4-57. https://www.documentcloud.org/documents/25511375-north-end-eis-volume-3-technical-appendices/

246 US. Caltrain. Pg 2-4. https://www.documentcloud.org/documents/25497266-

Yet the Caltrain system used more equipment to deliver a system that will have less utilization, an analysis of planning documents shows. Caltrain's system contains two substations, one switching station and seven paralleling stations.[247] That's a structure to draw down or regulate power every five miles along the route.[248] The Northend system installed 25 power-related facilities — four substations, three switching stations and 18 paralleling stations[249,250,251,252] — along its 156 route miles: that's a 6.25-mile average.[253] That means Caltrain's system built 20% more electrical infrastructure for a system that will operate 32% fewer trains.

Furthermore, these specifications exceed those used by the UK for the electrification of its main lines, the review shows. These mainlines carry hundreds of trains per day and have top speeds between 110-140mph, exceeding the capability requirements included in Caltrain's environmental documents. The designs typically used by Network Rail provide spacing guidelines for how far apart the various major electrical components can be, which determines how much should be built over any stretch of line:[254] Substations are typically built every 25-37 miles; there is one switching station at the midpoint between two substations so trains can change from one power feed to the next (12.5-18.5 miles from the substation); and then there are boosters, called paralleling stations, at the halfway points between the switching stations and the substations (six to nine miles). Across a sample 80-mile route, a railroad electrification project would likely need to build two substations, two switchers and six paralleling stations. That's an average of eight miles between major electrical components, compared to the five-mile Caltrain average.

Caltrain and California's High Speed Rail system will share tracks running between San Jose and San Francisco,

caltrain-vol-i-revised-deir-040615/

247 US. CA. Caltrain. "Peninsula Corridor Electrification Project: Second Addendum to the Final Environmental Impact Report 2 - Overhead Contact System (OCS) Pole and Wire Relocations." 2017. Pg 2. https://www.documentcloud.org/documents/25513816-caltrain-paralleling-station-spacings/

248 US. Caltrain. Pg ES-9. https://www.documentcloud.org/documents/25497266-caltrain-vol-i-revised-deir-040615/

249 Average distance interval for the 4 substations on the North-end system: Branford (MP 79.26), New London (MP 123.55), Warwick (176.91) and Roxbury Crossing (226.02)

250 Average distance interval for the 3 paralleling stations between the switching at Norton (MP 198.99; Attleboro, MA) and the substation at Roxbury Crossing (MP 226.02, Boston)

251 US. FRA/Amtrak. North-end EIS. Pg 2-33. https://www.documentcloud.org/documents/25507269-1994-northend-electrification-final-eis/

252 US. FRA/Amtrak. North-end EIS. Pg 2-35.

253 US. FRA/Amtrak. North-End EIS. Pg ES-6. https://www.documentcloud.org/documents/25507269-1994-northend-electrification-final-eis/

254 Keenor, Garry. "Overhead Line Electrification for Railways." 2021. Pg 28. https://ocs4rail.com/wp-content/uploads/2024/11/Overhead-Line-Electrification-for-Railways-6th-edition-R3.pdf;

Electrification specifications

Caltrain:

Substations: every 36 miles
Switching stations (midpoint): 18 miles
Paralleling stations (boosters): 5 miles
Pole spacing: 180 feet

$44m/mi

UK main lines:

Substations: every 25-37 miles
Switching stations (midpoint): 12.5-18.5 miles
Paralleling stations (boosters): 6-9 miles
Pole spacing: ~200 feet

$26m/mi

Amtrak Northend:

Substations: Every 49 miles
Switching stations (midpoint): 24.5 miles
Paralleling stations (boosters): 6.75 miles
Pole spacing: ~200 feet

$11m/mi

which officials there have described as 'blended' service. So, it's not surprising that Caltrain's design incorporated criteria from the California High-Speed Rail Authority, which are described in detail in a 2010 memorandum.[255] CA HSR's team of consulting designers called for using the same electrical system — with the same spacing for substations, switching stations and paralleling stations — on portions of the system where the trains would only run at 125mph as they did on the portions where speeds would hit 220mph. This seems excessive when compared to the designs used on the East Coast and in Britain, which can handle more trains and speeds faster than Caltrain's anticipated top speed of 110mph.

Second, there is the spacing of the poles that hold the wires. The closer the spacing, the greater the number of poles that are needed. Every pole needs a hole drilled for its foundation, concrete poured to anchor the structure and then metal for the pole itself. Caltrain installed poles for its system every 180 feet, even in the straightaways, according to construction documents and satellite photos.[256] The poles on the Northend electrification were spaced approximately every 200 feet in the straightaways, documents show. Satellite photos suggest the spacings are even wider. Planning documents from Britain show that pole spacings there are typically 200 feet, as well. Caltrain's spacing represents a 10% increase in poles compared to previous US practice and British norms.

Caltrain's budget overruns were the result of a myriad of factors: Lawsuits delayed its eligibility for federal funds until a federal administration hostile to transit took office;[257] that administration then delayed providing the funding for months; then the pandemic struck and shut down virtually all construction across the country for months. All of that was on top of an aborted attempt to build a custom signaling system. These are important factors to consider. However, the project's preliminary budget — contained in planning documents — shows that the specifications accepted by Caltrain had already pushed its costs to near-record levels from the very start. It called for spending $1 billion ($1.5 billion, including the new trains) on the project, which is $29 million per mile adjusted for inflation and projected forward to 2027$.[258] Caltrain's initial budget already surpassed Britain's most troubled electrification project.

Adopting specifications in line with East Coast and British norms would have likely reduced the upfront costs and cut construction time for Caltrain. As such, the Northend and British systems should serve as specification baselines for future American electrification projects. Furthermore, California HSR should take a second look at its electrification design criteria for future 'blended' segments it will share with commuter railroads, such as the proposed Los Angeles to Anaheim leg.

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255 US. California. High Speed Rail Authority. "Technical Memorandum: OSC Requirements." TM 3.2.1. 2010. Pg 20. https://www.documentcloud.org/documents/25513754-ca-hsr-overhead-proj-guidelines-tm3-2-1r01/

256 US. CA. Caltrain. "Caltrain Electrification: Construction Staging Area - Santa Clara and San Jose." February 2019. https://www.documentcloud.org/documents/25747605-santa-clara-fact-materials-removal-february2019-0/

257 Hicks, Nolan. "Trump's Election Means It's Now or Never for Congestion Pricing." Curbed/NY Mag. Nov. 6, 2024. https://www.curbed.com/article/trump-election-hochul-congestion-pricing-deadline.html

258 US. CA. Caltrain. Electrification EIS. Pg. ES-13.

11 Rolling Stock

Credit: Marc Hermann/MTA

11 Discussion: Rolling stock

Maximizing the acceleration and deceleration capabilities of trainsets is key to achieving Momentum's time savings goals. The gains offered by electrification and adoption of high-performance trainsets — known as EMUs — are significant. The train performance model used to calculate the travel times for this study was built upon a composite performance profile of the SEPTA Silverliner V and the NJT Jersey Arrows. Each is capable of getting up to 80mph in approximately 60 seconds, each is capable of stopping from 80mph in about 50 seconds. Strangely, the MTA's third-rail powered EMUs are far slower. It takes them roughly 120 seconds to reach 80mph, which is twice the amount of time it takes either the Silverliners or the Arrows.

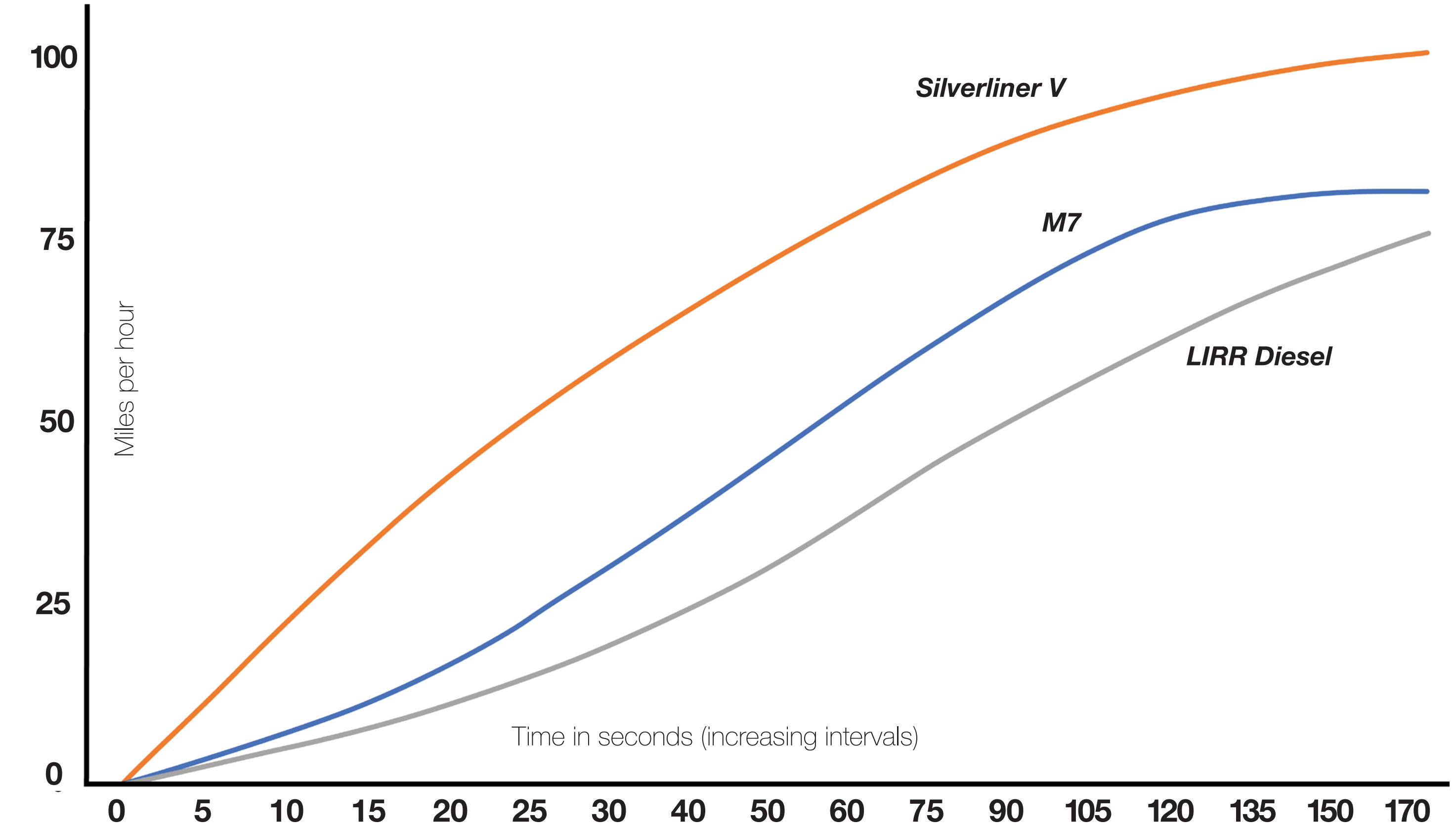
Weight plays an important role in determining a train's performance, particularly if the trainset is married to a lower voltage power system like the third rail networks owned by the MTA's LIRR and Metro-North. This is of particular note because the rolling stock the MTA uses on its third rail-powered commuter lines has gained far more weight than its counterparts, the Momentum analysis found. The M9 weighs 41% more than the M1 did. That is triple the 14% increase seen between the M2 and its modern successor, the M8 and double the increase seen in Philadelphia, where the Silverliner V weighs 22% more than its 1970s-era predecessor. The dramatic gain in weight is all the more notable because all three types of trains are governed by the same structural safety regulations, which have remained largely unchanged since the 1950s.

11.1 Speed, weight and the third rail

The MTA rates its current generation of third-rail EMUs — the 1990s-era M7 and the 2010s-era M9, which operate principally on the LIRR — as having much-reduced performance capabilities when compared to SEPTA's Silverliner or the Jersey Arrows. It takes them 120 seconds or more to accelerate up to 80mph.[259] These figures are laid out in charts that are used by the MTA and have guided some of the agency's internal debates over future electrification.[260] These tables treat the M7 and the M9 as if they are half as fast as SEPTA's Silverliner Vs, despite having the same motors and a weight advantage. The slower acceleration offered by the MTA trains cuts the benefit of electrification in half.

259 US. New York. Metropolitan Transportation Authority. "Electrification Benefits Methodology." 2025. Pg 2. https://www.documentcloud.org/documents/25506094-mta-m7-curves/

260 Interviewee P



A chart illustrating how much quicker the SEPTA Silverliner V is getting up to speed than the MTA's M7s, despite having the same motors and a weight disadvantage.

Credit: Zhexuan 'Franklin' Tang/NYU-Marron

The LIRR's trains weren't always so slow. In 1988, it took 75 minutes for a train to go from Ronkonkoma to Penn Station, making stops at Central Islip, Brentwood, Deer Park, Wyandanch, Farmingdale, Bethpage and Jamaica.[261] The current LIRR timetable allots 82 minutes for the trip even though the schedule has added just one additional stop, at Woodside. That's a 9% increase in trip time, despite the $477 million Ronkonkoma Double Track project and the $2.6 billion Main Line Triple Track project completed in recent years.

The exact causes of the slowdown are unclear. This analysis pursued several hypotheses: For one, that these planning charts could be one way to build padding into the schedules. Padding is a buffer of extra time — potentially more than a minute — between every stop. That would slow down service but would improve on-time performance numbers.[262] It's a tidy explanation and potentially one factor. The M7 and M9 are allocated roughly 100 seconds to stop from 80mph,[263] which is more time than allocated in either the Philadelphia or New Jersey systems. But that doesn't explain

261 Bleyer, Bill. Newsday. 1988. https://www.documentcloud.org/documents/25469843-shaving-minutes-from-rush-hour

262 Blatt, Ben. "Airlines Are Padding Flight Times. It's Not Your Imagination". The New York Times. Nov. 27, 2024. https://www.nytimes.com/2024/11/27/upshot/airlines-flight-times-padding.html

263 Interviewee P

Acceleration from 0-80mph

Overhead:

Jersey Arrow III: 59s

Silverliner V: 61s

Third rail:

M7: 120s

why a heavier train with the same motors accelerates more quickly. Another hypothesis was that the performance of the trains has been constrained. A report from the 1980s states that the performance of the M1 was downrated to match the capabilities of the ancient rolling stock the MTA inherited on the Long Island Rail Road for scheduling purposes.[264] The report recommended the limiter be removed, but it is unclear if the MTA ever followed through or if that limiter was carried over to the M3, M7 or the M9.[265] Additional research led us to a third hypothesis, which appears to be the best fit for the available facts: The M7 and the M9 are too heavy to achieve performance levels equal to the Silverliner and Jersey Arrow because of the weakness of the third rail power systems the MTA inherited.

11.2 LIRR's ballooning train weight

The LIRR's most recent train, the M9, weighs in at 132,000lbs for its lead car (A-Car). That is slightly heavier than its immediate predecessor, the M7, which weighs 127,000lbs per car. However, this slight bump between iterations disguises the significant increases in train weight seen over the lifespan of the Metropolitan car program. The M1 weighed just 94,000lbs[266] and the M3 clocked in at 112,000lbs. The differential between the M1 and the M9 is an eyepopping 41%. That is triple the increase seen in the New Haven Line's trainsets when comparing generations. The M2 weighed in at approximately 126,000lbs, while the M8 clocks in at 143,000lbs, statistics from the MTA show — a 14% difference.[267]

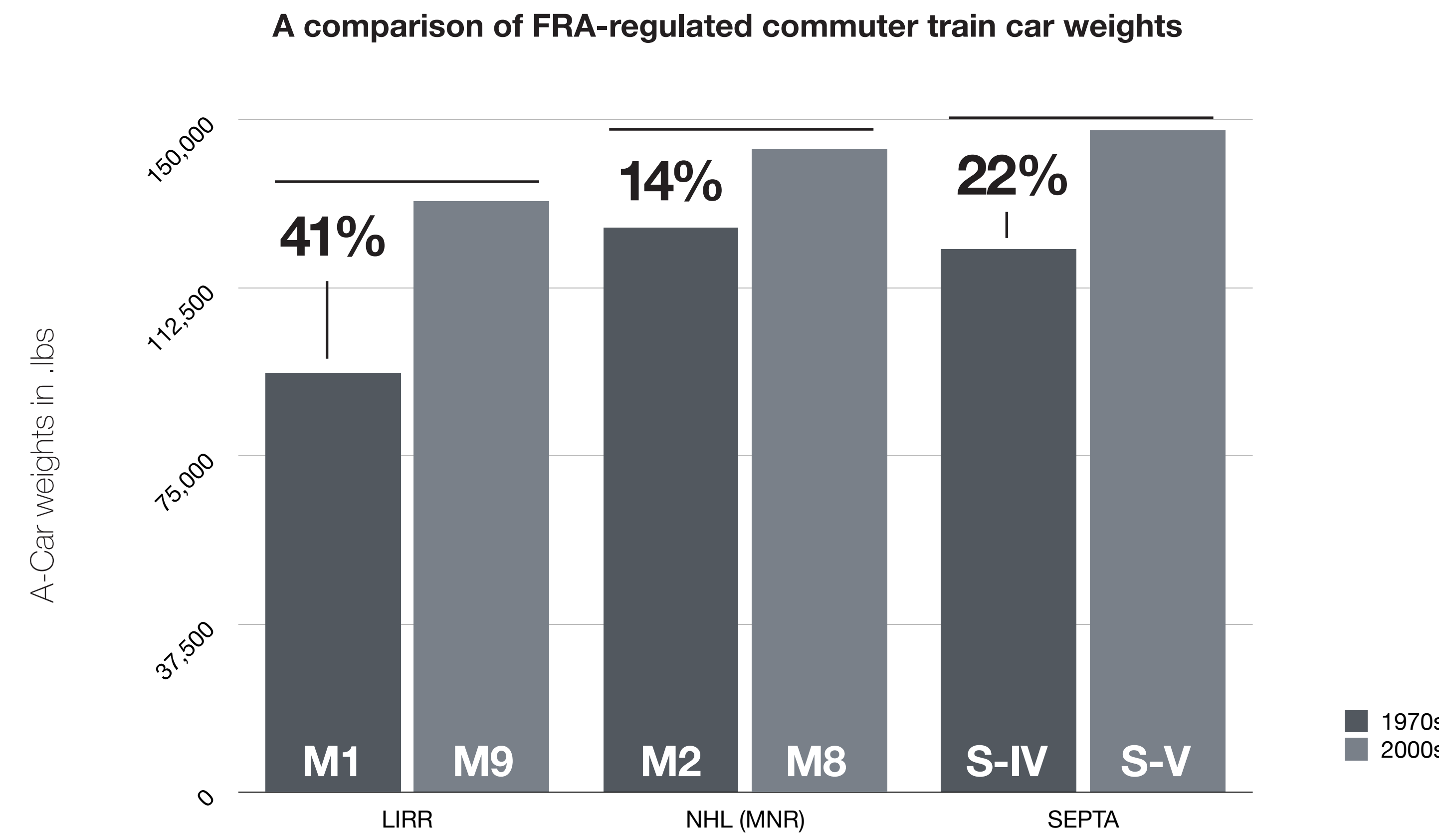
The difference in weight gain is made all the starker because the M8 and M7/M9 provide riders with nearly equivalent suites of improvements when compared to the M1 and the M2: Modern and dependable air conditioning systems, computerized station announcements and accessible bathrooms. Furthermore, both trains are subject to the same safety requirements by federal regulators and those regulations, like buff strength, have remained constant since

264 US. NY. The Regional Plan Association and The Long Island Association. "Long Island Rail Issues." November 1983. Pg https://www.documentcloud.org/documents/25866358-rpa-lirr-report-1980s/

265 The MTA did not provide substantive responses to a month of questions about performance limiters on the M3, M7 or M9 submitted through its press office.

266 Donohue, Brian. "Review of Passenger Railroad EMU and MU Rolling Stock in the US and Canada – Part I, New York State Region." American Society of Mechanical Engineers. 2024. Pg 9. https://www.documentcloud.org/documents/25515205-m1-stats/

267 Provided by the MTA. https://www.documentcloud.org/documents/25514986-mta-emu-weights/



A graphic illustrating the disproportionate weight gains on the LIRR's rolling stock when compared to other East Coast railroads.

the 1950s.[268,269,270] (The subway system provides another point of reference. Its trains have also adopted many of the new features found on the LIRR trains, including computerized announcements and revamped air conditioning, without seeing any increase in weight. The older R62s weigh 74,900lbs, the newer R142s weigh 73,000lbs.[271,272])

Weight should be considered a crucial element of any train design. Heavier trains accelerate more slowly and use more energy. This costs riders time and railroads money. A late 1970s study conducted as part of a Northeast Corridor improvement project found that a 33% difference in weight meant that the lighter train (408 tons) would use less energy traveling at 160mph than a heavier train (612 tons) at 120mph.[273] Furthermore, the improved acceleration alone

268 The standard, known as AAR S-034, dates back to at least 1956 and has been codified in Federal Railroad Administration regulations at CFR since at least 1979. It current resides at 49 CFR § 229.141. https://www.law.cornell.edu/cfr/text/49/229.141

269 US. Federal Register. Volume 44. No. 99. https://s3.documentcloud.org/documents/25516299/1979-federal-register-proposed-rule.pdf

270 American Public Transportation Association. "APTA PR-CS-S-034-99, Rev. 2Standard for the Design and Construction of Passenger Railroad Rolling Stock." 2006. Pg 11-3. https://www.documentcloud.org/documents/25516300-apta-emu-rules-and-history/

271 US. NY. MTA. New York City Transit. "R-62 Datasheet from NYCT Revenue & Non-Revenue Car Drawings." Courtesy NYCSubway.Org. https://www.nycsubway.org/perl/show?/img/cars/sheet-r62.jpg

272 US. NY. MTA/NYCT. Courtesy NYCSubway.Org. "R-142 Datasheet from NYCT Revenue and Non-Revenue Car Drawings." https://www.nycsubway.org/perl/show?/img/cars/sheet-r142.jpg

273 US. U.S. Department of Transportation/Federal Railroad Administration.

Weight gain by railroad

LIRR:

M1: 93,520lbs
M3: 112,400lbs
M7: 127,500lbs
M9: 131,822lbs

+ 38,302lbs

New Haven (MNR):

M2: 126,000lbs
M8: 143,466lbs

+ 17,466lbs

SEPTA:

Silverliner IV: 121,000lbs
Silverliner V: 147,500lbs

+ 26,500lbs

meant that the lighter train would be three minutes faster than the heavier train running at the same speeds between Washington and New York — and even though the hypothetical service pattern had just four stops.[274] This is a smaller weight gap than the gap between the M1 and the M9. (Much of this research into the importance of weight and train design was forgotten amid deep cuts to the federal research agencies in the 1980s discussed in Section 9.)

11.2.1 Third rail's extra weight penalty

Heavier trains carry an extra penalty for the MTA's commuter railroads because of the age and relative weakness of the third-rail power systems it inherited from the LIRR and New York Central commuter lines, documents show. These century-old systems were among the first ever developed for commuter or intercity service and carry the design compromises required by the novelty of electrification in the early 1900s. Heavier trains require more powerful motors, which in turn require more electricity. The increasing demand for electricity can lead to drops in voltage, particularly during the commute, when the electric system has to handle a large number of trains at once. This is not dissimilar from what happens to the water pressure in an old building if everyone inside takes a shower at the same time. Even older overhead catenary power systems like the one in Philadelphia reliably send more power to trains, which provides for better performance. (More modern third rail systems, like the one that powers the Bay Area Rapid Transit metro system, can deliver power more consistently, the analysis found.[275])

This is not a new challenge for the MTA. In the 1980s, it discovered how much weight can affect its electrical systems when Metro-North was forced to install 32 new substations so its power system could handle the extra weight of the M3.[276] One of Metro-North's proposed strategies to compensate for the slower acceleration at the time was to limit the M3 to just express service, to keep them from slowing down the local service. "For instance, if we find the acceleration rate isn't good enough for local service, we might consider just putting them in on express service where they would not have to make as many frequent stops," a Metro-North

'Passenger Train Equipment Review Report'. 1981. Pg 6-56. https://www.documentcloud.org/documents/25454741-1981-passenger-train-equipment-review-report-volume-2/

274 US. DOT/FRA. 1981. Pg. 6-55. https://www.documentcloud.org/documents/25454741-1981-passenger-train-equipment-review-report-volume-2/#document/p288

275 US. California. Bay Area Rapid Transit. "Silicon Valley Berryessa Extension Project. C700 - Line, Track, Stations, and Systems Design – Build." 2009. Pg 650-654 (pdf). https://www.documentcloud.org/documents/25516283-power-requirements-for-bart/

276 Hudson, Edward. "New M3 Car Is Causing Problems For Rail Line." *The New York Times.* Feb 26, 1984. https://www.nytimes.com/1984/02/26/nyregion/new-m-3-car-is-causing-problems-for-rail-line.html

An Manhattan-bound LIRR M7 arrives at Deer Park on a sunny morning in April 2024.

Credit: Mike Sisak

spokeswoman told The New York Times in 1984. The Long Island Rail Road's system was stronger and could handle the heavier trains, officials said at the time.[277]

By the late 1990s, it was time to replace the M1, which had served as the workhorse for the LIRR's electric fleet for three decades. Its successor, the M7, would also be purchased by Metro-North. The specifications sheet from Bombardier, the M7's manufacturer, says the train should be capable of about 70% of the Silverliner V's performance.[278,279] That means it should be able to get up to 80mph in 78 seconds, which is 42 seconds faster than it currently does in MTA use. Each M7 train car is about 34,000lbs heavier than the M1, which means it needs more power to get moving. After all, the laws of physics are immutable. But, at the time, Albany was raiding the MTA's budget and loading it up with debt to pay for megaprojects like East Side Access and Phase 1 of the Second Avenue Subway.[280] Instead of major

277 Daley, Suzanne. "Hudson and Harlem Lines Add Trains but Need Power." *The New York Times.* March 7, 1984. https://www.nytimes.com/1984/03/07/nyregion/harlem-and-hudson-lines-add-cars-but-need-power.html

278 The M7 specification sheet puts the maximum acceleration of the train at 2mph/second, which is about 70% of the Silverliner V's 2.8 mph/second.

279 Bombardier. "Electric Multiple Unit - M-7." https://www.documentcloud.org/documents/25473801-m7-specs/

280 Hamilton, Colby. "For the MTA, current crisis is 30 years and a governor in the making." WNYC/New York Public Radio. Aug. 25, 2011. https://www.wnyc.org/story/195964-for-the-mta-current-crisis-is-30-years-and-one-governor-in-the-mak-

spending on new substations, Metro-North and the LIRR had to limit how much power they could draw to protect the system's voltage — which slowed the trains down.

Metro-North conducted an extensive review of its electrical system before introducing the M7. It reported that the new trains would "demand more power from the electrical network," and that "occurrences" of "low voltages would increase to unacceptable levels if there were no limitations on the power demand of the new vehicles."[281] A report prepared by the LIRR and the New York Power Authority agreed: "Track voltage sags already [result] from physical limitations of the traction power supply. As the new trains are rolled out these problems will be exacerbated."[282] Filings show that the M7 needs the third rail to deliver at least 500 volts of electricity for its motors to run at full power. If the voltage drops below 400, the trains motors cannot run.[283] The Metro-North study proposed a two-prong "[t]emporary performance limit" that caps how much the motors can be used in the train's initial acceleration out of a station and limits the overall power draw of the train to just 750 amps per car.[284] The Metro-North report showed that running M7's motors would take more than 1400 amps. LIRR filings with federal regulators show it adopted a similar solution, capping overall power draw at 875 amps per car.[285] The charts included in the Metro-North report unfortunately do not detail how fast the M7 could accelerate if it were operating on a more capable power system. However, the charts do show that the Metro-North's performance limiters would slow the trains down dramatically. It would take between 115-150 seconds for the train to get to 80mph, which is the range of speeds seen today.

11.3 M11: Renewed focus on weight and performance

Weight and performance were key focuses of the design of the M1, which was much lighter than its predecessors. "The new cars will look fast — and they'll go fast," proclaimed the marketing materials from what was then the Metropoli-

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281 Yu, J.G. "Traction Power System Study for Metro-North Railroad." 2004. Pg 14. https://www.documentcloud.org/documents/25516278-mnr-power-system-analysis/

282 NYPA/LIRR. 2007. Pg 1. https://www.documentcloud.org/documents/25516285-lirr-voltage-sags/

283 US. New York. New York Power Authority and Long Island Rail Road (MTA). "Long Island Rail Road (LIRR) High Speed Flywheel Demonstration." Pg 5.

284 Yu. 2004. Pg 15. https://www.documentcloud.org/documents/25516278-mnr-power-system-analysis/

285 US. Department of Transportation. Federal Railroad Administration. Docket No. FRA-2003-15638. PDF Pg 2. https://www.documentcloud.org/documents/25867215-lirr-power-system-report-to-fra/

M11 weight target:

Derived from M8/Silverliner baseline:

107,000-114,000 lbs

Savings over M9:

17,800-24,800 lbs

tan Commuter Transportation Authority. "Their get-up-and-go rate will be more than twice that of any car on the LIRR today."[286] Many transit advocates have focused on pushing agencies to make full use of new U.S. regulations that make it easier to adopt European-style rolling stock, which often makes much greater use of aluminum as one way to shed weight. These new regulations underpin Amtrak's troubled Avelia program and Caltrain's new electrified trains. Northeast commuter railroads tend to be extraordinarily cautious when it comes to procuring new train designs because of worries about reliability and longevity and have been slow to embrace the new regulations.

This analysis suggests that a two-track approach to the future of rolling stock may be productive and offer compounding benefits. First, it suggests that there is substantial weight that can be wrung out of the LIRR and Metro-North's existing steel-bodied designs for their next iteration (potentially the M11). Modernization accounted for a 14%-22% increase in weight across two other programs, but led to a more-than 40% increase for the MTA's third-rail fleet. Bringing the weight back in line with other railroads' rolling stock would result in a target weight of 107,000-114,000lbs per car, a savings of 16%. The lighter trains would offer improved performance and reduce the strain on the LIRR and Metro-North power systems. Second, the lessons learned from the weight reduction program should help reduce the baseline weight for the transition from steel to aluminum shells as part of a more ambitious rethink of American commuter trains known as Alternative Compliance.

11.4 Alternative Compliance

There are additional opportunities to accelerate service. Amtrak's new Acela trains are 30% lighter than their predecessors thanks to a modernization of U.S. rail safety standards to bring them into line with common European regulations.[287] These trains differ from the traditional steel bodied cars in a couple of major ways: First, they use crumple zones like those found in passenger cars to maintain safety. Second, they reduce weight by making more extensive use of aluminum, a far lighter metal, in the body shells.

Caltrain purchased alternative compliance trains

286 US. New York. Metropolitan Commuter Transportation Authority (now the MTA). "The New Railroad for Long Island and New York City." http://www.trainsarefun.com/lirr/M1/lirr_%20M1_%20Brochure-inside2_BradPhillips.jpg

287 United States. Department of Transportation. Federal Railroad Administration. 'Passenger Equipment Safety Standards; Standards for Alternative Compliance and High-Speed Trainsets.' 2016. https://railroads.dot.gov/elibrary/passenger-equipment-safety-standards-standards-alternative-compliance-and-high-speed

for new electric fleet. While a direct comparison was not possible, as these are the first multi-level EMUs powered exclusively by AC power currently in operation in the U.S., an analysis did reveal substantial potential weight savings. Each of the cars weighs approximately 113,000 pounds when adjusted for length to the East Coast standard of 85 feet.[288,289,290] That makes the Caltrain equipment lighter than the single-level trains operated by the MTA and SEPTA. (A full analysis must take into account a second weight disadvantage that East Coast trains must deal with: carrying the necessary equipment to support multiple power systems. It is unclear how much of a disadvantage this presents.[291,292]) Still, this analysis suggests that alternative compliance could provide a reduction in train weight beyond the dieting program proposed for the M11. These benefits would be of greatest utility on lines that support both commuter rail service and inter-city services, like the Northeast Corridor, New Haven Line and the Hudson Line; and for the third-rail powered commuter networks.

288 The Stadler KISS is 82-feet and ¼-inch feet long. The standard US length is 85 feet, or approximately 3.6% longer.

289 The 113,000lbs figure was derived from the 652,000lbs weight of a six-car Stadler KISS train and then adjusted for the length differential.

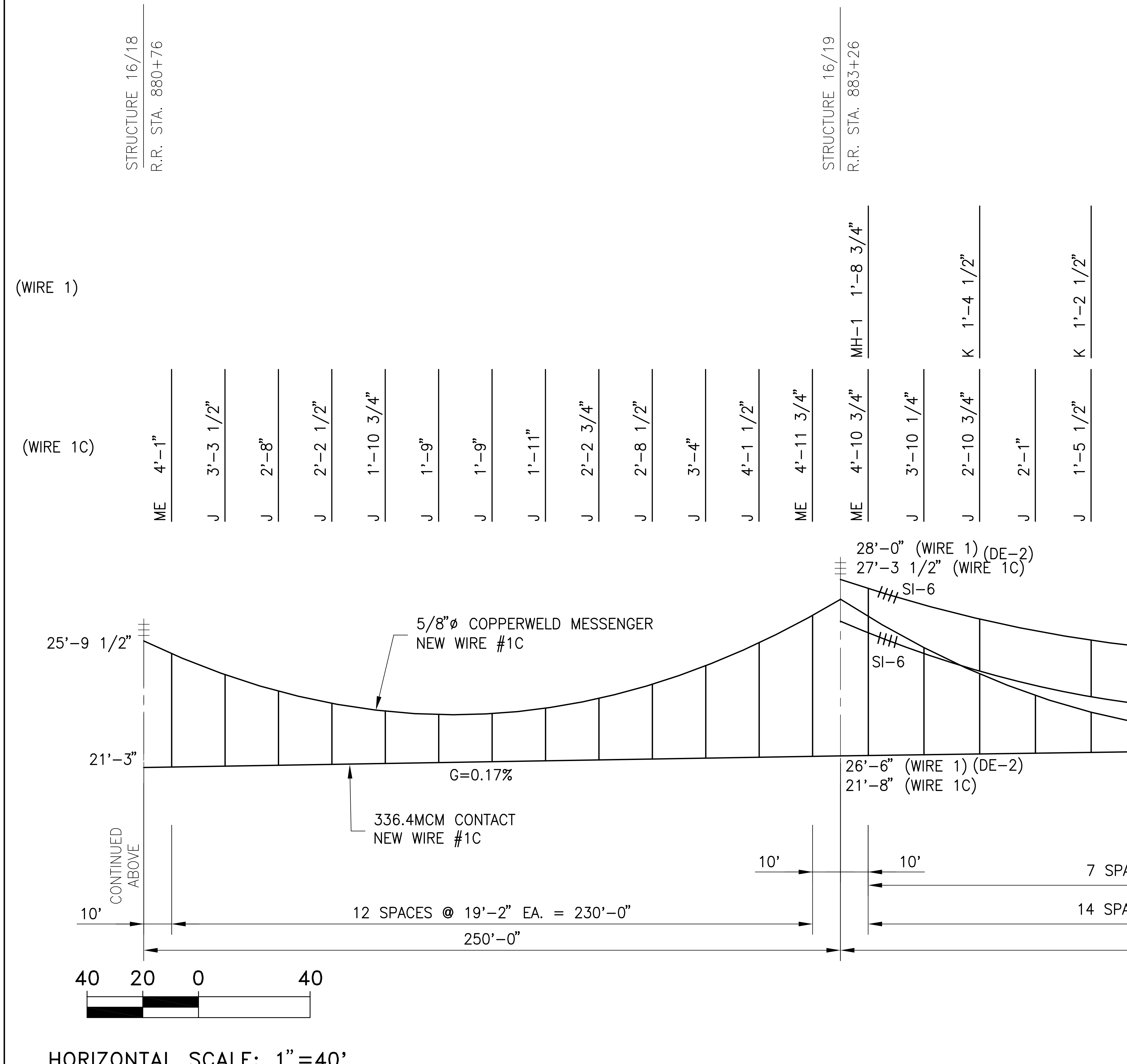
290 Stadler Rail. "Electric Double-Deck train DOSTO (6-car train) for the Swiss Federal Railways (SBB), Switzerland." 2010. https://web.archive.org/web/20100920093857/http://www.stadlerrail.com/media/uploads/factsheets/DOSBBZ0908e_DOSTO_E.pdf

291 The M8s multiple systems are well-known and documented (12kV/60Hz; 25kV/60Hz and over/under-running third rail). The SEPTA Sliverliner V supports both 12kV/25Hz, 12kV/60Hz and can be modified to support 25kV/60Hz, according to its RFP.

292 US. Pennsylvania. Southeastern Pennsylvania Transportation Authority. "SILVERLINER V: Electric Multiple Unit Commuter Rail Procurement Fleet." 2005. Pg 1-23. https://www.documentcloud.org/documents/25544359-silverliner-v-rfp/

12

Freights & Clearances



12 Discussion: Clearances and Freight Interoperability

Interviewees said that efforts to promote different aspects of the Momentum infrastructure package — such as overhead wires; and stations with high-level station platforms — frequently ran into internal opposition due to worries about compatibility with freight railroad operations and external objections from the freight railroads themselves. Passenger service and transit agency planners sought an examination of these interoperability concerns to see if these components really do interfere with freight operations, or if these objections are — as many transit planners said they suspected — a quiet attempt to block expansion of passenger service by companies that have long been hostile to its provision. "Passenger service is viewed as a nuisance and a parasite," said one. "[Expansion] can happen, but only in a world where any scenario we [the freights] cook up is not affected by passenger use," the person added. "The best case is the taxpayers cut them a giant check to pay for the entire freight railroad wish list. The worst case is nothing happens and they get to keep doing what they're doing."[293]

The irony of freight railroad opposition to passenger service should not be lost on anyone. Freight railroads enjoy their dominant position thanks to the public: First, Congress relieved them of their obligation to maintain passenger service with the creation of Amtrak. Second, regulators allowed the industry to carve up Consolidated Rail — also created by a government bailout in the 1970s — and create a highly profitable shipping duopoly that dominates the eastern United States. The two firms that split up Conrail, Norfolk-Southern and CSX, collectively posted operating income of $184 billion between 2009 and 2024.[294,295,296,297]

Despite the returns, Wall Street investors have put the freight railroads, including CSX and N-S, under pressure to boost payouts. This has led the companies to sell off some underutilized routes to state and local governments interested in using them to provide passenger rail or other transit services. However, the freight railroads have often encumbered those deals with 'interoperability' provisions under the guise of preserving compatibility with freight operations in the future. These provisions give freight railroads functional vetoes over what improvements the public can make to the lines in the future, even though the public has spent substantial sums to acquire them. There are few improvements freight railroads are more opposed to than electrification.

Interviewees cited the Long Bridge project as a prominent example of freight railroad opposition to electrification, even if they would not be required to use it. This new span will add two passenger tracks over the Potomac, allowing more service between Washington D.C. and the Virginia suburbs.[298] The bridge was just one element of then-Gov. Ralph Northam's $3.7 billion initiative to bolster the entire rail corridor between Richmond and Washington, which included buying the existing right-of-way from CSX.[299] The purchase from CSX does not include an express prohibition on electrification, but an 'interoperability' provision allows the freight carrier to object to planned improvements for the line. CSX used that authority to nix including provisions for future electrification into the bridge design, according to a person familiar with the project. "[CSX] said 'No f---ing way, take this out'" the person said.[300] There was no space for future power poles included in the bridge design. "This is how steadfast and how kind of crazy some of the stuff on the freight side is on electrification," the person added. A top official at the Virginia state authority tasked with overseeing the multibillion-dollar overhaul acknowledged in a public meeting that CSX was adamantly opposed to electrification of the line, despite the potential for enormous benefits for passenger service. "It's not going to happen anytime soon with the current technology and here's why," said DJ Stadtler, executive director of the Virginia Passenger Rail Authority. "The deal with CSX that we sign insisted on interoperability; and interoperability — I know they're squishy definitions — but they want to be able to run double stacked trains on the railroad. They would only do it on the passenger side in case of emergency, but we can't have the catenary overhead; that would keep it so they couldn't run the double

293 Interviewee O

294 Earnings statements for Norfolk-Southern and CSX from 2009-2024 compiled. https://www.macrotrends.net/stocks/charts/CSX/csx/operating-income; https://www.macrotrends.net/stocks/charts/NSC/norfolk-southern/net-income

295 For example, CSX Corporation reported net operating income of $5.2 billion in 2024 alone. That's five times greater than its net operating income of $425.2 million in 1996, which would be worth $850 million in 2024 adjusted for inflation.

296 CSX Corporation. "CSX Corp. Announces Fourth Quarter and Full Year 2024 Results." 2025. https://investors.csx.com/news-and-events/news/news-details/2025/CSX-Corp.-Announces-Fourth-Quarter-and-Full-Year-2024-Results/default.aspx

297 Phillips, Don. "Conrail split in a merger with CSX." The Washington Post. March 7, 1997. https://www.washingtonpost.com/archive/politics/1997/03/08/conrail-split-in-a-merger-with-csx/cb0060d3-6d1d-47e2-b0a2-2805b02059c9/

298 Interviewee F, Interviewee O

299 Lazo, Luz. "Virginia to build Long Bridge and acquire CSX right of way to expand passenger train service." The Washington Post. December 19, 2019. https://www.washingtonpost.com/local/trafficandcommuting/virginia-to-build-long-bridge-and-acquire-csx-right-of-way-to-expand-passenger-train-service/2019/12/19/c021ffbc-ff08-11e9-8bab-0fc209e065a8_story.html

300 Interviewee F

stacked trains."[301] Left unsaid: Norfolk-Southern runs freight trains with double-stacked containers — the aforementioned 'double-stacks' — beneath wires every day in Philadelphia.

This section aims to aid planners and local and state governments by detailing the physical space requirements for Momentum's components. This includes taking the interoperability concerns claimed by freight railroads at face-value and examining them. The resulting analysis found that they have little merit. Additionally, it identified at least three separate proposals, from the 1970s, 1990s and one from this decade to electrify key lines used by freight railroads, showing that at various points the industry itself believed that container shipping and electrification can co-exist. Officials should keep these facts front of mind and not accept vague interoperability agreements from freight railroads that could block lines from receiving future upgrades.

12.1 Space requirements between tracks

Historic railroads built substantial amounts of infrastructure in the pre-automobile age, including lines with four tracks or more and redundant routes to compete against each other, particularly in older parts of the country like the Northeast and the Midwest. However, much of that capacity is unused or underutilized in the modern age thanks to a slew of freight railroad mergers that reduced competition and a decline overall in the amount of freight moved by trains. For example, New York Central's famed Water Level route linking Albany to Buffalo (and onward to Chicago) was built with four tracks. But two tracks were removed to save on maintenance, so half of the right-of-way now sits disused. Or, for example, Detroit and Toledo, which are joined together by four parallel lines, each of which is owned by a competing freight railroad and all of which are underutilized.[302]

A key component of Momentum is putting unused or underutilized railroad capacity back to work for the benefit of the public by expanding commuter and intercity passenger services. However, freight railroads have imposed stiff requirements on any planned passenger improvements along these corridors — including the vague 'interoperability' requirements that give the private carriers functional vetoes over projects — even after selling the tracks back to the public, as with the Long Bridge proposal.

301 Virginia High Speed Rail. VHSR 2022 Virtual Town Hall Series. Nov. 3, 2022. https://www.youtube.com/watch?v=7mPdnTbPrSM&t=2567s

302 United States. Ohio. City of Toledo. "Toledo-Detroit Ridership Feasibility & Cost Estimate Study." 2019. Pg 2-5 – 2-8. https://www.documentcloud.org/documents/25523926-toledo-detroit-ridership-feasibility-and-cost-estimate-study-may-2019-final-05/

Freight railroads also make it difficult to activate unused or underutilized tracks by insisting upon terms that make it uneconomical or physically impossible to fit passenger service in the existing rights-of-way. One common tactic that the freight railroads use is to insist on oversized separations between freight rights-of-way and passenger rights-of-way. This distance is typically measured between the center lines of two tracks and is known as track-center spacing. Between Albany and Buffalo, CSX imposed a rule on the New York State Department of Transportation requiring 30 feet of space between the freight tracks and any passenger tracks where the top speed of service exceeds 90mph (as detailed in Section 5). Conrail, which is jointly owned by CSX and Norfolk-Southern, has required that NJ Transit include 25 feet of space between freight and passenger tracks as part of its proposal to re-install two tracks and boost passenger service on the Raritan Valley Line.[303]

Planners interviewed said there appears to be little rationale for these sorts of requirements. "That's just another example of a bull--- engineering offered up by the Class 1's [a common industry term for the major freight railroads] and just no one knows enough to push back," said a planner at a rail agency.[304] "Trains aren't that wide. Historically it's always 12-15 feet. There's no technical basis for it." Another called the spacing requirements "dumb."[305] This review found several current and past projects where railroads agreed to far less spacing. This indicates that the transit planners' suspicions about the unusually large spacings demanded by freight railroads are well-founded.

Planning documents from the 1970s-era Northeast Corridor Improvement Project show that tracks only required 14 feet of spacing when speeds exceed 120 mph.[306] Passenger rail and transit authorities hold the upper hand on the Northeast Corridor as it is entirely owned by the public. However, this review examined documents showing freight railroads have agreed to smaller buffer rules in recent years. The segment of California's high-speed rail system that will operate in tandem with the Bay Area's electrified commuter railroad, Caltrain, provides track center spacings of just 14-18 feet between the freight and passenger tracks.[307] These

303 United States. New Jersey. New Jersey Transit. "Capital Plan Project Sheets." PDF pg 179. 2022. https://www.documentcloud.org/documents/25473216-nj-transit-capital-plan-2022-update-appendix-b-project-sheets-7-24-23/

304 Interviewee D

305 Interviewee E

306 US. US Department of Transportation. Federal Railroad Administration. "Two-Year Report on the Northeast Corridor." 1978. Pg 95. https://www.documentcloud.org/documents/25504735-1978-freight-passenger-separations/

307 US. California. High Speed Rail Authority. "Book 4-A: Composite Plan, Profile, and Cross Sections." 2021. Pg 9-12. https://www.documentcloud.org/documents/25511188-final-eirs-jm-v3-18-pepd-alternative-4-book-4-a-composite-plan-pro-

tracks will carry a top speed of 110mph, which is 20mph faster than the speed triggering the CSX requirements on the Albany to Buffalo corridor. Furthermore, in the Chicago area, CSX itself agreed to spacings of just 20 feet in a recent project to double track the South Shore Line commuter railroad, which is also electrified.[308]

Track-center spacings on shared corridors:

- Northeast Corridor: 14 feet
- California HSR shared segments: 14-18 feet
- Chicago-South Shore: 20 feet

12.2 Stations: Clearances between platforms and trains

Freight railroads frequently object to the installation of high-level platforms, arguing that they interfere with shipping. Here, too, there appears to be little justification for these concerns. CSX agreed to allow Amtrak to expand the usage of high-level platforms along the Hudson Line to include the segments above the Metro-North territory, which already have the improved facilities. The agreement states that standard-width cargo can operate in tandem with high-level platforms: "The Parties agree that if a receiver or shipper of cars, shipment or lading that exceeds 10'8" in width ('Wide Load Car') locates on the Hudson Line during the Term of this Agreement, Amtrak will cooperate and share equally with CSXT the cost to re-establish and maintain sufficient clearance to operate Wide Load Cars to/from that receiver/shipper at locations of new High Level Platforms."[309]

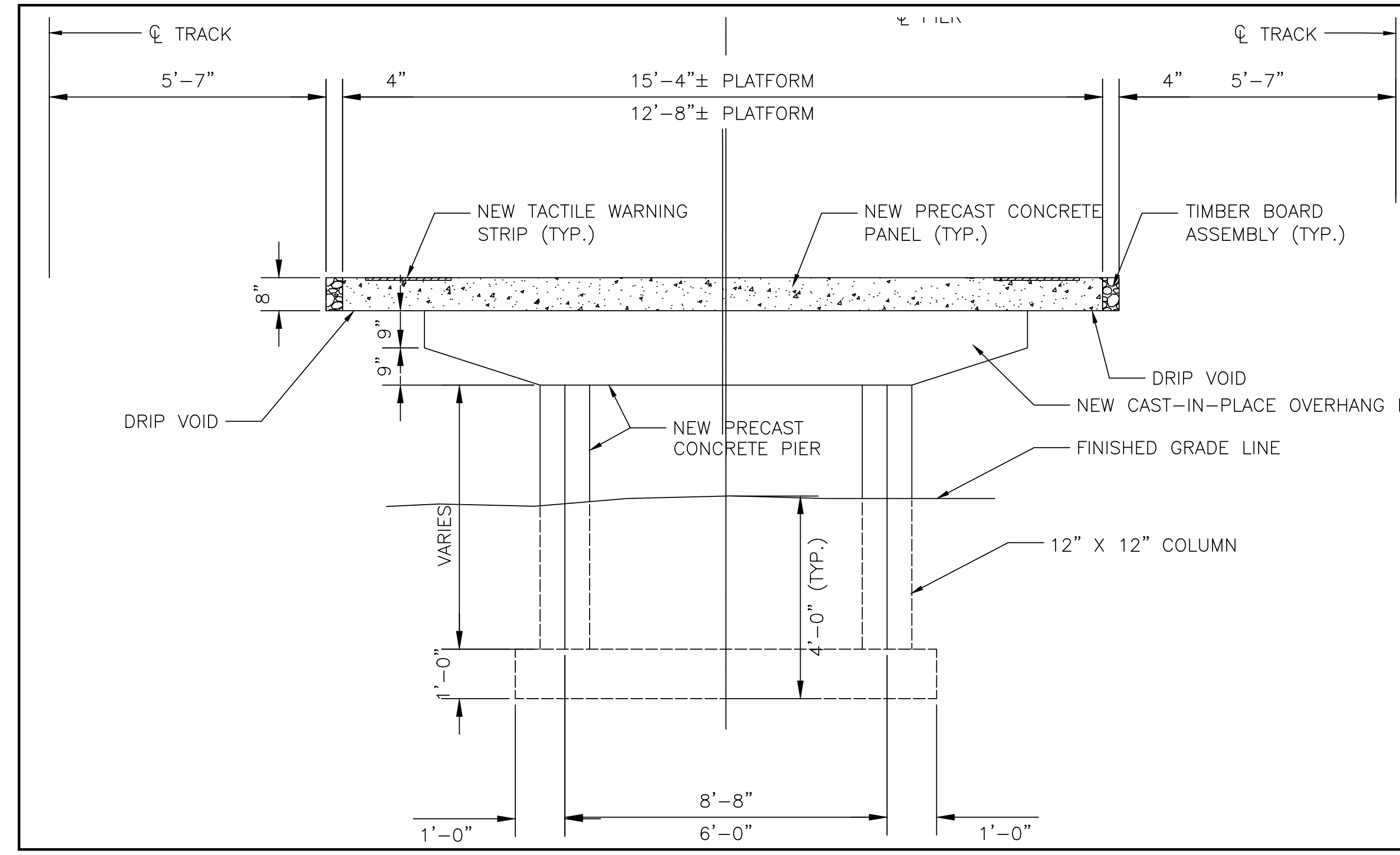
This is because the width of trains in the United States is highly standardized and functionally the same between passenger rail cars and freight rail cars, an extensive federal study found. Freight trains have a standard width of 10'8"; or 5'4" from the center of the track, the study shows.[310] That's wider than the usual 10 feet (5 feet from the center of track) for passenger cars. That grows to 5'5.5" when accounting for the 1.5 inches of buffer space needed to account for the sway of the freight car's suspension on track maintained to passenger

file-and-cross-sections/

308 US. Indiana. Northern Indiana Commuter Transportation District. "Environmental Assessment and Section 4(f) Evaluation for the Double Track NWI Project." 2017. Pg 2-7, 2-10. https://www.documentcloud.org/documents/25473218-2017-09-18-south-shore-eis/

309 US. STB. "Hudson Line Operating, Management and Land and Track Lease Agreement." 2012. Pg 32. https://www.documentcloud.org/documents/25471444-csx-nys-dot-amtrak-lease-for-hudson-river-line/?q=high+level&mode=document#document/p68

310 US. Department of Transportation/Federal Railroad Administration. "Report to the House and Senate Authorizing Committees: Study of Methods to Improve or Correct Station Platform Gaps." 2010. https://www.documentcloud.org/documents/25524006-gauntlet-track-costs/



A Metro-North diagram illustrates the spacings between platform and track found at its high level stations.

Source: MTA/Metro-North: Station Standards and Guidelines

standards.[311] Passenger trains need three inches on either side, expanding their width envelope to 5'3". (This appears to be why passenger trains are often described as being 10'6" wide.)[312]

Both of these width requirements are met by the standard design for a high-level platform in the Northeast, which provides 5'7" of separation from the center of the track. A century of experience shows that this is sufficient space for standard freight shipments.

Distance from track center:

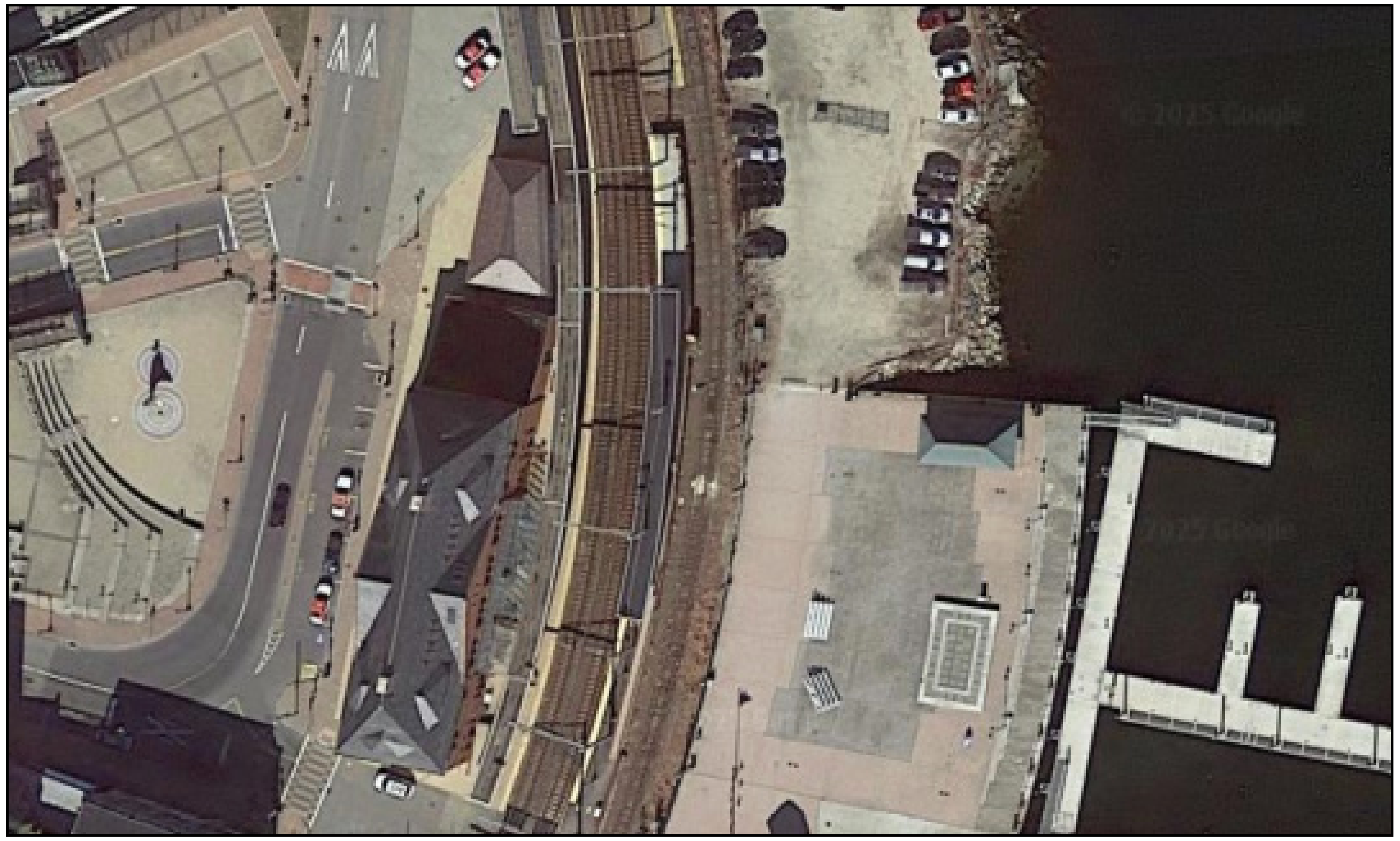
- Width of passenger train: 5 feet, 3 inches
- Width of freight train: 5 feet, 5.5 inches
- Width provided by high-level platform design: 5 feet, 7 inches

12.2.1 Clearances for Strategic Defense Lines (STRACNET)

Additional clearances may be required on some routes

311 US. DOT/FRA. "Report to the House and Senate Authorizing Committees: Study of Methods to Improve or Correct Station Platform Gaps." 2010. Pg 56. https://www.documentcloud.org/documents/25524006-gauntlet-track-costs/

312 DOT/FRA. "Report to the House and Senate Authorizing Committees: Study of Methods to Improve or Correct Station Platform Gaps." 2010. Pg 4. https://www.documentcloud.org/documents/25524006-gauntlet-track-costs/



This satellite view of the New London, Conn. station shows the two passenger tracks (left and center) and the freight bypass (right)

for national security purposes. The Department of Defense uses pre-designated rail lines to transport tanks and other pieces of large equipment, which are wider than traditional passenger or freight trains. Routes that are part of the Strategic Rail Corridor Network (STRACNET) must provide clearances that are at least 12 feet wide, which is 16 inches beyond the typical national rail standard of 10'8".[313]

These requirements do not bar the construction of high-level platforms on these routes, but it does mean that an additional factor must be considered in designing the tracks and stations. DOD's STRACNET guidance specifically lays out two possible solutions for high-level platforms on these designated routes: gauntlet tracks or bypass tracks. There are two potential reference stations for designers seeking inspiration. The New London, Conn., station, which is covered by STRACNET because this portion of the Northeast Corridor is used to deliver submarine components to the nearby Groton Shipyards. It uses a third track as a bypass to provide the needed clearances for the Pentagon-related shipments. Meanwhile, the now-replaced Capital Beltway Station had a gauntlet track.[314] (Amtrak and Maryland DOT sought as recently as 2021 to re-install the gauntlet track at New Carrollton.[315]) The U.S. DOT estimated that a fully interlocked and motorized gauntlet track would cost between $1.5-$2 million in 2006, which should cost about $3.5 million in 2027 adjusted for inflation.[316]

12.3 Catenary: Clearances between trains, structures and wires

Passenger and freight rail operators also both routinely voice concerns about the amount of vertical space — often called clearance — that is required for the installation of a catenary power system. These concerns are typically grouped into two buckets: the amount of vertical space required between the trains and the wires; and the amount of space required when there is a structure above the wires, like a bridge or a tunnel ceiling. These two measurements are added together with the height of the trains running on the particular route to determine the total amount of clearance needed for the catenary systems.

Freight railroads — sometimes directly and sometimes through their main lobby group — have suggested that electrification is simply incompatible with freight operations. The Long Bridge project in Virginia is one example where interoperability concerns have been cited. Canadian freight railroads killed a proposal in 2012 to electrify the bulk of Montreal's commuter railroad network, voicing similar objections.[317] However, this review found a substantial number of examples that undercut the assertions that electrification and freight are mutually incompatible because the wires would get in the way. Additionally, the review identified three major electrification proposals either authored by freight railroads or developed in conjunction with them, including a modern-day effort with California High-Speed Rail.

It is worth noting that recent publications by the freight railroad's main industry group do not explicitly make that claim. Instead, those documents portray electrification as an impossibility by suggesting freight railroads would be forced to use it and replace all of their locomotives, instead of running existing diesel locomotives beneath the wires;

313 US. Department of Defense. "Strategic Rail Corridor Network (STRACNET) & Defense Connector Lines" 2023. Pg. 16. https://www.documentcloud.org/documents/25524016-stracnet-2023/

314 Photo of the Capital Beltway Station with gauntlet track. https://www.railpictures.net/viewphoto.php?id=117634

315 US. Northeast Corridor Commission. "C35 Project List." 2021. Pg. A-31. https://nec-commission.com/app/uploads/2021/08/C35-Plan-15-Appendix.pdf

316 US. Department of Transportation. "Report to the House and Senate Authorizing Committees: Study of Methods to Improve or Correct Station Platform Gaps." 2010. Pg 51. https://www.documentcloud.org/documents/25524006-gauntlet-track-costs/

317 Riga, Andy. "AMT mothballs electric train idea." *The Montreal Gazette.* Sept 10, 2012. https://web.archive.org/web/20121116021058/http://www.montrealgazette.com/mothballs+electric+train+idea/7220376/story.html

and by suggesting that the entire U.S. freight network would have to be electrified.[318,319] Neither notion has been seriously contemplated by passenger rail planners.[320]

12.3.1 Vertical clearance baselines

Amtrak's passenger trains on the Northeast Corridor are typically 14'6" tall. The specifications issued by the passenger railroad require those trains be able to run on catenary wires that are as low as 15'6", which would provide just one foot of separation between the wire and the train.[321] Engineering specifications from Britain and plans prepared to 1970s effort to modernize the electrification system in the old North River Tubes beneath the Hudson show that space can be reduced further. The Northeast Corridor Improvement Project (NECIP) documents show the vertical spacing between a train and the wires can be reduced to just eight inches, with another eight inches of space between the contact wire and the overhead structure — for a total of approximately 16 inches. [322] The British Rail specifications show that engineers there found ways to cut the vertical spacing needed between the contact wire and the overhead structure to just 5.9 inches (150mm).[323] That reduced the total clearance needed from the top of a train and the bottom of an overhead structure to as little as 14.8 inches (375mm). Both amounts of clearance outlined by the NECIP and British Rail are less than the clearance specification adopted by Amtrak. That requires a minimum spacing between the train and wire and between the wire and an overhead structure of at least nine inches each — 18 inches in total.

British minimum vertical clearances:

- Distance between train and contact wire: 5.9 inches (150mm)
- Distance between contact wire and ceiling: 8.9 inches (225mm)

318 Association of American Railroads. "Oppose Rail Electrification & Support Sensible Climate Policy." Jan 2021. https://www.documentcloud.org/documents/25537795-freight-railroad-electrification-fact-sheet/

319 Association of American Railroads. "Study of Catenary Electrification of the North American Class I Railroad Network." February 2025. https://www.aar.org/wp-content/uploads/2025/02/Final-Electrification-Report-02252025.pdf

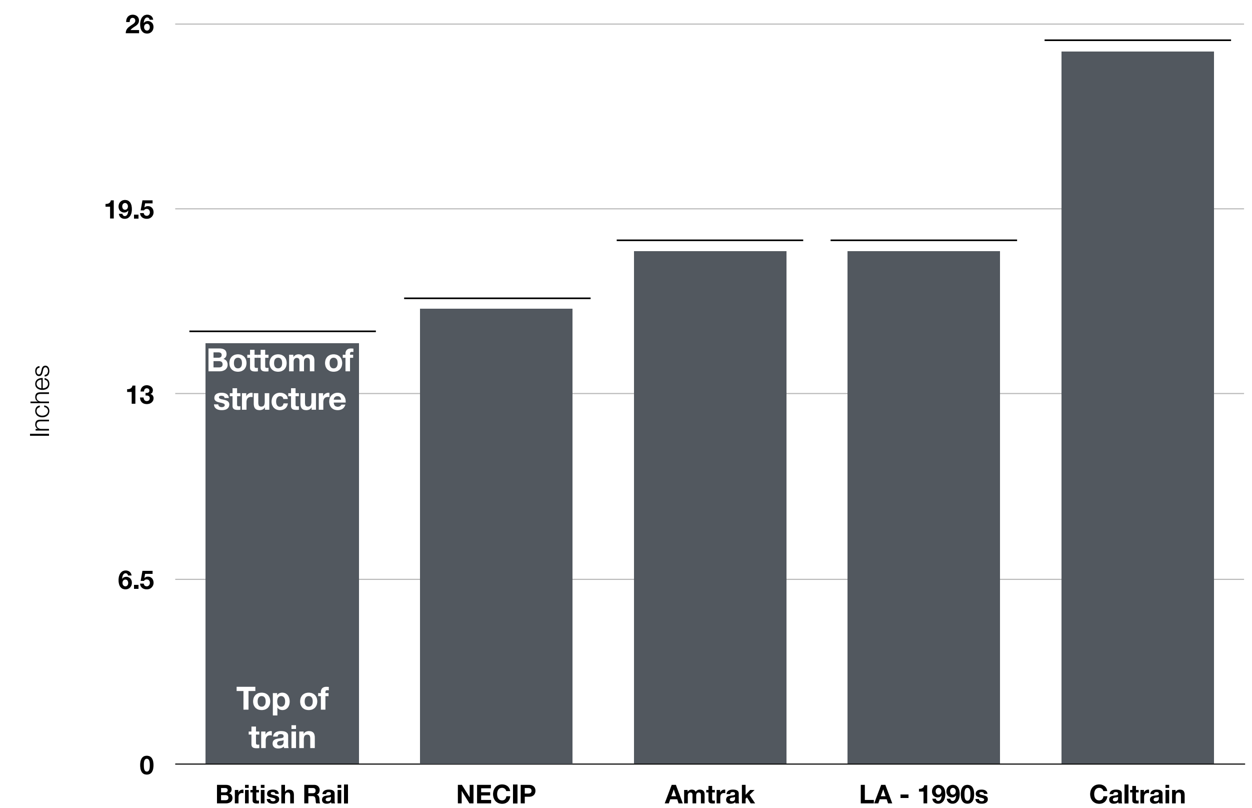
320 US. Department of Energy. "An Action Plan for Rail Energy and Emissions Innovation." Dec 2024. https://www.energy.gov/sites/default/files/2024-12/doe-eere-modal-reports_rail-energy-emissions-action-plan.pdf

321 US. Amtrak. "PRIIA 305 Next-Generation Equipment Committee Single-Level Passenger Rail Cars." 2011. Pg 11-13. https://www.documentcloud.org/documents/25537802-specs-single-level-passenger-rail-car/

322 US. DOT/FRA. "Northeast Corridor High Speed Rail Passenger Service Improvement Project. Task 5 – Electrification." 1975. Pg 3-20 – 3-25. https://www.documentcloud.org/documents/25537809-ne-corridor-high-speed-rail-passenger-service-improvement-project-task-5-electrification-august-1975-final-report/

323 UK. British Railways. "Railway Electrification: 25kV A.C. Design on B.R." 1988. https://www.railwaysarchive.co.uk/docsummary.php?docID=2; https://www.documentcloud.org/documents/25537807-british-rail-clearances/

A comparison of vertical clearance requirements for catenary



- Total distance: 14.8 inches (375mm)

US minimum vertical clearances (NECIP):

- Distance between train and contact wire: 8 inches
- Distance between contact wire and ceiling: 8 inches
- Total distance: 16 inches

Amtrak standard clearances:[324]

- Distance between train and contact wire: 9 inches
- Distance between contact wire and ceiling: 9 inches
- Total distance: 18 inches

12.3.2 Freights, electrification and growing requirements

Momentum's literature review identified four substantial electrification programs that freight railroads either authored or with which they cooperated. Each of the proposals was born from a desire to reduce oil consumption due to a defining crisis of its era: the energy crisis of the 1970s, an air pollution and smog crisis in the late 1980s

324 US. Amtrak. "Electrified Territory Outline Specifications for Electrification Transmission and Distribution." 2009. Pg 22. https://www.documentcloud.org/documents/25537827-amtrak-et-outline-specification-transmission-distribution/

and early 1990s, and the ongoing climate change and traffic crises of the 2000s through today. Additionally, the review shows that the minimum vertical clearance specification for modern catenary projects has grown, even though the type of power system has remained constant at 25,000 volts and 60 Hertz (25kV/60Hz).

A 1970s Conrail study to electrify the old Pennsylvania Railroad Main Line from Harrisburg to Pittsburgh found electrification was operationally and economically feasible. Beyond the savings from switching from fuel to electricity, it found the route would benefit significantly from the greater power provided by electric locomotives.[325] "Electrification of the entire study route requires nearly $1.2 billion. Cumulative operating savings for 29 years of over $9 billion yield a return on investment of 18.1%. The consumption of oil would be reduced by 1.7 million barrels per year," a second report from 1980 stated.[326] However, the 1980 report said that, despite the substantial benefits, then-nationalized Conrail was too resource-constrained to construct the system without government support, which never came.

In the early 1990s, Southern Pacific and Union Pacific helped fund a proposal that would have electrified many of the rail lines in the LA basin as part of the launch of the region's then-newborn commuter railroad, LA MetroLink, as part of an effort to tackle the region's air pollution crisis. The electrification proposals were aimed at reducing pollution by creating a high-capacity commuter rail service that would get people to park their cars and by cleaning up the locomotives that haul goods to and from the major ports in the LA region.[327] The extensive engineering diagrams drawn up for that proposal included a generous clearance of 21 feet for double-stacked freight trains, which is nine inches more than the 20'3" of clearance provided for the same trains in the Northeast.[328,329] Additionally, the minimum clearance between the wire and the top of the train was set at nine inches with another nine inches between the contact wire and the bottom of the overhead structure — totaling 18 inches in total. Both of these clearances exceed minimums found on the East Coast and in Britain.

These requirements grew again for the recently completed Caltrain electrification, which had to negotiate an agreement with Union Pacific to build the project even though the railroad's predecessor sold the route to the public years before. That project set the minimum vertical clearance between the train and the contact wire and between the contact wire and the bottom of the structure to 12.5 inches.[330] That means there is a minimum of 25 inches of vertical clearance between the train and the overhead structure, where only 15-16 inches would be required under the British or Northeast Corridor spacing standards. Tighter minimum spacing may have allowed Caltrain to reduce the number of structural modifications it needed to make as part of the project, further reducing its cost.[331]

Minimum vertical clearance by project:

- British standard: 14.8 inches
- NECIP standard: 16 inches
- Amtrak NEC standard: 18 inches
- LA 1992 standard: 18 inches
- Caltrain standard: 25 inches

12.3.3 Freight trains and minimum clearances

Establishing the minimum vertical spacing requirements is important for the second step of this analysis, which examines how much vertical space is needed to fit wires on rail lines that host freight service. This review found that double-stacked container trains will fit beneath the standard catenary setups with existing Northeast Corridor clearances on most lines. As mentioned before, the size of freight trains is highly standardized into specific profiles, which are known as 'plates.' The largest plate — representing loaded double-stacked trains — needs a vertical clearance of 20'3", documents show.[332,333] It should be able to safely run under catenary wires that are at least 20'11" high, a specification met by the NEC designs.[334] A real life example unfolds daily

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Courtesy: Tim Staub

A Norfolk-Southern freight train carrying double-stacked containers easily passes beneath SEPTA's catenary power system

in Philadelphia where Norfolk-Southern runs double-stacked trains beneath SEPTA's catenary power system on a stretch of its Manayunk/Norristown Line. SEPTA wire schematics show the clearance heights range between 21'3" and 22'5" — a minimum of 13 inches of clearance between the top of the container stacks and the bottom of the contact wire. Both the LA MetroLink design and the system constructed by Caltrain designed in far more vertical clearance space than SEPTA's system. This is an example of a specification that could be trimmed back to generate savings.

Back in New York, this analysis underscores the questions about the clearances demanded on the Hudson Line between Poughkeepsie and Albany by CSX as part of its lease to New York State, as first mentioned in Section 5. The route only has sufficient space clearance to fit freight cars that are no taller than 19 feet (Plate F, in freight parlance), but CSX insisted on vertical clearance requirements of at least 22 feet in the deal. That's nearly three times the amount of vertical clearance space that freight trains get running under the wires in Philadelphia. This analysis shows that those trains would be able to operate safely with the contact wire as low as 19'8".

Freight can operate safely beneath wires and does so regularly. The interoperability concerns do not hold up under scrutiny.

Projected and real-world minimum clearances:

- Projected - Hudson Line (Plate F): 19'8"
- Projected - Double-stack (Plate H) minimum: 20'11"
- Real world - Double-stack (Plate H) on SEPTA: 21'3"

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