Morrisville Yard: Improving NJ TRANSIT Service on the Northeast Corridor

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Introduction

The $82 million Morrisville Yard Improvement Project, designed by Parsons Brinckerhoff, transformed a portion of the former freight classification yard into a passenger train storage facility capable of providing overnight stopover for up to 12 passenger trains and a total of 140 cars. Conrail continues to maintain a freight yard on the site, west of the NJ TRANSIT yard facility.

The passenger yard project includes a 1,000 linear foot pit and pedestal track for train service and inspection, a 100-foot service and inspection facility; two grade crossings; 37,200 feet of new or rebuilt running track and catenary; a 7,400-square-foot crew quarters building; and access roads, parking and utilities to service the yard. To provide a reliable and high-capacity route between the new yard and the NEC, the project included the redesign of the Morris and MY interlockings and the rehabilitation or replacement of four bridges.

Why Morrisville?

An existing freight yard in Morrisville, Pennsylvania, presented a perfect target of opportunity for NJ TRANSIT transportation planners. Originally built by the Pennsylvania Railroad, Morrisville was a hub of activity through the Penn Central era, when large numbers of freight trains shared the Northeast Corridor (NEC) with passenger traffic. After the formation of Conrail and the subsequent removal of most freight operations from the NEC, Morrisville served a diminished role. The hump classification yard was phased out in the 1980's and remaining freight operations were concentrated in the former receiving yard to the west. Thus a substantial piece of property, with a historically rail-oriented use and a short and direct connection to the NEC, became surplus and readily available to NJ TRANSIT. Located just two miles west of NJ TRANSIT's western terminal station at Trenton, and with a direct, grade-separated connection to two of the four NEC tracks, the Morrisville site seemed made to order for NJ TRANSIT operations.

NJ TRANSIT had stored its NEC fleet, or as many trains as could fit, at Barracks Yard, about a half mile east of Trenton Station. The yard site had only four tracks, squeezed together adjacent to the high speed mainline, with minimal servicing capabilities. While the Barracks site had some expansion capacity, remaining land lay on the opposite side of the Northeast Corridor. Thus any new tracks would be split away from existing tracks by the 4-track NEC main line, a less than optimal arrangement from either train storage or yard operation perspective.

Design

Functions

The purpose of the Morrisville facility was to provide overnight storage and servicing for the electric train fleet on NJ TRANSIT's busiest route: the Northeast Corridor. NJ TRANSIT's NEC operations include 16 passenger stations spread across 58 route miles from Trenton to New York Penn Station, inclusive. NJ TRANSIT currently operates 126 daily trains on the route, and its operations are tightly interwoven with Amtrak's. Amtrak operates 90 daily trains over the same route and, more importantly, is the owner and maintainer of all fixed plant on the NEC. Therefore, NJ TRANSIT's new venture had to be carefully coordinated with Amtrak to avoid any adverse impacts on either carrier's operations.

Morrisville Yard was designed to provide the following functions to NJ TRANSIT:

- Overnight storage for up to NJ TRANSIT trains. Trainsets are composed of both electric multiple units (EMU's) and electric locomotives with push/pull trainsets.
- Daily inspection and servicing of equipment. These operations consist of interior cleaning and mopping, replenishing supplies, brake inspection and maintenance and servicing that can be done by hand tools. For heavier maintenance activities and for periodic inspections, trains are rotated into NJ TRANSIT's Meadows Yard in Harrison, NJ.
- Crew reporting and sign-in.

Morrisville Yard is being implemented in phases:

- Phase 1, which opened in March 2004, provides storage for up to 11 trains on 12 tracks. Most tracks accommodate 12 EMU's or 11 coaches plus locomotive.
- Phase 2, which begins construction this year and will open next year, will add another 12 trainsets and will include a two-track, 1200 feet long electrified Service & Inspection facility, a Wheel Truer, a new Yard Master observation tower and new crew quarters for the additional personnel required to maintain the expanded service.
- Phase 3, currently under design, will provide for a new traction power substation, taking 138 kV power from Amtrak's NEC Substation #34.

Design Issues

There were many hurdles to overcome to bring this project to fruition including complex design issues, local coordination, environmental permitting, design coordination with two other railroads and construction coordination between NJ TRANSIT and Amtrak force account and the contractor.

In many ways this project was different from a traditional NJ TRANSIT project as NJ TRANSIT's jurisdiction does not apply in Pennsylvania. This made the approval process much more onerous, putting issues such as local zoning and planning board approvals, which NJ TRANSIT historically had not dealt with in a formal manner, on the critical path. The following highlights some of the special design and scheduling challenges that the design and construction team encountered.

NEC Access and Interlocking Redesign

Existing 110 mph Operations

While the Morrisville site is very accessible to the Northeast Corridor, development of a passenger yard at the site entailed major work on the connections. Understanding the geography of the connections is necessary to understand the access issues. A schematic of the connections appears in Figure 1. NJ TRANSIT shares its route between Morrisville Yard and the NEC with Conrail freight traffic.

The normal route for westbound trains into the yard involves diverging movements through existing No. 20 turnouts on the NEC. This route needed only routine rail and tie work to be suitable for high-volume passenger operations. By contrast, providing a suitable route for eastbound trains through Morris was much more complex and required a substantial design and construction effort. The existing eastbound connection to the NEC was via a No. 20 turnout known as Switch 62, which lay on a 0.6-degree superelevated curve on NEC Track 2. In the past 30 years, as speeds increased on the NEC while freight traffic dwindled, Amtrak had increased superelevation on this curve. When Track 2 speeds through Morris Interlocking were increased to 110 mph several years ago, the curve had been superelevated to 2-1/2", resulting in an equal amount of negative elevation for freight trains diverging through Switch 62. As a result of this negative elevation, Amtrak had limited train speeds on the diverging moves over Switch 62 to 15

mph. Nearby alignment constraints such as open deck bridges, catenary structures and other crossovers limited flexibility to improve this alignment economically.

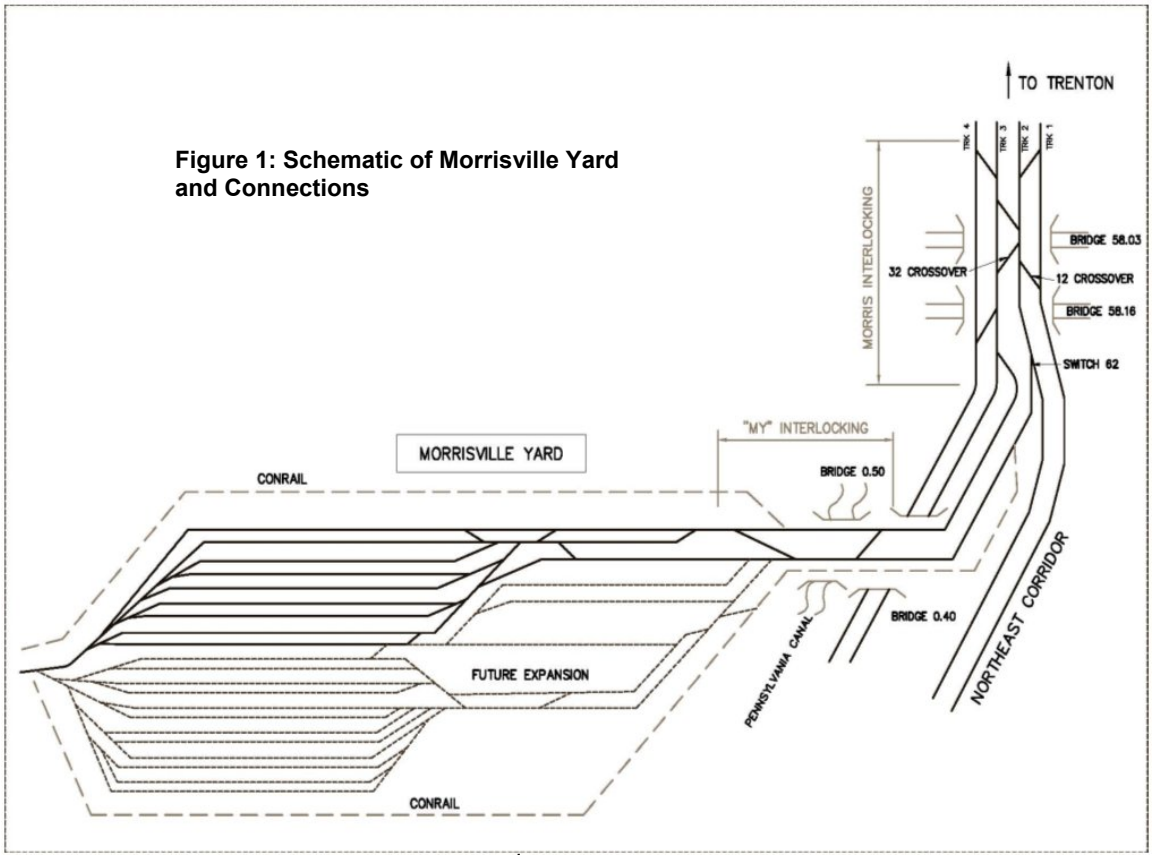

Figure 1: Schematic of Morrisville Yard and Connections

Operations Analysis and Compromise

NJ TRANSIT's transportation planners ran simulations of Morrisville Yard operating scenarios. Their analyses confirmed that retaining the existing 15 mph speed restriction on Switch 62 for trains to/from Morrisville Yard would increase interlocking clearing times to the point that it would cause significant delays to NEC traffic. Increasing speeds to 30 mph on this route became an imperative.

The resulting design involved substantial communication, compromise and coordination with Amtrak and NJ TRANSIT. A critical prerequisite to increasing speeds through Switch 62 was to reduce superelevation on Track 2 in order to reduce negative elevation through the switch. Amtrak agreed to reduce superelevation on this track to 1-3/4", even though Track 2 is a primary route for high-speed Acela Express trains. In return, Amtrak requested assistance in renewing this segment of their interlocking with tangential switches and concrete ties to improve maintainability. In addition, Amtrak requested that Track 2 be realigned to lengthen the east spiral, to improve ride quality. Reworking the east spiral required a compound curve on the 110 mph route in order fit the realigned curve to existing conditions.

Horizontal Alignment

The design team began by drafting a series of alignment alternatives and presenting them for review by NJ TRANSIT and Amtrak. Iterations continued over a few months until the entire design and review team knew this half-mile stretch of track intimately. Amtrak's reviewers were responsive and cooperative, but firm in their requirements. They were determined to squeeze in

the best possible alignment that local constraints would permit. By the time the design was completed, what started out as the realignment of a single turnout ended up as the replacement of a turnout and two crossovers, the renewal of two open deck bridges on Tracks 1 and 2 and the realignment of 4200 feet of track. The project team followed all the rules for alignment design but judiciously bent a number of them where needed. The resulting design provides a good compromise between minimizing construction cost while maintaining and improving the alignment.

The realignment and extension of the Track 2 spiral was the most challenging alignment design task. In the middle of this spiral were an open deck bridge known as Bridge 58.16 and a timber-tie No. 20 crossover, connecting Tracks 1 and 2, known as 12 Crossover,. If the spiral were lengthened to the east, the spiral would extend into 32 Crossover, another No. 20 on timber-ties, which linked Tracks 2 and 3. If the spiral were lengthened to the west, the central curve would be shifted northward into a row of catenary structures. Amtrak and NJ TRANSIT opted for extending the spiral to the east, affecting 32 Crossover, rather than replacing catenary structures under traffic.

After exploring and refining a number of options in close coordination with Amtrak and NJ TRANSIT, a horizontal alignment was agreed upon. The resulting horizontal alignments of NEC Tracks 1 and 2 through the project area are compound curves with standard clothoid spirals. The resulting spiral on Track 2 was lengthened from about 220 feet to 403 feet. In addition to replacement of switches, the realignment entailed redecking of two open-deck bridges, which is described below.

Special Turnouts

The project required replacement of a turnout and two crossovers. Although each was a custom design, the design team's objective was to incorporate as many Amtrak-standard turnout components into each turnout as possible.

Switch 62 was a standard Amtrak tangential No. 20 turnout, adapted to a 0.6 degree superelevated curve. The frog was a custom design due to the curvature on the "straight" route. In addition, the concrete tie set between the toe of frog and the last long tie beyond the frog were customized for this reason. However, the designers incorporated a standard switch and a standard concrete tie set in the section from the point of switch to the end of the closure curve at the toe of frog.

A new 12 Crossover was custom-designed for a spiral alignment on both main tracks. Since track centers are not constant through spirals, the crossover tie set (i.e. ties lying between the points of frog) had to be custom designed. In addition, a 45 mph alignment had to be provided for the crossover route to avoid a downgrade in signal indications for crossover movements. This led to the requirement for special tie sets through the switch and closure area as well. Given that track superelevation varies from 1-1/8 to ¼" through length of the crossover, the total curve underbalance for any given speed would range from the dynamic amount plus 1-1/8 inch in the west turnout in the crossover to the dynamic amount minus ¼ inch in the east turnout. Therefore, to reduce peak unbalance levels, a larger-radius closure curve was designed into the west turnout than the east turnout. Thus both turnouts, while very close to No. 20's in dimensions, deviate both from standards and from each other. Table 1 shows a comparison of the two turnouts. Even the movable point frogs are unique. As the table shows, the difference in the frog angles between the two turnouts is about 23 minutes.

Switch	Switch Centerline Radius (ft.)	Balance Elev. (in.) at 45 mph	Actual Elev.(in.)	Unbalance Elev. (in.) at 45 mph	Closure Curve Radius (ft.)	Frog Angle
Standard #20	3289.33	2.47	0	2.47	3289.33	2°-51'-51"
12 West	4614.00'	1.76	-1.13	2.89	5415.00'	2°-45'-41"

12 East	3169.70’	2.56	0.22	2.34	2830.00’	3°-08’-14”

Table 1: Comparison of 12 Crossover with Standard Amtrak No. 20 Turnouts

The resulting alignment provides for 45 mph crossover movements with 2.9 inches of unbalance in the west turnout and 2.4 inches in the east turnout. These are acceptable lateral forces for passenger trains but marginal for freights. However, an existing timetable speed restriction of 40 mph on all freight movements on the NEC provides an extra safety margin. This 5 mph reduction in maximum speed results in a maximum unbalance of 2.5 inches through the crossover, which is acceptable for freight traffic.

The final piece of customized trackwork was 32 Crossover, which connects Tracks 2 and 3. To gain every available foot of space to extend the Track 2 spiral, the designers extended the spiral all the way into the long ties of 32 Crossover. However, the design stops short of superelevating the crossover or creating a non-standard frog. Instead, a small amount of superelevation transition was incorporated into Track 2 on the crossover ties, running off from 1/8” at the westernmost long tie to zero crosslevel at the end of the frog. This required a customized tie set with raised rail seats on the north rail of Track 2. Otherwise, the new 32 Crossover has Amtrak standard geometry and details.

Superelevation and Profile

The fact that 12 Crossover linked Tracks 1 and 2 vertically created a challenge in designing superelevation and profiles. The profile and superelevation of Tracks 1 and 2 are directly related, because they must share common long ties for a distance of 45 feet through 12 Crossover. A decrease in superelevation also means a change in one track’s profile relative to the other. It became readily apparent that when one designs a crosslevel and profile that is mathematically consistent and compliant with standards on one track, the vertical connection through the long ties forces a profile into the adjacent track that must be incorporated into that track’s design. When forced to optimize for either Track 1 or Track 2, the design favored Track 2. This is because the Track 2 spiral was constrained in length by 32 Crossover, so it needed to be as uniform as possible. Track 1 had a much longer spiral, unconstrained by other trackwork, which afforded more margin for adjustment.

One additional consequence of the Track 2 realignment had to be addressed: the realignment raised the profiles of Tracks 2 and 3 at the west end of Bridge 58.03, a second open-deck structure that lies just east of 32 Switch. Thus it was necessary to retimber Bridge 58.03, with a redesigned dapping plan to raise the track by 2 inches at the west end.

Schedule

The schedule for the completion of the design and construction became paramount as Morrisville Yard was to play a key role in the expansion of NJ TRANSIT service on the NEC. The project team’s main goal was to have Morrisville Yard operational in early 2004 to support the increased demands of the newly constructed Secaucus Junction, which would add 7,500 new commuters from Northern New Jersey to the NEC. To achieve this aggressive schedule, PB and NJ TRANSIT extracted “early action” projects that could commence independently of the final design, such as the letting of material procurement contracts for long-lead items, including special trackwork, signal equipment and structural steel for catenary and bridges. Some of these packages were for the procurement of materials to be used by NJ TRANSIT and Amtrak force account, such as curved switches and dapped ties, and others for the contractor, such as catenary steel and through-girders for the bridges.

PB and NJ TRANSIT also fast-tracked the advertisement of the final bid package for the project by advertising the bid package without every project element being at the final design level. This method allowed NJ TRANSIT to receive responsive bids that expedited the start of construction. The remaining design work was completed during construction in a manner not to delay the

contractor. For example, the final design of MY and Morris Interlockings were both completed after the bid phase due to the lengthy coordination process with Amtrak and Conrail.

Reconstruction of four bridges in the project area also contributed to the project's complexities. Two of the bridges are owned and maintained by Amtrak within Morris Interlocking. Amtrak redecked its two open-deck bridges on the NEC in order to modify the horizontal and vertical alignment of its tracks. The Morrisville Yard project team prepared dapping plans for the new bridge timbers. As a result of the redecking, the track alignment was shifted by up to five inches laterally and two inches vertically to accommodate the new alignment. This small amount made the difference between a 90 mph alignment and the 110 mph alignment required by project design criteria. The design team recalculated bridge stresses to confirm that resulting eccentric loading would cause undue stresses on the bridge members.

The other two bridges included in the yard project are owned by Conrail. In order for NJ TRANSIT to develop the Morrisville Yard, it entered into an agreement with Conrail to take over the maintenance of these structures. Even though the bridges themselves were not historic, portions of the former Pennsylvania Railroad mainline corridor were identified as eligible for historic status. In addition, one of these bridges spanned the Delaware Canal, a national historic landmark. On both of these bridges, the superstructures were replaced in kind to satisfy the Pennsylvania Historic and Museum Commission's requirements so as not to significantly alter the historic viewshed. When the Bridge 0.50 over the Delaware Canal was rebuilt, all work had to be performed from track level at the top of the bridge because construction equipment was not allowed on the towpath or in the canal below.

Another challenge was the reconstruction, under traffic, of Bridge 0.40. This 240-foot-long thru-girder bridge carries three tracks over the Northeast Corridor on one a single deck at a skew angle of about 75 degrees. With freight trains using the bridge daily, taking all tracks out of service was never an option. At a minimum, one track had to remain in service at all times. The solution was a phased construction sequence that consisted of dismantling the bridge's 15 segments and replacing them, one segment at a time. Multiple temporary track connections were made to allow Conrail freight trains to cross the bridge throughout the construction. The bridge work took 14 months.

The construction of Bridge 0.40 was further complicated by the catenary for Northeast Corridor Tracks 3 and 4, which was attached to the bridge fascia girders and the underside of the deck to be replaced. The project team designed and developed a unique system of brackets that attached the catenary to the bridge abutments and center pier, which remained in place throughout the construction. These brackets allowed the bridge deck to be removed and replaced without having to move and reattach the catenary during each of the five major phases of construction to replace the thru-girders and bridge deck. This resulted in significant time savings by minimizing the need for track outages and obstructions on the NEC where Amtrak allowed very limited construction windows.

Lighting

Because train servicing in the yard is performed mainly at night, a key element of the design focused on the lighting. Traditional methods of lighting a rail yard entail the use of either of a high-mast system, with light poles up to 100 feet high, or lighting fixtures attached to the 50-foot catenary structures. High mast systems generally have shadow problems in rail yards, particularly when the yard is full of train sets. This is because the designer is trying to limit light spillover on adjacent properties and therefore the number of fixtures is minimized when trying to balance the amount of serviceable light with the inherent off-site impacts. For years NJ TRANSIT maintenance crews have not been satisfied with the amount of light in their yards, which reduces efficiency and can create safety issues.

Because a Falls Township ordinance limits light fixture heights to 25 feet, a new approach was needed; the solution was to design and construct a catenary-type lighting system consisting of

two 30-foot-high steel poles installed on either side of a track group. Steel wires are strung from the poles, with halogen light fixtures suspended over each inter-track aisle. The new system has proven so effective that NJ TRANSIT made it now its standard for any future rail yard lighting systems.

Summary

NJ TRANSIT and its design team has addressed a number of complex design issues in order to build and operate a storage yard at Morrisville, to take advantage of the site's exceptional strategic location. Operational issues on the NEC were resolved by extensive alignment iterations and judicious modification of standard turnout designs to fit the site. Schedule issues were addressed by a fast-track procurement strategy. Bridge renewal was carefully staged to maintain service at all times while avoiding impacts to historic property beneath the bridge. Innovative lighting designs put the illumination where it is needed, at trackside, while minimizing spillover onto adjacent property. Thanks to sustained coordination efforts and innovative design, NJ TRANSIT at last has a state-of-the-art facility to prepare its trainset fleet for service each day on its busiest corridor. When currently-planned expansions are completed, NJ TRANSIT expects this yard to play a pivotal role in helping the agency meet its ambitious service commitments for decades to come.