Analyzing the Potential for Commuter Train Run-Through Service at New York Penn Station

August 7, 2014

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Abstract

This paper provides a brief review of Amtrak research on the potential of through running of commuter operations in Penn Station, New York. It is intended to help inform the larger community interested in the concept as well as to assist in the planning and analysis within a number of studies of Penn Station and the Northeast Corridor that are currently underway. The paper describes through running concepts in general, and then identifies operational and infrastructure conditions specific to Penn Station which should be addressed in order to undertake a successful revenue service.

Analysis discussed in this paper finds that: a) absent the construction of purpose-built facilities to provide wider station platforms and, b) the introduction of more robust vertical passenger access, a through running service with high performance service characteristics found in other railway systems is not achievable at Penn Station.

Further, current operations are optimized around the existing terminal infrastructure with its two main support yards serving in a critical role to achieving very high levels of performance. Without investment in new station facilities to compensate for the utility provided by yards, the introduction of a through running revenue service with commuter trains would lead to fewer peak period trains and/or less reliable operations under representative service scenarios evaluated.

Potential Through Running Territory

Table of Contents

Through Running Overview

Trains which continue in revenue service through New York Penn Station are considered "through running" trains. In 2013, 42 weekday Amtrak trains already "run through" New York Penn Station on their trips along the Northeast Corridor, carrying passengers between Boston and Washington and points between and beyond. However the local commuter rail services provided by New Jersey Transit and Long Island Rail Road terminate in Penn Station and there is no through-service between them. Instead, commuters and local travelers are presented with two entirely different commuter rail systems running east and west from Penn Station with the station functioning in a manner similar to an airport hub (albeit with uncoordinated services) between the three operators. There is also interest in extending Metro-North commuter rail service across the Hell Gate Bridge and into Penn Station. This would add a fourth railroad to the station and also create another potential market.

Who is interested in through running and why?

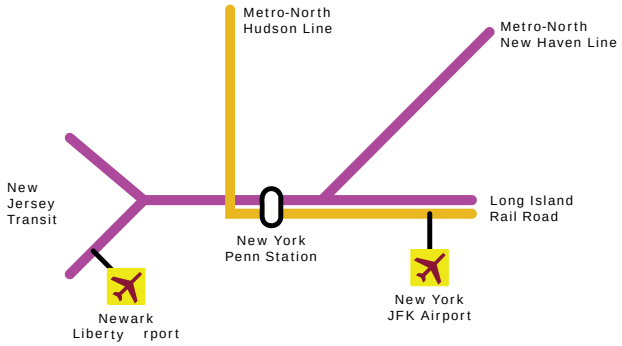
Advocates, policy makers, and authority managers have expressed interest in through running for commuter trains. The potential benefits that have been discussed include:

- Increased train capacity made possible by reducing station dwell times, route conflicts and non-revenue train movements through the terminal complex.
- Reducing the number of trains sent to yards to layover and potentially reducing the need to expand those yards.
- Facilitating regional mobility – for example, to reach airports and business districts in New Jersey and locations east of New York City, and to provide a new measure of resiliency for the region to respond to increasing numbers of destructive weather events.

These potential benefits are only conceptual but there are precedents found in other cities that have implemented through running operations. The active question is whether through running would be beneficial under Penn Station New York's somewhat unique infrastructure and facilities. This paper outlines some of the issues.

PENN STATION'S REGIONAL ACCESS

Potential Through Running Markets in the New York Region



The travel market for through service is not well documented, partly because there is no regularly scheduled through bus or rail operation today (apart from Amtrak). In interviews, planners described potential markets such as:

- Long Island - New Jersey: This trip is difficult to make by automobile and already served by rail with a change of trains at New York Penn Station. Through trains would make the trip more convenient. Through service might also improve access to Newark Liberty Airport from Long Island and from New Jersey to either JFK or LaGuardia Airports.

- Hudson Line - Long Island: This would be a new market for regional rail service and could facilitate access to JFK airport from Westchester and Duchess Counties.

- New Jersey – New Haven Line: This connection is available today using Amtrak service, but local rail connections could facilitate regional travel and commuting to a broader array of smaller stations.

- Market growth over time: The introduction of service may cause a growth in the travel markets over time due to the new interstate commuting opportunities that become feasible.

While these potential markets appear to be the most obvious for testing or implementing new through running services, a more thorough data collection and market analysis effort would be in order before pursuing any of the above options, given the limited research that has been complete to date.

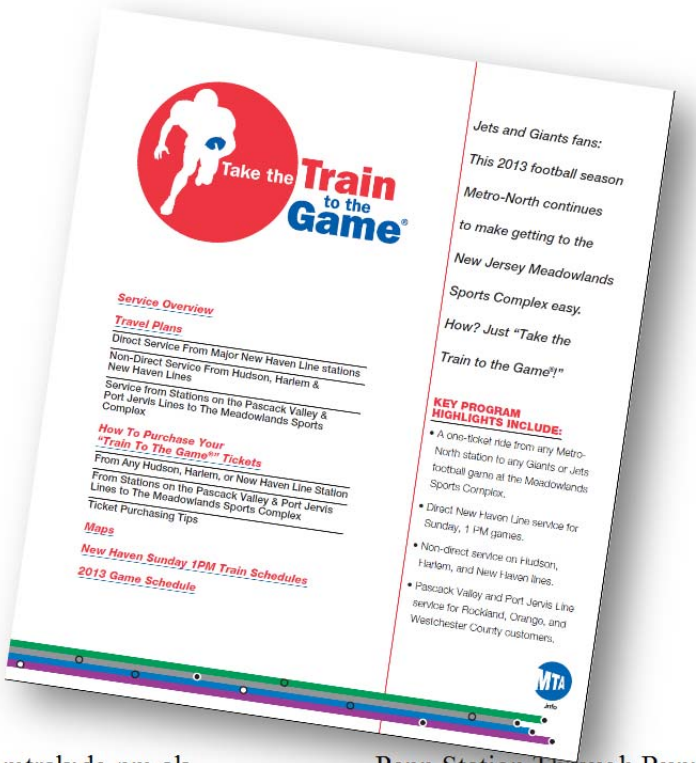
It is anticipated the FRA-managed "NEC FUTURE" Tier I Environmental Impact Statement study and its outcomes will have examined this market in greater detail and may be able to shed more light on the market potential at the conclusion of the study. The environmental permitting began in 2012 and is scheduled to run to 2016. Other interested agencies, such as the Regional Plan Association or MPO's, as examples, may also be able to offer further insight on the market(s) potential.

Through Running on the Northeast Corridor Today

Commuter rail operators have already partnered to offer regularly scheduled through service on the Northeast Corridor. All provide the opportunity for commuters to travel through a city, which is a destination of its own, to points beyond the city without changing trains. Examples of through service at NEC cities are:

- Providence, RI where selected MBTA trains from Boston extend to Wickford Jct., RI;
- New Haven, CT with the extension of certain Shore Line East trains to Stamford;
- Stamford, CT and Newark, NJ as part of their respective Trunk Line systems;
- Philadelphia, PA with the nation's most extensive through service operation (see Appendix C);
- Wilmington, DE with the extension of selected SEPTA trains to Newark, DE;
- Baltimore, MD with MARC service to Washington extending to Perryville, MD.

New Jersey Transit and Metro-North have offered a unique, direct service from New Haven to Secaucus Junction for connection to the Meadowlands Sports Complex for Sunday professional football games. New Jersey Transit provides the equipment to Metro-North, which has qualified some of its crews to operate it. However, the service can only be provided for weekend games with 1:00 p.m. kick-offs. Providing service for a 4:00 p.m. kick-off would result in the New Jersey Transit equipment being in the wrong position for Monday morning commute service, since it has to return from Connecticut.



MTA Brochure for Through Service between Connecticut and the Meadowlands Sports Complex

Through Running in Other Cities: a Review of Characteristics

Amtrak staff has reviewed examples of through-running operations in other cities. Specific examples include Philadelphia, Melbourne, Frankfurt, Berlin, Munich, Vienna, Zurich, Paris, and Toronto. Many other examples exist. Operationally, through-running systems generally display the following characteristics:

The commuter trains keep moving through the city in a continuous direction in revenue service on a trunk line. This provides for operating efficiency by reducing the amount of time in the main station tracks that would otherwise be required to "turn" (reverse) the trains in the station. Trunk lines use land efficiently and minimize or avoid yards occupying urban core space.

Most networks are designed with a "trunk line" that is fed by branches on each side. Trains are generally fleeted along a trunk line with two or four tracks through the center of the city. The uniform operation maximizes capacity available for revenue service trains. Some systems have auxiliary station tracks to facilitate queuing, junctions, transfers, and turn-backs. The Melbourne system has a downtown loop (similar to the famous "Loop" in Chicago) that facilitates turning back trains to their original line without reversing direction. The loop also distributes passengers among several downtown stations.

Most through networks have multiple downtown stations to distribute passenger traffic in the core. For example, the Philadelphia system has five major stations in the downtown on the trunk line. Each arriving train discharges only a portion of its passengers at each station, reducing the load on the vertical circulation system and the number of people on the platform at each station. An exception to this rule is Toronto, which only has Union Station in downtown but multiple station tracks and an advanced local transit distribution system.

Infrastructure has been adapted for through running. In the majority of cases, major expenditures have been invested to transform historical rail operations into modern metropolitan systems with efficient through running. Philadelphia replaced two stub-end commuter rail operations with a run-through regional system by building a new tunnel, one mile long, under the downtown that includes a new Market East Station that replaced the former Reading Terminal. The project cost was approximately $330 million in 1983 dollars, and it would cost significantly more if built today. A key element with these investments was to retire some station tracks in the then-existing Suburban Station terminus station and in order to widen platforms, matching the configuration of new very wide platforms at the Market East station to permit through operations.

The boarding process for most systems is similar to rapid transit. Departures leave from pre-assigned platform tracks that are relatively fixed. Acoustical dampening is often present to improve communications and, although commuters wait on platforms for their trains, the waiting time is aided through robust information systems. However, service disruptions can quickly require managing access to avoid hazardous overcrowding on the platforms.

Audio/visual systems identify each train and the following trains. Each platform usually serves multiple routes with different trains running only a few minutes apart. This is a key part of the infrastructure performance of most through-stations.

Platforms are designed for through operation. Platforms typically have multiple staircases which offer robust vertical circulation capacity and allow bi-directional flows without any staff oversight. Many are long enough to simultaneously accommodate two trains per track (Philadelphia is a notable example of this practice). Platforms sometimes have designated "keep clear" routes to allow detraining passengers clear routes to the stairs. Modern stations will tend to have more generous platform dimensions with fewer columns.

Train equipment varies, but in the best examples, the train equipment is purpose built for rapid passenger exchanges at stations that help keep the trunk line fluid. Specific design elements include large automatic doors, standee space, good visibility between the inside and outside of the vehicle, and customer information systems inside and outside the vehicle.

Train counts can be very high. The Philadelphia system has over 500 weekday train movements on its four-track trunk line. Average peak hour headway is 3 minutes.

Train lengths, capacities, and propulsion vary. Passenger capacity varies from 200 to 1,000+ passengers per train. Examples exist with EMU equipment and also locomotives with coaches.

Some networks have permanent diametrical line pairs and others do not. There is not "one way" to design through running networks.

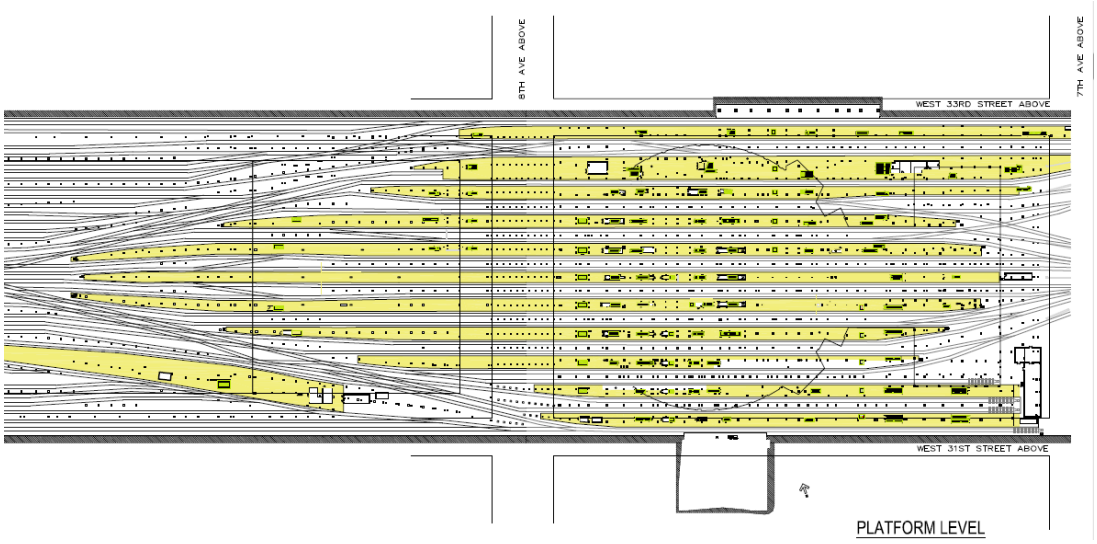
Network resiliency and robustness can be an issue. When formerly separate systems are integrated there can now be network disruptions producing chain reaction disturbances i.e., late inbound trains become late outbound trains. Spare trains, sometimes multiple spare trains, are held in "ready tracks" to be inserted into the system when needed to prevent major disruptions. Systems with a common equipment platform are more stable than a composite system, because the train consists are more universal, permitting easier equipment substitutions during contingency operation.

Penn Station Compared to Other Systems

Based on the review of run-through operations in other cities, Penn Station has characteristics that are different from other systems with through running which present challenges for implementation. The differences include:

- **Single CBD Station**. Unlike most other thru-running systems, there is only one major downtown station, concentrating passenger loading at one location. Access to the rest of Manhattan (and other Boroughs) is reliant upon the vast NYCTA subway system and dense street grid around Penn Station.
- **Narrow Platforms.** Penn Station platforms are narrow, typically 16-18 ft. wide, and cluttered with columns, staircases, and elevators. Pre-loading of passengers on the platforms is not practical or safe.
- **Uni-directional Vertical Access.** The use of escalators without parallel stairs in nearly all locations limits the ability for bi-directional passenger flows and decreases overall platform utilization rates.

Penn Station, New York Existing Platforms and Vertical Access



- **Staged Passenger Boarding.** The combination of narrow platforms, constrained vertical circulation, and high passenger counts produces longer dwell times than for many other rail systems. Outbound travel on Amtrak through trains (the only current through service) must be held back in the concourses until a sufficient number of detraining passengers has cleared the platform to avoid hazardous overcrowding. Given the same infrastructure, run-thru commuter trains should anticipate the same requirements.

- **Multiple Technologies.** The various lines feeding the station use different propulsion power and signal systems. The equipment among the three agencies has different platform boarding designs, communications systems, clearance dimensions and maximum operating speeds. While this could be overcome, it represents a significant complication and makes service planning and service recovery more difficult than systems with a pooled, unified fleet. The cost to harmonize the combined fleet would be in the hundreds of millions of dollars.
- **Multiple Operators.** Through operation with more than one operating company is unusual, but not unprecedented. The RER system in Paris is operated partly by SNCF (the suburban rail operation) and partly by RATP (for the underground trunk line).
- **Multiple Unions.** Entirely different labor union operating craft agreements are in place for each agency. The differences, while perhaps not insurmountable, do present substantive issues to be addressed prior to a through running operation.

There are some similarities to reference cases:

- Train counts per main line track in New York are similar or exceed operations in Philadelphia and Frankfurt.
- Train lengths and passenger capacities have parallels with other systems (but with differently designed stations).

Penn Station and Relevant Improvement Programs

As originally constructed, the terminal relied on Sunnyside Yard (SSYD) to carry out its dominant intercity mission; accepting and delivering trains to go west along with a small volume of through trains from New England. Penn Station's design did not envision the terminal serving as a major regional commuter facility. Instead, the Pennsylvania Railroad (PRR) assumed continued operation of most commuter trains to; Jamaica, Long Island City, Brooklyn or Jersey City terminals. LIRR trains that did go to Penn Station were confined to turn-backs in the station or on a limited number of "tail tracks" immediately beyond the LIRR platforms. A small volume of commuter trains from New Jersey eventually operated with Electric Multiple Unit (EMU) equipment, able to turn back in the station, and even smaller number of conventional electric locomotives pulled commuter trains originating in Bay Head, NJ to Sunnyside Yard (SSYD).

This situation began to fundamentally change as intercity operations were reduced beginning in the 1950s, (culminating in the dismantling of the iconic, original station above street level in 1963) but matched by the gradual expansion of commuter services. The revised mission for the

terminal, with pronounced peaking of high volume train and passenger movements, badly stressed the system. Overcrowded trains and overcrowded station concourses became the norm.

The Metropolitan Transportation Authority (MTA), by then the owner of the LIRR, acted decisively and constructed the John D. Cammerer West Side Yard in Manhattan as well as making very substantial investments in platform extensions and new or expanded concourses in its portion of Penn Station. The yard added 30 new storage tracks and the station modifications enabled uniform operation of 12 car trains to all LIRR station tracks, providing maximum operating flexibility and capacity utilization. The investments enabled the LIRR to operate up to 38 trains per hour, providing approximately as much as 53,000 seats in the peak direction into the station, an astounding figure for commuter service anywhere in the world.

NJ Transit invested heavily through the creation of its East End Concourse and other passenger flow improvements to expand concourse space and vertical access over its normally used portions of Penn Station. The agency also funded major infrastructure improvements to the signaling and train control systems under the Hudson River and within SSYD to expand daytime storage and servicing capacity. Finally, it adopted an operating strategy of greater reliance on utilizing SSYD in lieu of cycling all of its equipment back west to New Jersey. While very expensive (NJT loses use of the equipment for revenue service for 2 or more hours for each train to SSYD), the approach permits maximum use of "drop and go" station operations during peak periods to utilize the most efficient station operation (more on this later). Today, more than 60 NJT trains operate through the East River tunnels each weekday to support the service. The combined investments and operating methods have enabled NJT to schedule 21 trains in the peak hour, providing, depending on the mix of train lengths and type of equipment used, between 27,000 to 29,000 seats into Penn Station.[1] Together with Amtrak intercity service operating in the peak periods, the traffic density per main track in the Hudson River tunnels is the greatest of any passenger rail line in the American Hemisphere.

Amtrak, for its part, undertook substantial improvements to its designated concourse spaces, creating improved and expanded waiting areas and investments in vertical access infrastructure to facilitate more efficient and reliable boarding of trains. It also funded its share of the infrastructure improvements in train control and reliability. Taken together, the combined investments of the agencies have allowed the station complex to serve a record 650,000 passenger trips (including New York City Transit passengers) each day, more than double the volume compared to when Penn Station's original Head House was demolished half a century ago. This

[1] As many as 23 TPH have been run by NJT in previous years. But, construction west of Penn Station as well as platform capacity limitation in the station itself have caused NJT to reduce the overall scheduled level to maintain reasonable reliability.

volume comes with challenges. Today at Penn Station, improvements to vertical circulation and expansion of pedestrian concourses are needed, whether or not run-through services are ever expanded at Penn Station.

Critical Role of Station Dwells on Penn's Operation

These investments, together with disciplined operations, are decisive factors enabling Penn Station to operate at such high performance levels. Carefully planned operations through the station and its 21 platform tracks are essential to fully utilize the capacity of the seven main line tracks connecting to the terminal. To help achieve this balance in the system, the operating railroads have agreed to a standard set of station dwell time protocols for the various types of operations in the station in order to reliably support the daily operations.

The protocols were developed through the Tri-Venture Council[2,] a collaborative entity among the railroads, and have been the basis for implementing current services as well as evaluating future scenarios. They reflect the various capabilities of equipment in service as well as the combined experience of operating the terminal. Minimum (shorter) dwell times are permitted only on a case-by-case basis. Amtrak's longer dwell times take into account longer distances traveled, greater luggage volumes, commissary, and reserved system processing / security time factors. The following table provides a condensed version.

Authorized Scheduled Dwell Times for Penn Station, NY
Revised December 6, 2013

Type of Operation		Dwell	Comments
LIRR	Revenue to Revenue	18 min	From ERT / Station turn / to ERT
NJT	Revenue to Revenue	22 min	From NRT / Station turn / to NRT
Amtrak	Revenue to Revenue	55 min	One midday train per day
LIRR	Revenue to Non-Revenue	6 min	To West Side Yard (WSYD)
NJT	Revenue to Non-Revenue	7 min	To Sunnyside Yard (SSYD)
Amtrak	Revenue to Non-Revenue	10 min	To SSYD (w' Crew change)
LIRR	Non-Revenue to Revenue	15 min	From West Side Yard
NJT	Non-Revenue to Revenue	15 min	From Sunnyside Yard
Amtrak	Non-Revenue to Revenue	25 min	From Sunnyside Yard
LIRR	Through Operations	12 min*	Future run-thru dwell time
NJT	Through Operations	12 min*	Future run-thru dwell time
Amtrak	Through Operations	15 min	Preferred dwell times
*Tri-Venture Council agreed upon dwell time for future commuter service through operations			

[2] The Tri-Venture is a collaborative effort between the LIRR, NJT and Amtrak to coordinate and facilitate service and capital planning at Penn Station.

Current Operations at Penn Station

In 2014, sustained high levels of service occur each weekday morning and evening. Morning peak operations extend from 6:00am to 10:00am and the evening peak operations begin at 4:00pm and continue to 8:00pm. The 7:30am to 8:30am period is typical of the morning peak and is described herein in further detail. During this hour, there are 124 scheduled movements; 62 trains enter the terminal from the East, West and North, and a combination of 43 new or continuing trains operating to New Jersey or Long Island or Albany with the balance entering into supporting layover yards.

The service plan is achieved through a complex mix of operations between the three carriers applying all of the dwell time factors listed above. By aggregating these scheduled dwell times, it is possible to calculate the effective utilization of the station tracks to determine the total number of dwell time minutes scheduled. For the 2014 base line schedule, a total of 1,214 scheduled platform dwell minutes are derived with an average of 13.2 minutes per train during the peak hour. At this level of utilization, the collective operations of the three agencies also effectively *fully consume all available station track capacity during the hour*. Even if additional tunnel line capacity can be created, there are only very limited opportunities to take advantage of it due the level utilization of the station tracks. This balanced mix of operations is shown as below.

Penn Station Inbound and Outbound Train Counts (1)

7:30am to 8:30am

Type of Operation	NJT	Amtrak	LIRR	Total
Inbound North River Tunnels	22	3	-	25
Inbound Empire Tunnel	-	2	-	2
Inbound East River Tunnels	-	-	35	35
				62
Outbound North River Tunnels	12	2	-	14
Outbound Empire Tunnel	-	1	-	1
Outbound East River Tunnels	9	3	16	28
Outbound to West Side Yard	-	-	19	19
				62

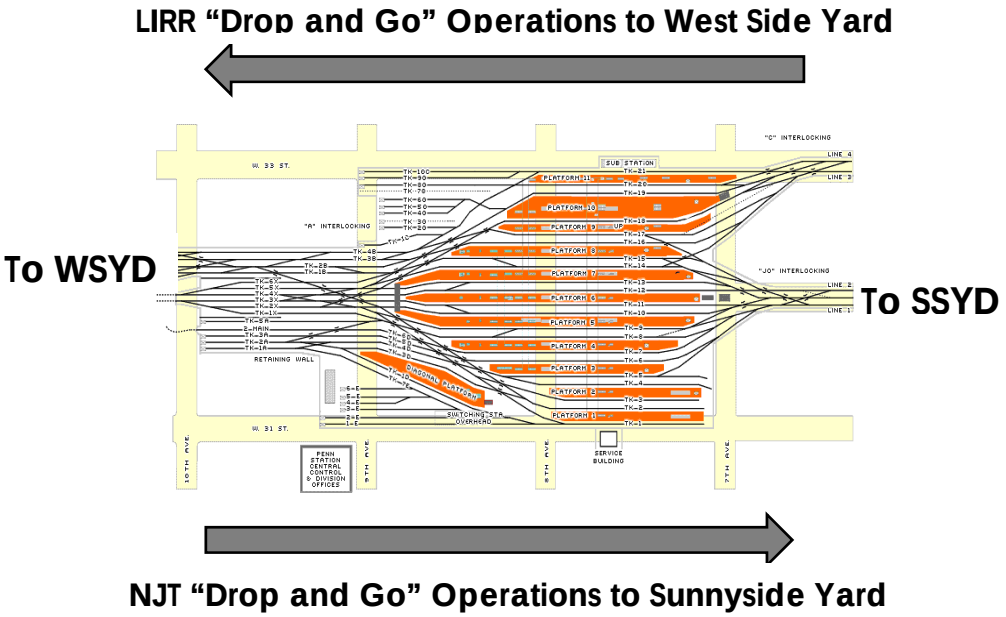
(1) Penn Station Central Control “Commission Counts” January 2014

Drop and Go Operations at Penn Station

As can be observed from the above table, both LIRR and NJT rely on finely tuned revenue to non-revenue or "Drop and Go" (or "Down and Back" in LIRR parlance) operations to achieve their collective service plans. Under this approach, trains enter the station, discharge their passengers and then immediately proceed in the same direction they entered the station to either West Side Yard or Sunnyside Yard, depending on the operator. It presents the most efficient operation, capacity-wise, of all of Penn Station's operations.

Over one half (54%) of LIRR trains and nearly half (41%) of NJT trains operate in this manner during the peak hour. The LIRR either stores or cycles equipment back east from West Side Yard. NJT also will store trains at SSYD or utilize a technique called "Looping", in which a train does not enter the yard body tracks but instead travels around SSYD's perimeter to return to Penn Station. Quick access to the two yards is a critically important component to achieving high traffic levels for both operators.

The two support yard's roles during the peak periods effectively already make Penn Station a through terminal and not a stub-ended facility.



Through Running Operating Concepts

Short of building new infrastructure capacity such as the proposed Gateway Program, through-running concepts can only be developed through modification of two types of existing services:

a) Combining of LIRR/NJT drop and go operations to offer new revenue frequencies to Queens and New Jersey and/or,

b) Combining of LIRR/NJT revenue station turns to offer through revenue services between Queens and New Jersey.

Drop and Go -28 trains using this technique are operated by the LIRR and NJT during the hour and it may be possible to combine the operations for through service. However, NJT runs only 9 of them so the opportunity to combine all train movements on a one-to-one basis is less than half of the total. Drop and Go operations have the shortest dwell times utilized in the station. As such, any change to this operation will impose additional time requirements during the same time period. Based upon the approved dwell time standards, combining LIRR and NJT trains and switching all of them to a revenue to revenue operation would revise the total 7:30-8:30 a.m. dwell time to 1,419 total minutes and raise the average dwell time per train to 15.4 minutes – approximately a 16.9% increase in total dwell time. This level of increase is likely not possible since there are no additional platform tracks in the station to absorb the greater dwell times. C*onverting all revenue to non-revenue train movements to a through operation would require a reduction in total train movements through the terminal.*

Station Turn combinations - may offer some opportunities to combine trains between the LIRR and NJT operations. Instead of a LIRR train reversing direction in Penn Station and operating eastward back to Long Island and a NJT train reversing to head westward back to New Jersey, schedules might be developed allowing a combining of the two services as a through operation. Using the same dwell standards and assuming all trains of this category are eligible, execution of a run-through service would reduce total scheduled dwell time to 908 minutes with an average of 9.9 minutes dwell. However, such a level is not achievable since NJT must continue to turn approximately 40% of its trains on stub-end Tracks 1-4 under any circumstance, making them ineligible for through running. It is also quite unlikely the two railroads, each with very complex networks with numerous choke-points at various locations away from the terminal, could ever optimize all elements. Therefore, for purposes of this discussion, it is proposed that 50% of the theoretical benefit be considered. This would bring total dwell time minutes down to 1,061 with the average at 11.5 minutes – approximately a 12.6% decrease compared to base line operations.

A potential NJT / MNR Hell Gate commuter service, utilizing NJT trains to Connecticut, would face the same set of requirements. Converting the NJT revenue to non-revenue trains to SSYD to become through operations along the Hell Gate would also require doubling the dwell times in Penn Station for each affected train and encounter the same lack of platform track capacity, albeit on a smaller scale compared to the combined LIRR/NJT operations. Also, the non-revenue NJT traffic flows in tunnel slots only towards SSYD in the morning and from it in the evening, opposite of what MNR would need for commuter service to the Bronx and Connecticut.

The absence of purpose-built infrastructure; wide station platforms, robust vertical passenger access, common equipment, etc., prevents reducing dwell times at Penn Station to those found in most through-running operations with comparable passenger volumes. As a consequence, combined NJT/LIRR or MNR services would need to continue to respect these infrastructure conditions and likely produce no substantive efficiencies in terminal operations. Further, current operations are optimized around the existing infrastructure and the introduction of through running (without major investments) would lead to fewer trains operated or increased risk of less reliable operations at the same train volume.

Some Findings and Observations

Through running of trains at Penn Station is technically feasible but would bring many operational challenges and likely require very large investments to make it reasonably successful. Depending upon the operating strategy chosen, implementation of through running could enhance or degrade total capacity of the terminal. It is more likely that a mix of strategies would be selected and total terminal capacity would not materially change. The table below illustrates the range of capacity changes that have been evaluated.

Penn Station Capacity Changes with Through Running Operations

Scenario	Total Dwell Minutes	Average Per Train	Change
2014 Operations	1,214	13.2	Base
Convert Drop & Go	1,419	15.4	(16.9%)
Convert Station Turns	1,061	11.5	+12.6%
All figures shown are based upon 7:30am to 8:30am 2014 weekday operations			

From a capacity-related perspective, it is apparent revenue through running commuter services would not yield major increments (if any) in train movements because the station already operates as a through station with much of its traffic. The existing through operations are tailored around

the substantial limitations inherent in Penn Station's design to achieve optimal service levels among the three operators (not withstanding independent infrastructure reliability-related problems). Key to this operation is the relationship of two high-performance yards: West Side Yard and Sunnyside Yard which accept or discharge trains in rapid order to support the most efficient of dwell time categories used in the station. Equally key are high volume transit connections and convenient pedestrian access to substantial employment sectors within the City. The Northeast Corridor's reliance upon a single point of entry to Manhattan demands such connections function efficiently. Their current deficiencies are a source of concern and present increased risk that expansion of the system could be stymied unless they are improved as part of future developments.

This analysis did not attempt to determine station alterations or improvements which could address the inherent limitations of Penn Station to reduce dwell times. Such investigations are considered better undertaken as part of a comprehensive planning process, such as the NEC FUTURE, Penn Vision or Gateway Program studies currently underway. The entire terminal and regional network must be factored into the analysis to fully understand the operational impacts of through running. Among the modifications recommended for possible study would be the opportunity to remove a selected number of existing station tracks to facilitate a through-running operation after additional capacity is created by the Gateway Program or through a comparable set of investments. The expanded station footprint may provide sufficient capacity to absorb station turns that are expected to remain necessary under any operating scenario while also establishing realistic through running conditions.

Similarly, the broader group of above studies are better scoped and positioned to evaluate the regional market benefits of through operations. Given, a sufficiently strong enough case, the three states and New York City may determine to move forward and undertake through operations to serve worthy markets. However, it must also be recognized such an undertaking should be approached carefully and comprehensively to provide the complete picture as follows.

In 2012, after twenty nine years of operation, SEPTA dismantled the nation's largest through service network (even though most trains continue to technically operate in this fashion), due to comparatively low volume of through riders and high levels of passenger complaints about the confusing route structure. SEPTA made this decision only after extensively evaluating modifications to its communications and way finding systems before separating the public information into the former Pennsylvania and Reading territories.

APPENDIX A

Topic	Reference Cases	Penn Station
Network Design	• Branch lines feed from opposing directions a downtown trunk line which usually has multiple stations. • Network is usually presented and managed as a unified system (e.g. S-Bahn, Regional Rail, RER, etc.)	• Branch lines feed from opposing directions a single downtown terminal station with train storage yards on each side of the terminal complex. • Network is presented and managed as two separate systems.
Station Design	• Core stations typically have wide platforms serving main line tracks. • Stations have adequate capacity circulation for traffic levels (although some congestion occurs on the busiest systems). • Platform assignments are relatively stable and posted long in advance (or permanently). • Passenger information systems describe the next several trains on each platform. • Multiple stations distribute passenger traffic load.	• Narrow platforms reduce passenger capacity per platform. • Platforms do not face main line tracks. • Vertical circulation is constrained. Escalators create uni-directional movement. Elevators are compact. • Platform assignments are dynamic and are only posted only a few minutes before departure. • Passenger information systems do not resemble reference cases. • Most traffic is concentrated at a single station.
Train Headways	• Minimum headways on reference case systems are approximately two or three minutes between trains per mainline track. • Trains on main line tracks clear platforms quickly to make way for the following trains.	• Minimum headways on Penn Station approaching tunnel tracks are approximately two to three minutes. • Boarding trains often dwell on platforms for 10 minutes or more. Arriving trains are routed to various tracks.
Train Equipment	• Typically the system fleet is pooled but has multiple equipment versions and generations. • The highest capacity systems have high capacity passenger doors. • Single and multi-level equipment is in use. • Train lengths and passenger capacity vary but can be very high.	• Each rail operator has its own fleet, which have differences. • Door sizes vary, but are often smaller than international precedents. • Single and bi-level equipment is in use. • Train length and capacity varies but can be very high.

APPENDIX B

Condensed Notes from Amtrak Interviews

Amtrak staff interviewed several planners and managers in the region to solicit their perspective on through operations at New York Penn Station. Some highlights are presented below.

There is interest in through running from railroad managers. Everyone recognizes there are challenges and costs, but also potential opportunities, although not fully quantified. One interviewee advised not give in to the, "cold water bucket brigade." Through running is also seen as a possible strategy to accommodate Metro-North extending service to Penn Station.

It is not a silver bullet for capacity. Through-running is at best a marginal increase in capacity, while presenting numerous challenges. In the end, there is going to have to be major infrastructure investment if the goal is to increase capacity significantly. Through-running may require certain investments to really work properly.

But it *might* help improve operations. Penn Station needs to be thought of as a common station for multiple railroads. Through service is the kind of initiative that helps focus attention on the needs for a station that better serves the customer.

The evening peak is a challenge, even though it has less traffic than the morning peak. There are actually more inbound commuters in the morning peak then outbound customers in the afternoon peak but the railroads prefer to schedule more time for outbound trains to be on the platform for boarding, so evening train congestion and on time performance can be a problem. Current studies are simulating perturbed operations to test schedule resiliency and robustness. If total platform times were reduced by through running, or if operations were more robust due to fewer routing conflicts, it could lead to greater train capacity or better on-time performance.

Reversing direction takes time. Trains have to perform certain tests when changing direction. The existing yards in the core are congested, so it may make sense to think about sending the trains out to the suburbs during midday.

The total customer market may be relatively small and is not yet defined. Markets tend to grow around the availability of service over time. The strongest existing market may be Long Island to New Jersey. Automobiles are not very competitive for this trip, and it is currently possible to make this trip by changing trains at Penn Station. Another possible market may be the Hudson Line to Long Island and JFK airport. Connecticut to New Jersey is also a possibility.

Institutional challenges have been an issue. The policy framework is key; agencies should embrace inter-operability and compatibility in their project planning. For example, when new equipment is ordered, there is an opportunity to optimize the equipment for through service. It is important to consider the larger policy implications, such as regional connectivity to airports. It is also important to consider potential cost trade-offs, such as expanding yard capacity as compared to establishing run-through service.

There is not really a consensus about whether to start small or think big. Running just a few through trains per hour could be a manageable test platform but might actually reduce capacity. However, a large amount of through running may face larger hurdles require such as the need for improved infrastructure and compatible train fleets.

The big picture can get shut out by the operating challenges. There are major operating challenges, but they can dominate the discussion. The discussion has to address the bigger picture. What is the size of the market? What is the trade-offs, or gains for operations, infrastructure, and capacity? What are the impacts on regional mobility and competitiveness? Does it make sense or not?

Sometimes you trade resiliency for efficiency. When services become more integrated, delays can propagate more easily. A late inbound train automatically becomes a late outbound train. A tightly wound schedule can sometimes break more easily.

APPENDIX C

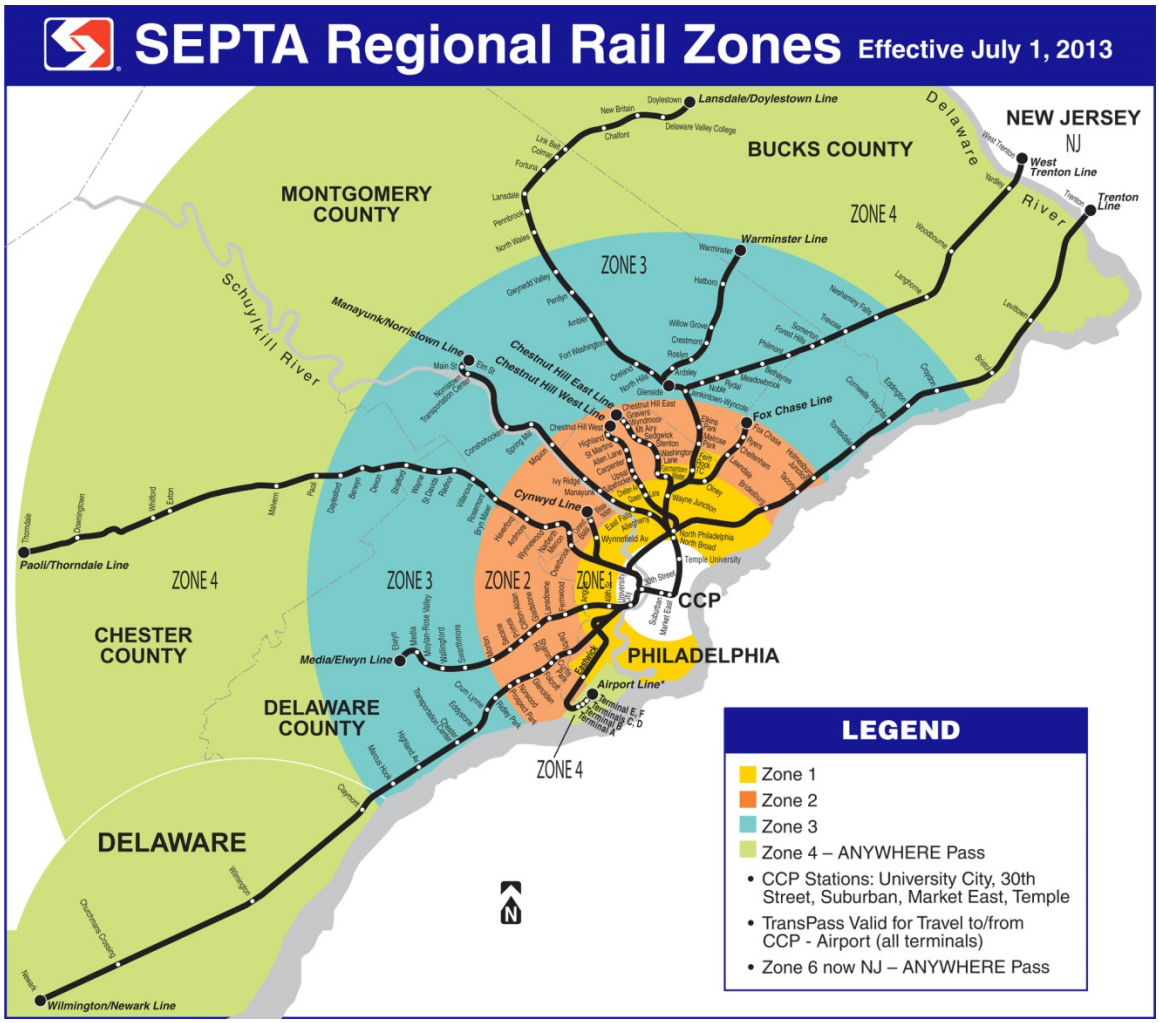
Philadelphia Case Study

Philadelphia was historically served by two separate commuter rail networks, each operating from a stub-end terminal in the center of the city. The Pennsylvania Railroad operated commuter trains from the subterranean Suburban Station west of City Hall, while the Reading Railroad operated its local trains from the Reading Terminal, a major train station elevated above the city streets east of City Hall.

In 1983, after two decades of study and discussion, the City of Philadelphia opened a new tunnel, built with funds from the Urban Mass Transit Association, which united the formerly independent commuter rail systems into a unified network operated by the Southeastern Pennsylvania Transportation Authority (SEPTA). From that point on, most trains ran through Philadelphia from one network to the other. The SEPTA system has over 500 weekday train runs operating over 700 revenue schedules (because many inbound trains become an outbound revenue train). All trains serve the core of the system.

A run-through operating plan was developed by University of Pennsylvania faculty and SEPTA managers. The concept was based on the German “S-Bahn” model, with paired diametrical lines with designated numbers (e.g. R1, R2, R3, etc.) The paired lines were determined based on operating considerations such as train lengths, frequency of service, and track layout, in an attempt to optimize the system. Crews are changed at the midpoint of the network, Suburban Station, in a process that requires approximately three minutes during the normal passenger loading process. Most trains run as locals, mostly to the terminus of the route, however SEPTA does offer peak period express service and short-turns some routes.

The system resembles an S-Bahn system in many respects; however, for operational reasons the strict line pairings were eventually relaxed. Some inbound trains began to run outbound on a different diametrical line or to deadhead outbound quickly to cover an additional peak hour trip. This was primarily because the entire SEPTA system never received the modernization and capital investment required to transition fully to an S-Bahn model. Schedules had to be built around NEC limitations as well as the constraints presented by numerous single-track branch lines. Even though it never achieved the full S-Bahn model, the Philadelphia the system remains a run-through system. The majority of inbound trains run through the city and become outbound trains. Moreover, the Airport Line and similar through-markets saw some benefits from through service.



Philadelphia Ridership Pattern and Station Operations

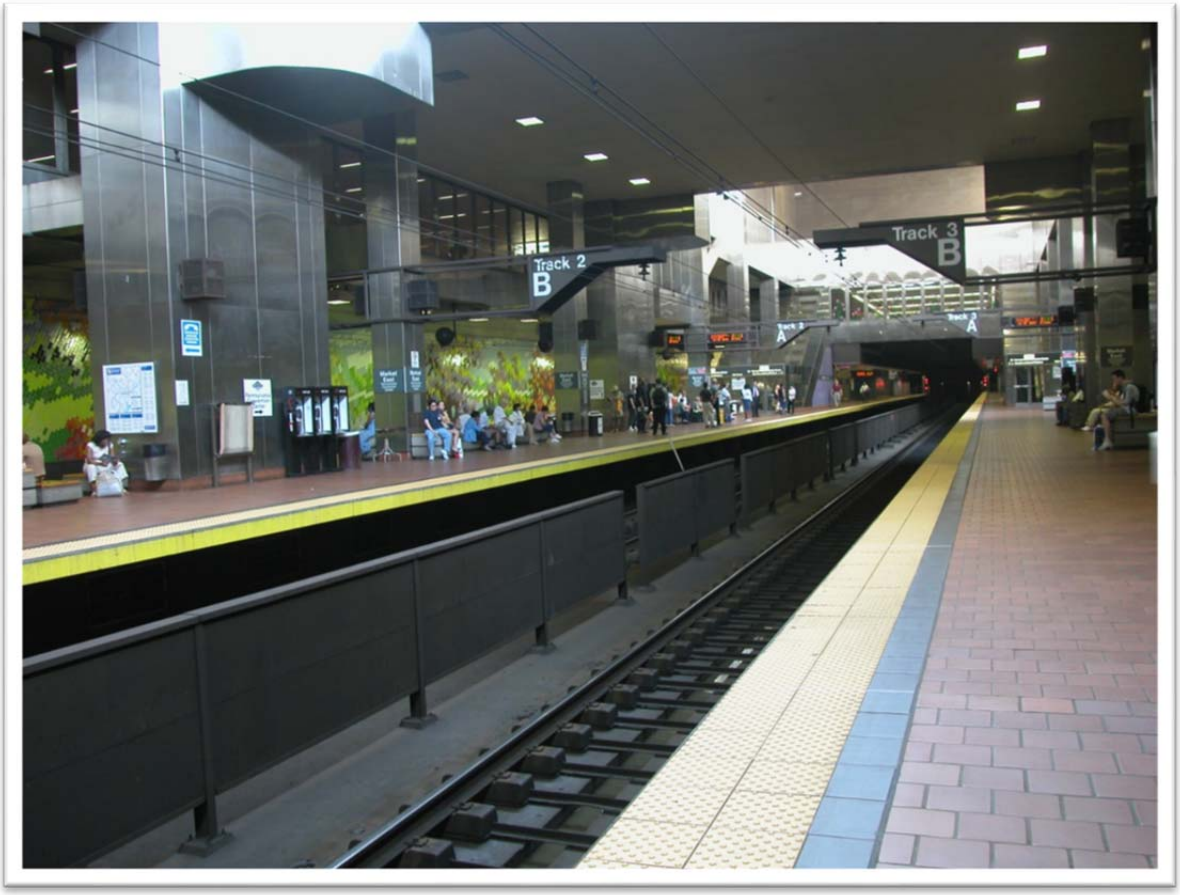
The SEPTA Regional Rail system has approximately 124,000 riders per day. This is the highest in SEPTA history. Annual ridership has increased 50 percent since 1998. Most customers travel to or from the five stations near the center of the City as shown in the table below:

Core Station	Weekday Ridership	Percent of Core Ridership
University City	5,161	5%
30th Street Station (Amtrak)	25,408	22%
Suburban Station	48,396	43%
Market East Station	26,976	24%
Temple University	7,010	6%
Subtotal	**112,951**	**100%**

Source: SEPTA 2013 Annual Service Plan

The distribution of customer traffic over multiple core stations means that each station has fewer customers to process, helping to reduce station congestion.

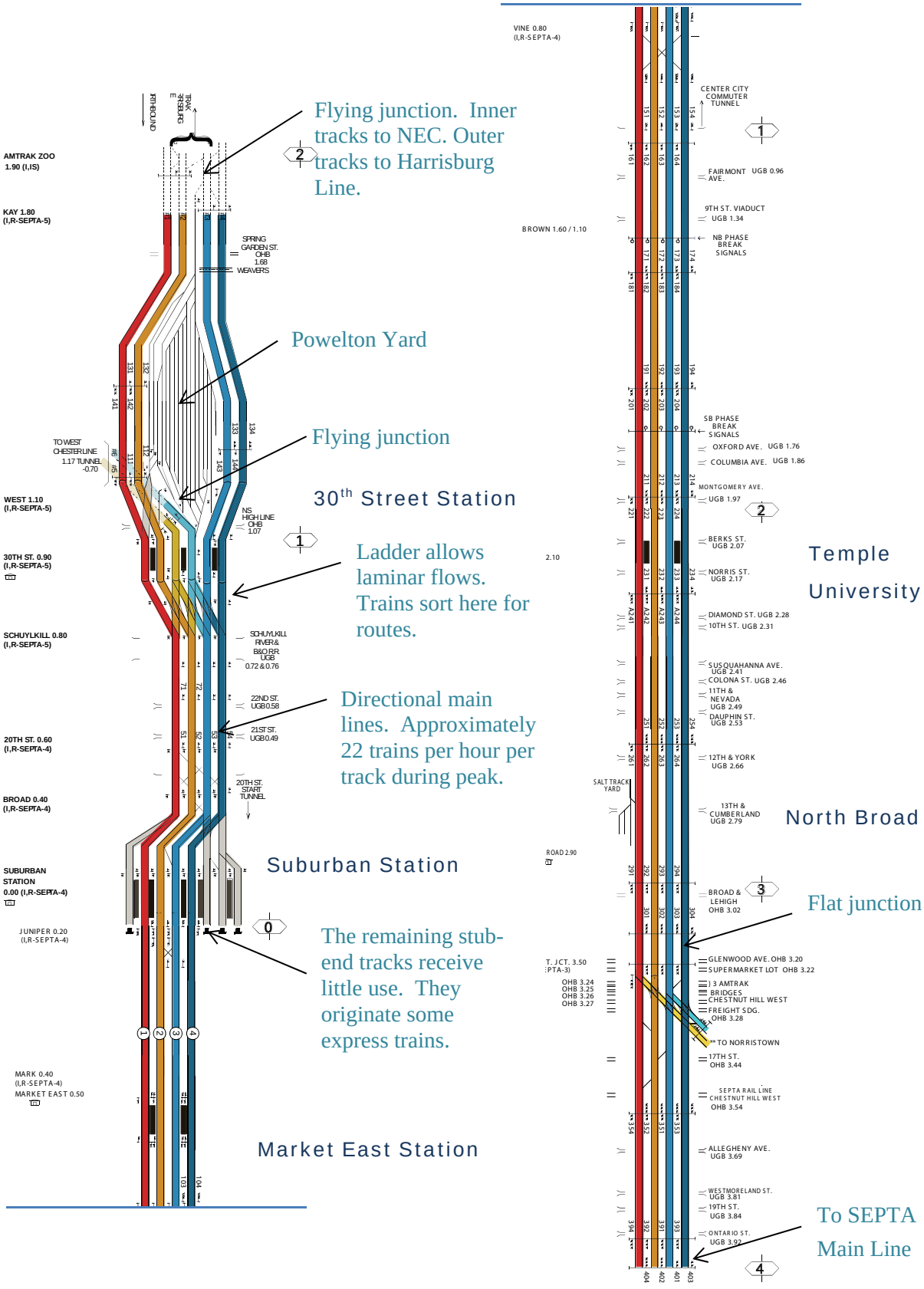
The boarding process is open. Customers can wait on the platform for their desired train or wait on the station mezzanines. The main line platforms are approximately 40 feet wide. Train services use pre-determined platform tracks, which are marked with static and dynamic signage. Customers usually board from the same location each day, although there are occasional exceptions related to operating conditions. Many track substitutions have no impact. (e.g. the same platform serves traffic on tracks three and four, so a track substitution between three and four has no impact).



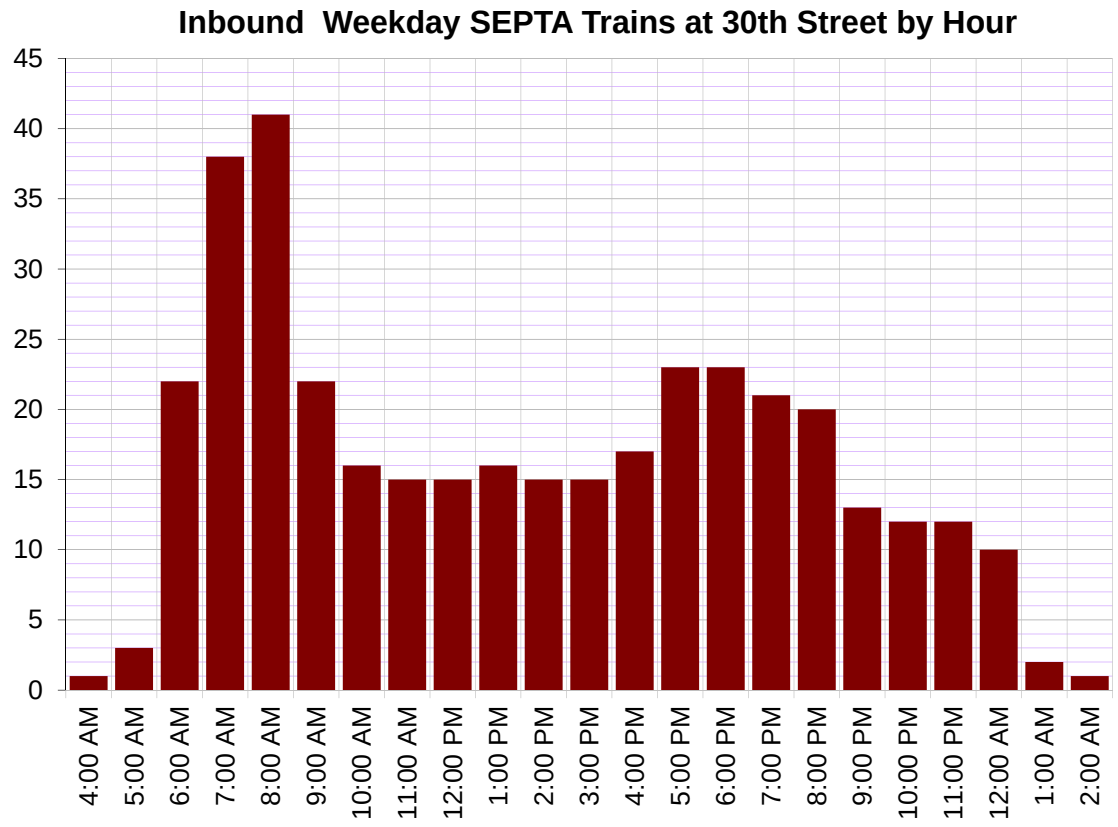
Above: SEPTA Market East / Convention Center Station opened in 1984 and serves over 500 weekday train movements. Two island platforms face four mainline tracks. Each platform is roughly 30 feet wide and 840 feet long, sufficient to accommodate two typical length SEPTA trains simultaneously, with four escalators, four stairways, and two elevators with street level access. Windows provide some natural light from street level. A station mezzanine level with customer service functions has direct connection to the Gallery shopping center and the Convention Center. Photo: Flikr/davidwilson1949.

The core stations have a relatively high quality of interior amenity for North America. Suburban Station, which was constructed in the 1920s, has been modernized with suspended ceilings, acoustic attenuation, audio/visual systems, bright lighting, and restoration of the original Art Deco period details. The Market East Station opened in 1984 and provides a spacious and colorful station with natural daylight on the platforms provided by street-level windows. Thirtieth Street Station has a glass and steel train shed for the elevated platforms and is attached to a neoclassic landmark station building. It has more narrow platforms but relies on six station tracks to provide adequate line capacity. Both Suburban Station and Market East Station have adequate vertical circulation capacity with multiple staircases, escalators, and elevators.

SEPTA branch line headways are generally 30 minutes or 60 minutes, with peak period express extras. Most commuters ride on monthly passes, but customers may purchase tickets at ticket windows or onboard the train from the conductors. Specific train routes are indicated by overhead monitors, audible announcements, and small signs on the trains. Because of a shortage of funding, outer stations are mostly low-level, which increases station dwell times and requires train crews to operate the manual trap doors for the steps on the cars. SEPTA has many small stations with relatively low ridership. Parking capacity is at a premium at many stations, but SEPTA benefits from stations with very high walk-up accessibility.



Above: SEPTA track charts for the run-through trunk line.



The chart above shows inbound train frequency by hour, with more than 40 scheduled inbound arrivals during the peak hour. Therefore, if traffic were divided evenly among tracks, the mainline SEPTA tracks would each accommodate approximately 20 trains during the peak hour for an average headway of three minutes.

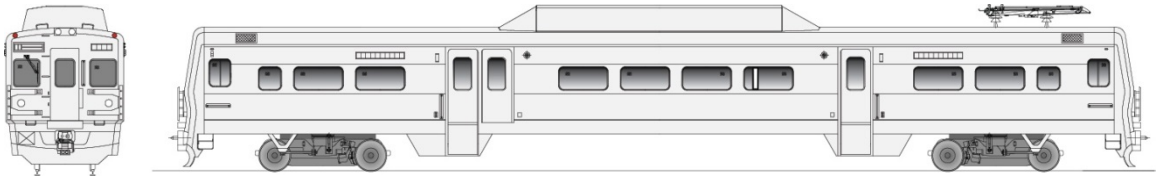
Philadelphia Infrastructure Design

Scheduled headways on the SEPTA main line tracks are as low as three minutes. The Philadelphia Regional Rail network has 13 spokes feeding the Center City tunnel. Most trains run through the tunnel, changing crews at Suburban Station. The tunnel has four mainline tracks. Although they have bi-directional signals, the tracks normally operate as paired directional main lines. In concept, Market East and Suburban Station each have two island platforms serving the directional main line tracks (thus there is an eastbound and a westbound platform). At 30th Street Station the four tracks divide into six tracks served by three island platforms, which allows for sorting and queuing trains for the various branches. In normal operation at 30th Street Station the southern three tracks handle inbound traffic and the northern three tracks handle outbound traffic. Thus, the northernmost platform is an outbound platform and the southernmost platform is for inbound trains. The center platform serves both inbound and outbound trains on the branches that duck under and run southwest: the NEC (Wilmington/Newark) Line, West Chester (Media) Line,

and Airport Line. The eastern approach to the station has a triple ladder that allows for laminar flows on the main line tracks.

Suburban Station also has an additional four stub-end tracks with platforms (a legacy of before 1984 when the station was a stub-end terminal). The stub-end tracks are used to terminate, store, and originate a small number of peak-period trains, but very few passengers overall make use of these platforms because the majority of trains run-through the tunnel on the main line tracks.

Train speeds in the tunnel area are relatively low– typically 30 miles per hour or less. Signal blocks are closely spaced (trains are governed by cab signals with wayside signals in place). Permissive block signals allow trains to closely follow each other. Platforms are on permissive blocks. The PRR track layout was originally designed for terminal operation, envisioning slow speeds and lots of crossover movements across the station throat at Suburban Station. Geometrics are not optimized for through-operation, but are likely to be permanent, not least because of extensive overbuild of the line. The legacy track design affords high capacity, fleeted operation, with laminar track flows possible at several locations. Trains generally cross over the directional main lines at pre-determined locations, but the track infrastructure affords *ad hoc* operation for exigencies.



Above: SEPTA Silverliner V electric multiple unit elevation

Philadelphia Train Equipment

The SEPTA system primarily uses electric multiple unit trains, operating on AC 12.5kV catenary power, with peak-period services augmented with electric push-pull coach trains. Peak hour trains are generally six cars or less (with exceptions) and many services operate with fewer cars. The short train lengths generally mean that trains will clear interlockings in a short amount of time, allowing for more rapid sorting of trains at crossover points.

The EMU fleet offers several advantages for SEPTA such as scalability of train length to demand and quick acceleration that is a benefit for a system with numerous stations less than one mile apart. The push-pull trains operate with consists of seven cars offering over 850 seats, thereby maximizing capacity during the peak period. Most push-pull trains operate as outer zone express

service to maximize train performance. Because the lines are relatively short, many trains can run two peak-direction runs during the peak period.

Impact on Land Use in the Philadelphia Region

The reinvention of Philadelphia commuter rail had profound effects. Shortly after the completion of the new tunnel, a wave of skyscraper office buildings was constructed near Suburban Station, which now had double the number of commuter rail lines for access. The skyscraper construction wave eventually receded, but was later replaced by a growth in economic activity tied to the universities and hospitals near the University City station and 30th Street Station. These destinations would have been difficult to access from the former Reading Terminal in the eastern part of downtown, but with completion of the tunnel and through operations these newer western CBD destinations s enjoy extensive commuter rail coverage from throughout the entire region. When considered in total, the run-through service probably influenced the land use pattern in the region in a fundamental way.

Impact on Philadelphia Commuter Rail Operations and Economics

The run-through operation also probably saved the commuter rail system from decline and possible abandonment. SEPTA had previously been retrenching railroad operations due to poor operating economics and lack of capital investment. The run-through operation allowed for consolidating the network to gain efficiencies in fleet utilization and maintenance, while also creating a more attractive product for customers who could now reach many more destinations with greater ease.

Through running vs. Distributed Station Plan

The run-through operation, while introducing operating efficiencies, has had only a modest reach on capturing the region-wide market. As shown in the above table, fully 91% of SEPTA's commuter rail riders use the system to travel to one of the five CBD stations as compared to traveling through the CBD to suburban points (or within suburban points). However, while funding of the tunnel originally envisioned great potential of through running, the investment turned out to have even greater value in keeping Philadelphia connected to the greater region during times of substantial development pattern change. Construction of the tunnel enabled convenient access to virtually all of Philadelphia's extended CBD core area and allowed the commuter rail system to evolve to keep pace with a changing market. In a city with a significantly smaller local transit system compared to NYC to rely on, construction of the commuter tunnel has, by nearly all measures, proved to be a profoundly wise investment.