Operations Studies

APPENDIX A

A.1 Rail Network Operations Simulation of Future Build Option J1

A.2 Rail Network Operations Discrete Delay Events Option J1

A.1 RAIL NETWORK OPERATIONS SIMULATION OF FUTURE BUILD OPTION J1

Prepared for:

Metropolitan Transportation Authority – Capital Construction

Rail Network Operations Simulation of Future Build Option J1

Penn Station Access
Future Build – Option J1 Network Simulation
DRAFT Report

MTA-CC Contract No. PS864

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Gannett Fleming
Transit & Rail Systems
Excellence Delivered ***As Promised***

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REVISION HISTORY

Revision	Date	Comments
1.0	August 11, 2020	Initial Release as Draft
2.0	August 20, 2020	Revised in response to review comments

EXECUTIVE SUMMARY

This Technical Memorandum presents the results of the Penn Station Access (PSA) Year 2025 *Option J1* rail network operations simulation model. The study territory extends between Penn Station New York (PSNY)[1] and New Haven, Connecticut. In this report, quantitative results are presented for the following rail line segments:

- PSNY to the west limit of Gate Interlocking (NY Terminal or 'West of Gate');
- West limit of Gate Interlocking to CP 216 (Amtrak Hell Gate Line (HGL)) ;
- CP 216 to New Haven (Division Post); and
- Entire simulation territory including Penn Station NY-New Haven and all Metro-North (MNR) service to Grand Central Terminal (GCT).

Operationally, the three reporting segments ('West of Gate', the Hell Gate Line, and the New Haven Line) are quite different. Analyzing each separately can help the reader understand the nuances of the simulation.

The Option J1 simulation model was created and processed using Berkeley Simulation Software's Rail Traffic Controller (RTC) software. The model assumes proposed Year 2025 infrastructure conditions with the implementation of all proposed and funded capital improvements within the overall study territory as identified in the List of Assumptions (see Appendix A) in addition to the proposed PSA Option J1 improvements on the HGL.

With regard to operations, **Metro-North GCT** service levels were assumed to remain static relative to the April 2016 timetable (at the direction of MNR/MTA). **Amtrak's** proposed 2025 timetable NYP-BOS[2] was modeled and includes approximately 39% more service compared with current levels (60 train starts compared with 43[3]). **Long Island Rail Road** (LIRR) and MNR coordinated in providing a modification of LIRR's G.O. 504 operating plan (effective November, 11, 2019 to January 5,2020).

This modified operating plan identified LIRR trains to be excluded from simulation, allowing MNR PSA trains to claim those berthing slots at PSNY in simulation.

Additionally, Amtrak and New Jersey Transit equipment (deadhead) moves to and from Sunnyside Yard were included in simulation. Platform occupancy by Amtrak trains operating south of PSNY was also represented in the model.

The focus of infrastructure development for this project has been on the Hell Gate Line and on ensuring the addition of Metro-North service would not create signal delays for Amtrak. The increase in Amtrak and Metro-North service, however, has an effect on the New Haven Line as well. Lastly, the proposed increase in Amtrak trains also affects traffic into Penn Station, whereas the PSA trains are "replacing" certain existing LIRR trains in Penn Station. (The LIRR trains, in turn, will be re-routed to instead serve the new East Side Access (ESA) terminal at GCT.)

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[1] Officially, the study territory extends west to Bergen Interlocking which is west of PSNY and west of the North River Tunnels, but proposed PSA trains will not operate on the NEC main line west of 'A' Interlocking which is within PSNY. Hence for informal ease of reference the Study Territory extends between Penn Station New York and New Haven, Connecticut (Division Post).

[2] NY Penn to Boston.

[3] The odd number '43' is because there is one additional train in the 2016 Friday-only Amtrak train schedule.

The model was simulated in a "deterministic" manner. Deterministic simulation means that no external terminal delay nor dwell time variability is introduced into the simulation model. An example of variability would be minor differences in terminal start or station platform dwell times that might occur due to weather or a stuck door, both of which can and do happen from day-to-day and from train-to-train in reality, even when operations are normal. The simulation was reviewed to verify that it was operating all trains in "timetable order" as closely as possible according to their actual timetabled departure times and normal or nominal routings.

The simulation results show that LIRR and Amtrak trains operated at 100% on-time performance (OTP) at the standard reporting threshold of 6 minutes late. Existing Metro-North trains operated very close to 100%. Table 1 provides simulation results for the entire simulation network.

Table 1 – Deterministic Results – Option J1 – Entire Network – 24 hours

Operator & Service	No. of Trains	Avg. Speed w/ Dwell (mph)	Delay (min/100 train-miles)	OTP (3m)	OTP (6m)	No. of Late Trains (>3m)	No. of Late Trains (>6m)
Amtrak Acela	28	41.7	1.0	100.0%	100.0%	0	0
Amtrak Regional (1)	46	36.9	3.4	100.0%	100.0%	0	0
MNR PSA	101	34.1	8.1	100.0%	100.0%	0	0
MNR GCT	556	33.2	4.5	98.7%	100.0%	7	0
MNR Diesel	135	38.1	2.6	98.5%	99.3%	2	1
Overall Amtrak & MNR	**866**	**34.9**	**4.1**	**99.0%**	**99.9%**	**9**	**1**
LIRR (2)	518	34.1	10.1	95.9%	100.0%	21	0

Note 1: Includes Springfield Line trains in simulation. Springfield-Hartford-NHV shuttles not included in OTP calculation.
Note 2: LIRR G.O. 504 includes deadhead trains.

While OTP metrics are important to consider, schedule recovery time[4] can mask delays that trains may incur along their routes. Therefore, it is at least equally important to evaluate signal delays that trains may incur. Signal delay represents the interaction of the trains with each other via the signal system as opposing-direction trains encounter conflicts at junctions such as New Rochelle and as faster trains begin to encroach on the signal 'wake' of a slower same-direction train ahead on the same track or route.

It must be emphasized that signal delay is not the same as lateness. Signal delay is independent of on-time performance. Therefore, signal delay is a useful measure of relative congestion on a rail line or segment thereof. Trains that encounter signal delay are not necessarily late and have not necessarily stopped. Lateness is measured against the timetable (train schedule) as written. A train that does not encounter any signal delay could still be "late" if its scheduled running time is insufficient, and a train that encounters signal delay could still arrive at its destination on time according to its schedule.

Table 2 provides a comparison of signal delay for each of the segments of the study territory. The NY Terminal ('West of Gate') segment recorded the most delay in total due to the density of trains within, entering, and departing the Terminal. New Haven Line trains incurred the least amount of

[4] Schedule recovery time is built into a timetable to allow trains to potentially recover time lost to delay along their route.

signal delay, indicating that the infrastructure is sufficient, and the operating plans are well coordinated.

On the HGL, PSA trains hold for Amtrak trains when merging from three/four-track territory to two-track territory on the line, contributing to incurred PSA signal delay. Amtrak trains incur delay while physically still on the HGL due to signal delay encountered merging onto the New Haven Line[5] at CP-216 and due to train scheduling where Amtrak trains follow in the wake of PSA trains onto the HGL at Gate and an overtake was not intended by the timetabling. Most of these minor delays could be remediated by making small modifications to Amtrak or PSA train schedules. This is a normal step in the timetable development process.

Table 2 – Option J1 Deterministic Simulation – Delay Comparison

Operator & Service	West of Gate		Hell Gate		NHL	
	No. of Trains	Delay Min/100 train-miles	No. of Trains	Delay Min/100 train-miles	No. of Trains	Delay Min/100 train-miles
Amtrak Acela	28	6.6	28	3.7	28	0.5
Amtrak Regional	32	18.5	32	5.5	46	1.4
MNR PSA	101	14.7	101	2.5	101	2.9
MNR GCT	0	-	0	-	252	1.3
MNR Diesel	0	-	0	-	45	2.7
LIRR	518	10.1	0	-	0	-

With the exception of the NY Terminal territory west of ‘Gate’ where higher aggregated signal delay is expected for reasons already discussed, signal delay in simulation was low to very low. This indicates that the relative incidence of train conflicts is low and individual delays are typically very minor. Note that a train that incurs delay in simulation was not necessarily stopped, although it might have been. ‘Delay’ is incurred whenever a train is operating on a cab signal indication that is less favorable than it could have received via the same route in the same direction if no other traffic has been in conflict with it, whether that traffic was operating in the same direction or in the opposite direction.

[5] Stop delay incurred by eastbound HGL trains at CP 216 has been reported as NH Line delay.

1. METHODOLOGY AND ASSUMPTIONS

A. General

Table 10 in the Appendix lists key assumptions pertaining to the Option J1 simulation model and analysis. Importantly, it does not attempt to repeat the extensive and detailed information concerning source data/documents and technical direction that is common to all of the rail operations simulations developed for the PSA Project to date. A complete list of source data can be found in Table 11 of the Appendix.

B. Software and Infrastructure

The Option J1 model was processed using Version 74K of Rail Traffic Controller (RTC) software dated March 20, 2019. RTC is licensed by Berkeley Simulation Software based in California.

Below is a list of assumptions regarding infrastructure:

- Year 2025 conditions were assumed, with the implementation of all proposed and funded capital improvements within the overall study territory (independent of the PSA project);

- Implementation of Option J1 infrastructure improvements on the HGL, including an upgraded Automatic Train Control/Cab Signal (ATC/CS) signal system.

The geographic limits of the physical territory emulated by all of the network simulation models developed by Gannett Fleming to support this study are as follows:

- Grand Central Terminal Upper and Lower levels from Mile Post 0 to CP 1
- Hudson Line from CP 1 to Poughkeepsie
- Harlem Line from CP 5 to Wassaic
- New Haven Line from CP 112 to Division Post at New Haven, including State Street Station
    - New Canaan Branch from CP 234 to New Canaan
    - Danbury Branch from CP 241 to Danbury
    - Waterbury Branch from CP 261 to Waterbury
- Amtrak's HGL from CP-216 (New Rochelle) on the New Haven Line to Harold Interlocking[6] and the remaining territory from Harold Interlocking to and including Penn Station New York.

[6] The configuration of Harold Interlocking was updated to reflect the final configuration (under construction) that includes the proposed LIRR "East Side Access" connection to Grand Central Terminal (scheduled to open in 2022) as well as the "Eastbound Reroute" and "Westbound Bypass" paths utilized by all Amtrak and most PSA trains in simulation. That portion of the simulation model infrastructure database was furnished by Amtrak.

The models also include a short section of LIRR territory east of Harold Interlocking on LIRR's Main Line (ending near LIRR Mile Post 5.6 approximately 2 miles east of Woodside Station) and a short portion of the Port Washington Branch (to just east of Shea Stadium Station near MP 7.8). These territories were included so that LIRR trains would exhibit operational stability when entering and leaving the simulation and to understand the impact those trains would have on the operation of MNR and Amtrak service to and from the HGL and visa-versa

Figure 1 and Figure 2 show the existing configuration of the HGL and the proposed Option J1 configuration that was modeled for this analysis, respectively. The Option J1 design also includes implementation of multi-tiered Amtrak Type A, B, and C maximum civil speeds and speed restrictions.

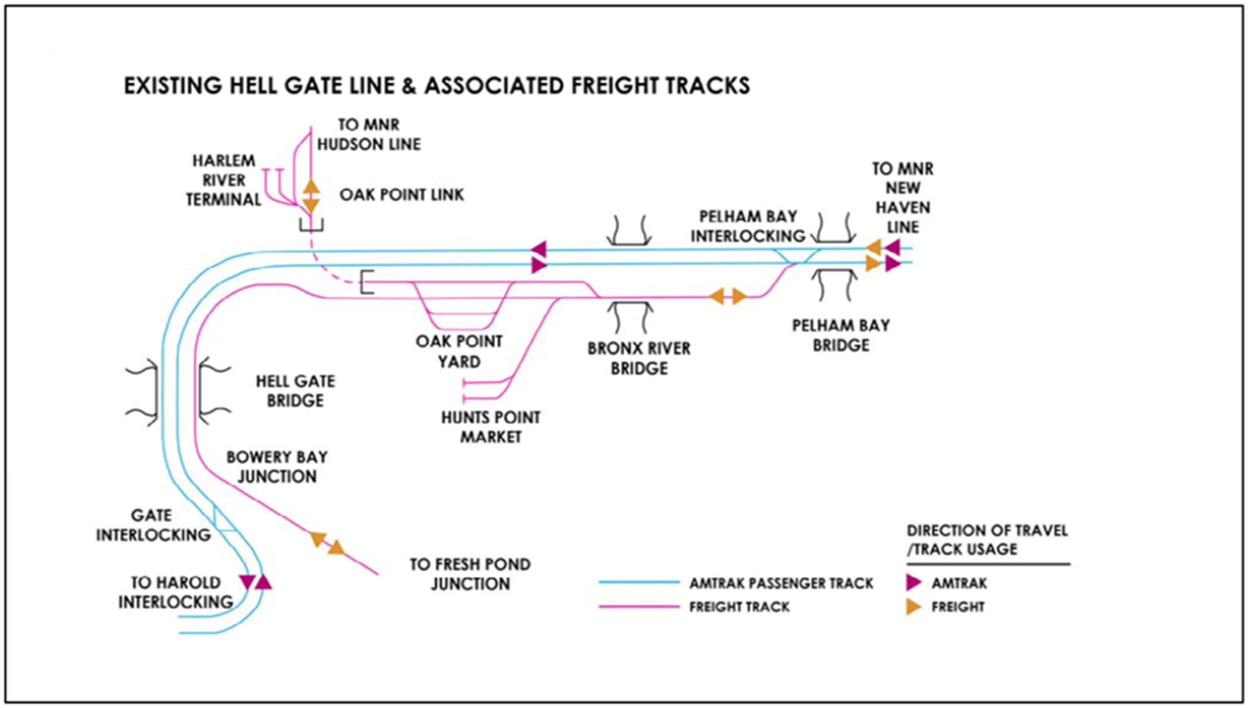

Figure 1 – Schematic configuration of existing HGL and adjacent freight-only tracks.

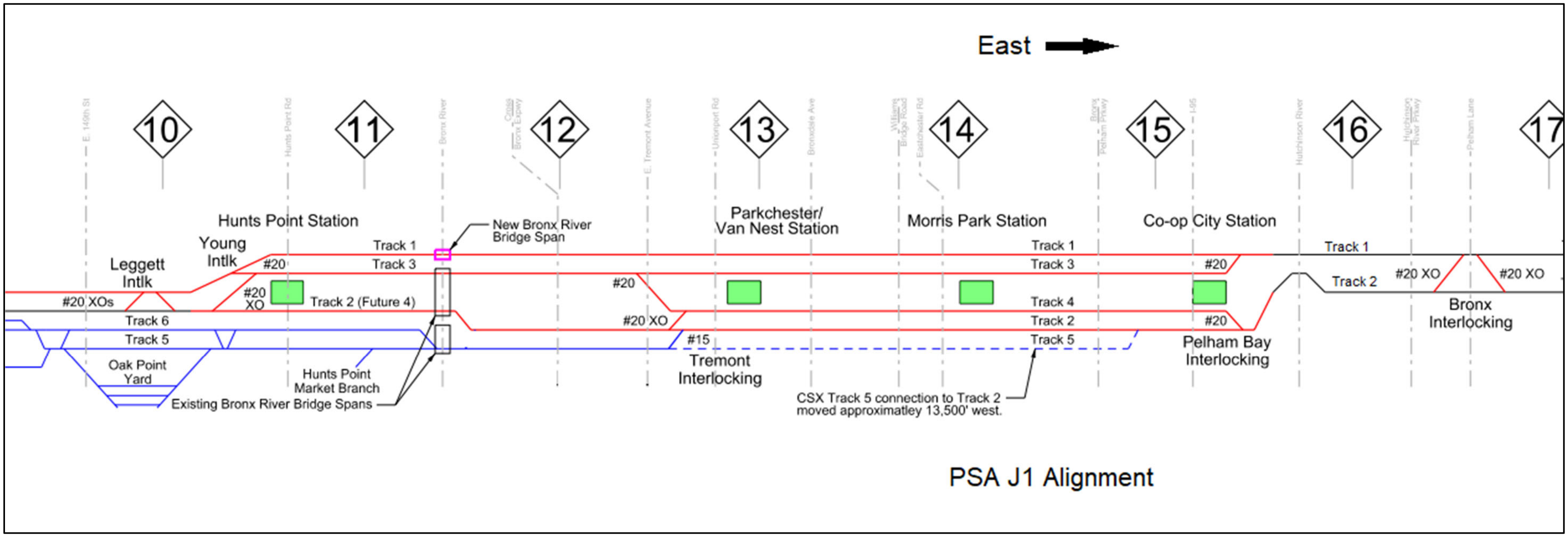

Figure 2 – PSA Option J1 Track Configuration Schematic

Metro-North provided an update to the configuration at CP215, which is reflected in the model and can be seen below in Figure 3. The updated configuration includes a new crossover from Track 4 to Track 2 east of the existing one (crossover noted in image). The new crossover will allow parallel moves from Track 4 to Track 2 and from Track 2 to Track 1. It was not necessary to use this type of parallel move in the deterministic Option J1 simulation. However, this does not mean that it is not necessary or would not be useful if operations are delayed or disrupted. Verification will require randomized or discrete delay event simulation.

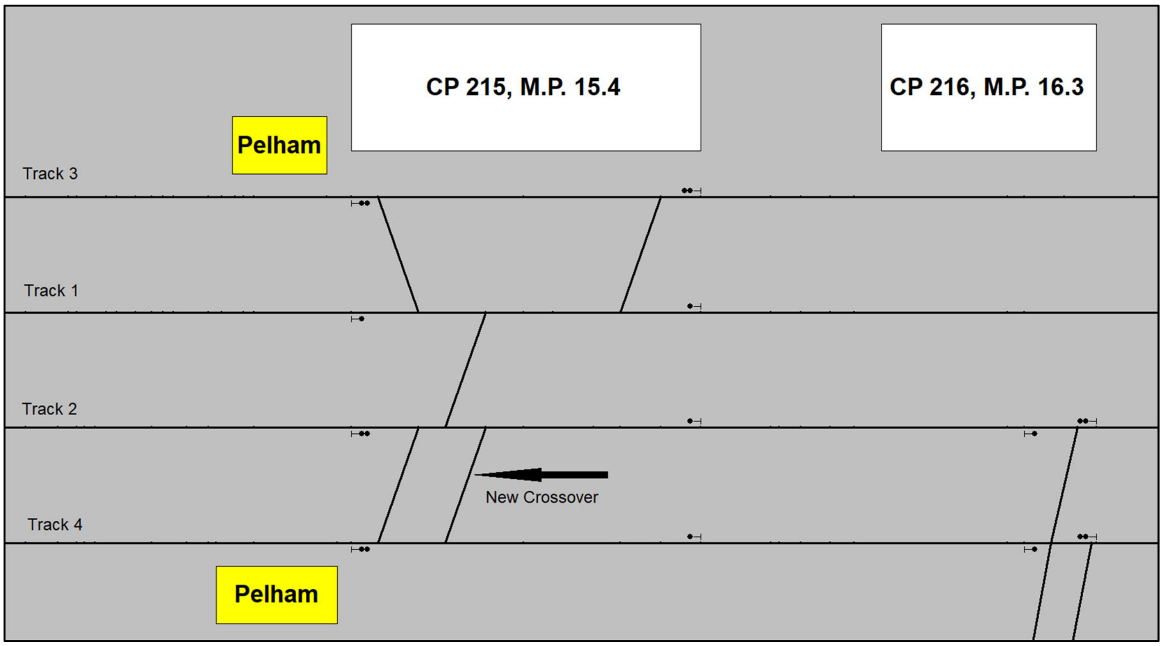

Figure 3 – Updated Configuration of CP 215

Metro-North also provided an updated conceptual track design for proposed New Rochelle Yard having a capacity of six trainsets. The yard is fully subscribed with PSA trains overnight in simulation and is otherwise (generally) not occupied by more than three trains concurrently during the day. Figure 4 provides an image of the yard occupancy at 6:13 PM in simulation.

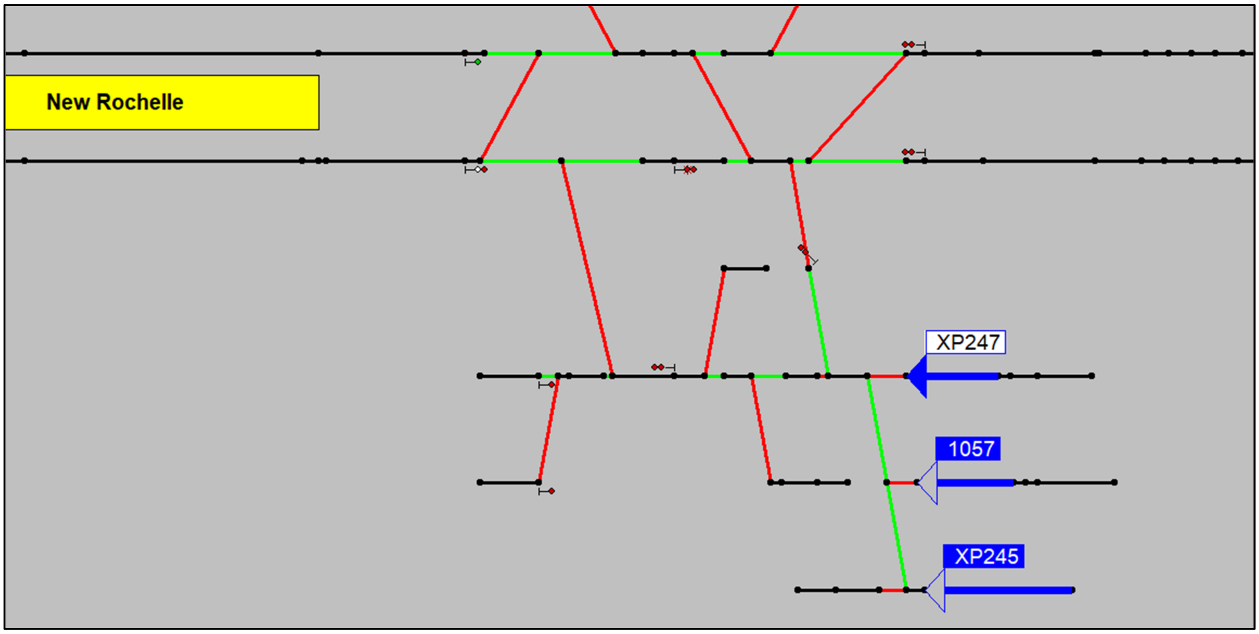

Figure 4 – New Rochelle Yard in RTC Simulation – 1813h (6:13 PM)

Figure 5 presents the overall Option J1 simulation model network schematic as depicted in RTC. The main lines and branches are labeled for clarity, along with Grand Central Terminal and Penn Station New York. The HGL is shown in orange near the center of the image. Figure 6 shows a more detailed image of the HGL as modeled in RTC.

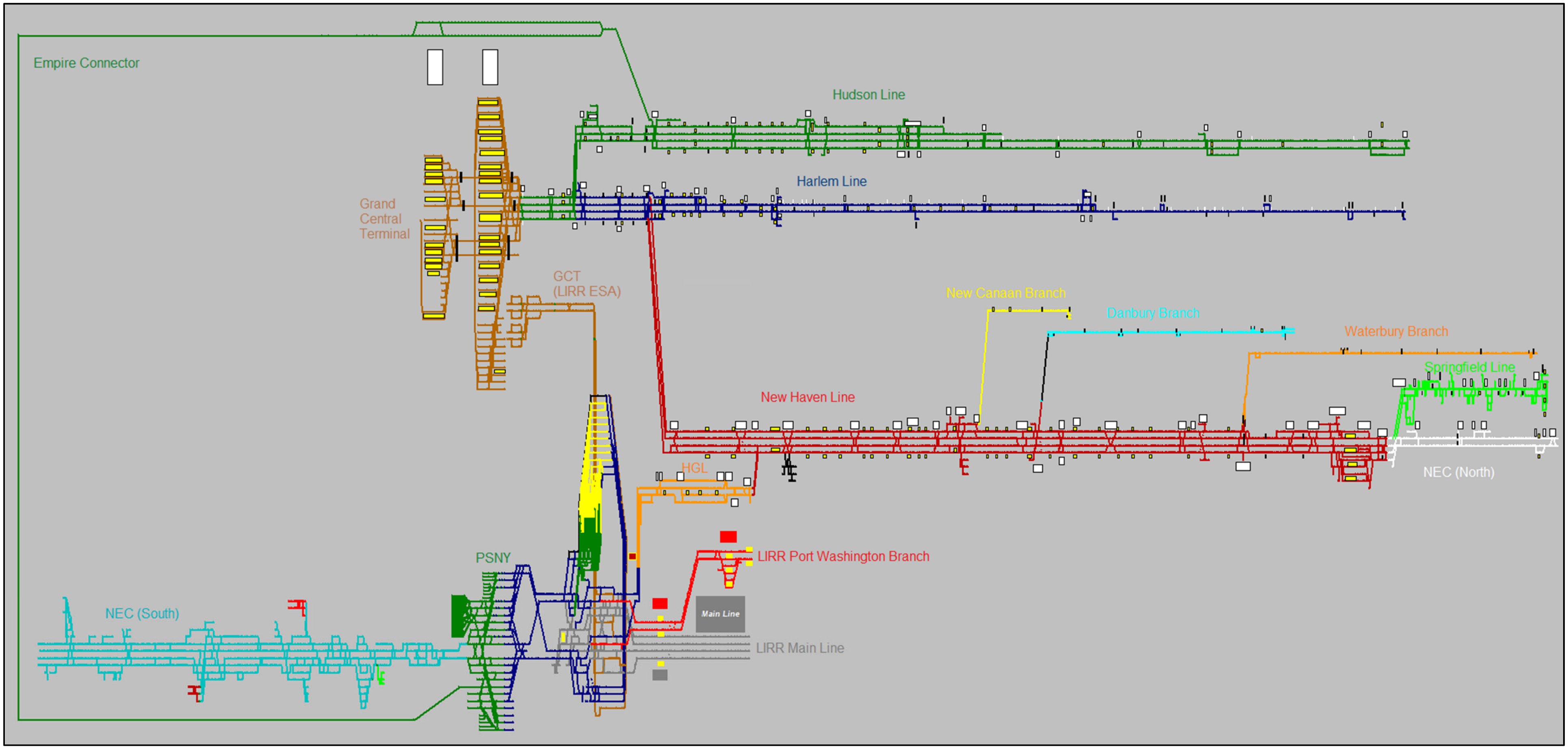

Figure 5 – Overall 2025 Option J1 RTC Network Schematic

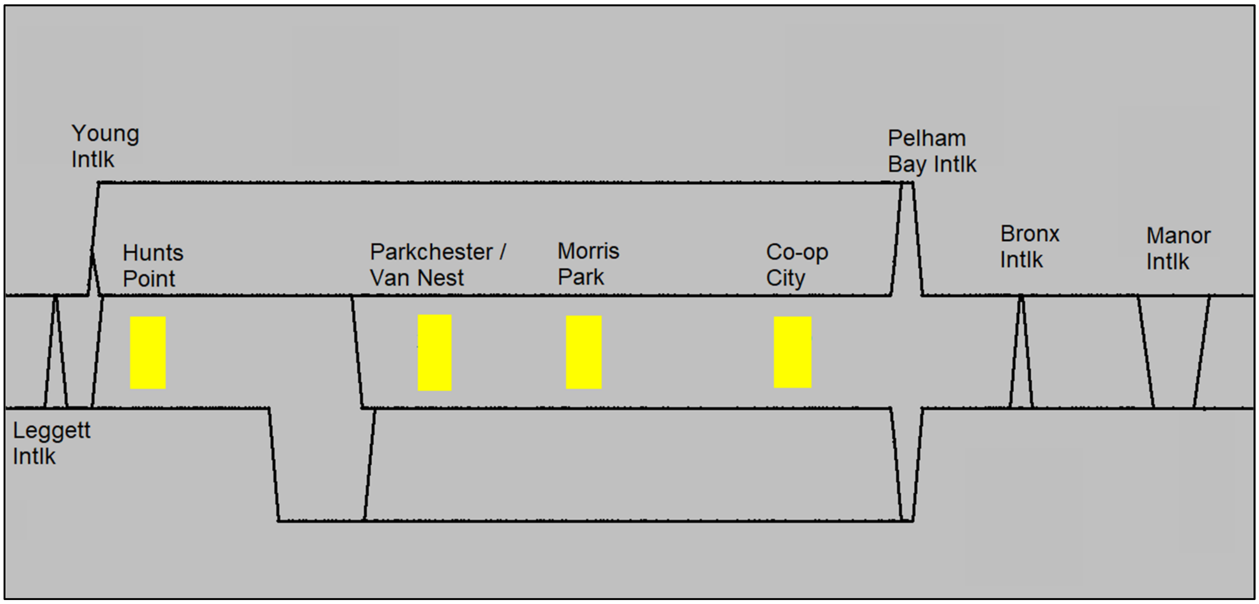

Figure 6 – Proposed Hell Gate Line Configuration as Modeled in RTC

C. Signal Block Layout

In 2014, Gannett Fleming Transit & Rail Systems (GFT&RS) developed a higher-capacity conceptual block plan and signal control line design for the HGL that was compatible with Amtrak's existing dual-frequency, 9-aspect cab signal system.

In May 2020, the conceptual design was progressed with block boundaries optimized to the requirements of the Option J1 track configuration. Block boundaries were repositioned in the Option J1 model to reflect the May 2020 design.

D. Operations

The RTC simulation model includes the following train services/operations:

- *Metro-North GCT Service*- Metro-North agreed that the timetable from April 2016 adequately represents projected GCT service for year 2025 as only minor adjustments are anticipated, which does not justify updating the timetabling of these trains and thereby rendering comparison with the Base Case and the Future No-Build dubious. The model includes all Metro-North service to GCT, including the New Haven branch lines (New Canaan, Danbury, and Waterbury).

- *Metro-North PSA Service*- The proposed MNR service to Penn Station includes 101 revenue trains to/from New Rochelle and Stamford and 7 deadhead (DH) trains operating among those locations to support that service.

- *Amtrak* Service- The proposed Year 2025 timetable for Amtrak between PSNY and New Haven/Springfield/Boston is emulated in the simulation model. Additionally, Amtrak non-revenue equipment positioning operations to/from Sunnyside Yard (SSYD) are included, as are Amtrak trains operating south of PSNY that turn at the PSNY platforms. Amtrak DH movements were developed using the proposed 2025 Amtrak Weekday Service Plan, guidance from Metro-North and Amtrak and referencing the New York Penn (NYP) Dwell Standards provided by Metro-North to make a reasonable assessment as to whether trains were turning at NYP or were terminating or originating as DH moves to SSYD. It was assumed that all Empire Corridor trains originate or terminate at SSYD.

- *LIRR Service*[7]- The model was updated with LIRR-provided documentation for G.O.504 train operations. Timings were provided at PSNY, Woodside, Forest Hills, and Kew Gardens. Metro-North and LIRR coordinated to determine which LIRR trains would be replaced by PSA trains at PSNY and those LIRR trains were excluded from the model.

- *NJT Service*- Deadhead (DH) service between PSNY and SSYD was modeled per the PSNY Capacity Study "Option 6" timetable. Timings to/from SSYD were modified based on TIMACS data received from Metro-North (X1-X2 7MAY17 BB200526.xlsx).

The simulation emulates a 24-hour non-holiday Friday. The selection of "Friday" was intentional because it is normally the most challenging operating day of the week for Metro-North.

[7] Because of the volume of LIRR trains, trains that are arriving or departing West Side Yard (WSY) were not separated into revenue and DH components in simulation. Therefore, delays associated with travel to/from the WSY will be reported in the statistics for the "Entire Network". Results for the 'West of Gate' territory exclude the WSY and so result in a more accurate reporting of delay for LIRR trains.

2. DETERMINISTIC SIMULATION RESULTS AND FINDINGS

This section details the results and findings of the deterministic Option J1 simulation analysis already described. No randomized simulations have been performed to date using the Option J1 operations simulation model.

The "Deterministic Results" tables for the four territories presented in this report provide the key quantitative results for the Option J1 simulation. The tables include:

- The number of Metro-North, Amtrak and LIRR (where applicable) trains simulated;
- Average speed of the trains as a group, taking station dwell time into account;
- Delay per 100 train-miles (signal delay pro-rated by 100 miles for ease of comparison);
- The On-Time Performance (OTP) at terminals and stations served by both MNR and Amtrak trains;
- Number of late trains as measured at terminals and stations served by both MNR and Amtrak trains.

OTP was measured at 3-minutes late and at 6-minutes late. Metro-North requested the 3-minute threshold because it is a finer diagnostic screen than the standard 6-minute threshold and is therefore more likely to reveal nuances in operating performance and reliability in simulation.

Overall signal delay is represented as "delay per 100 Train-miles", which is the signal delay prorated by 100 miles. (e.g. If a train traveled 50 miles and incurred two minutes of delay, it would accrue 4 minutes of delay per 100 train-miles).

A. Option J1 Results – Entire Simulation Territory

The metrics in Table 3 below pertain to the entire study territory. This includes all of Metro-North territory plus the Hell Gate Line to PSNY and a small section of the LIRR Main Line and Port Washington Branch (reference Figure 5 – *Overall 2025 Option J1 RTC Network Schematic*).

Presentation that focuses solely on the individual segments (territory west of Gate; the Hell Gate Line; and the New Haven Line) can be found below in sections 2.B, 2.C, and 2.D.

Table 3 – Deterministic Results – Option J1 – Entire Network – 24 hours

Operator & Service	No. of Trains	Avg. Speed w/ Dwell (mph)	Delay (min/100 train-miles)	OTP (3m)	OTP (6m)	No. of Late Trains (>3m)	No. of Late Trains (>6m)
Amtrak Acela	28	41.7	1.0	100.0%	100.0%	0	0
Amtrak Regional [1]	46	36.9	3.4	100.0%	100.0%	0	0
MNR PSA	101	34.1	8.1	100.0%	100.0%	0	0
MNR GCT	556	33.2	4.5	98.7%	100.0%	7	0
MNR Diesel	135	38.1	2.6	98.5%	99.3%	2	1
Overall Amtrak & MNR	**866**	**34.9**	**4.1**	**99.0%**	**99.9%**	**9**	**1**
LIRR [2]	518	34.1	10.1	95.9%	100.0%	21	0

Note 1: Includes Springfield Line trains in simulation. Springfield-Hartford-NHV shuttles not included in OTP calculation.
Note 2: LIRR G.O. 504 operations include deadhead trains.

The deterministic simulation of Option J1 operates at 99% OTP at a demanding threshold of three minutes “late”. These results are indicative of a well-designed and smooth-running operation overall. However, a closer look at the West of Gate, Hell Gate Line, and New Haven Line territory results will help to understand the nuances of the simulation.

B. Option J1 Results – ‘West of Gate’ (NY Terminal)

Figure 7 shows an image of the NY Terminal territory and Table 4 presents the deterministic simulation results of the Option J1 simulation for the territory west of Gate Interlocking into PSNY plus a section of the LIRR Main Line and Port Washington Branch.

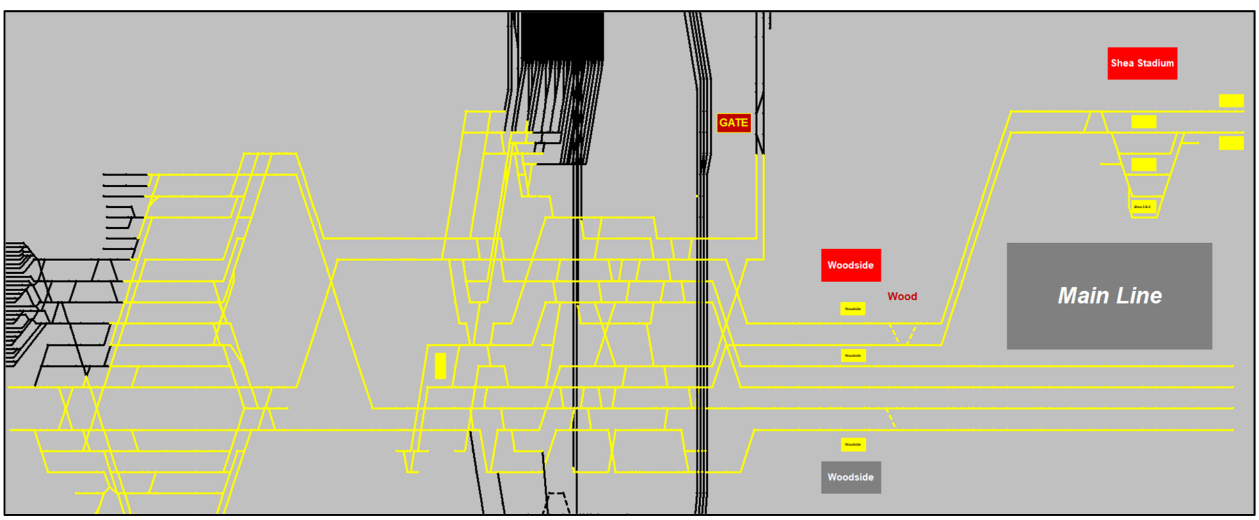

Figure 7 – Simulation Model Territory ‘West of Gate’ (NY Terminal)

Table 4 – Deterministic Results – Option J1 – 'West of Gate' – 24 hours

Operator & Service	No. of Trains	Avg. Speed w/o Dwell (mph)	Delay (min/100 train-miles)	OTP (3m)	OTP (6m)	No. of Late Trains (>3m)	No. of Late Trains (>6m)
Amtrak Acela	28	36.2	6.6	100.0%	100.0%	0	0
Amtrak Regional	32	33.6	18.5	100.0%	100.0%	0	0
MNR PSA	101	31.7	14.7	100.0%	100.0%	0	0
LIRR (1)	518	34.1	10.1	95.9%	100.0%	21	0
NJT Deadhead (2)	98	-	-	-	-		
Amtrak Deadhead (2)	110	-	-	-	-		

Note 1: LIRR G.O. 504 operations include deadhead trains.
Note 2: Running times between PSNY and SSYD for simulation coding were based on typical peak and off-peak scheduled running times furnished by Amtrak via MNR for the study.

Most notable in the results for this segment is that the delay (in minutes per 100 train miles) is greater in this territory when compared to Table 3, which shows the entire network. This is expected, given the concentration of trains operating in Penn Station. Schedule recovery time included as an element of timetable development by the various service operators allows the trains to be "on time" despite encountering minor delay at Penn Station.

Table 4 shows the number of DH trains operating in the New York Terminal in simulation. There are no statistics shown for the DH trains because statistics are not commonly reported for DH train movements. It was observed in simulation, however, that all of the non-revenue (DH) trains operated in such a manner that they arrived at the NYP platform in time for their revenue service 'turn' to depart on time. Signal delay incurred by revenue trains caused by interaction with DH trains in simulation is reflected in Table 4.

Figure 8 and Figure 9 show simulation screen images of the NY Terminal area at 9:47 AM and 3:32 PM respectively. The trains in these images are colored by train type so it is easy to recognize the DH trains interacting with revenue trains in the NY Terminal area. Figure 10 shows a sample Track Occupancy Chart (TOC) of Penn Station, also color coded by train type for ease in identifying DH trains.

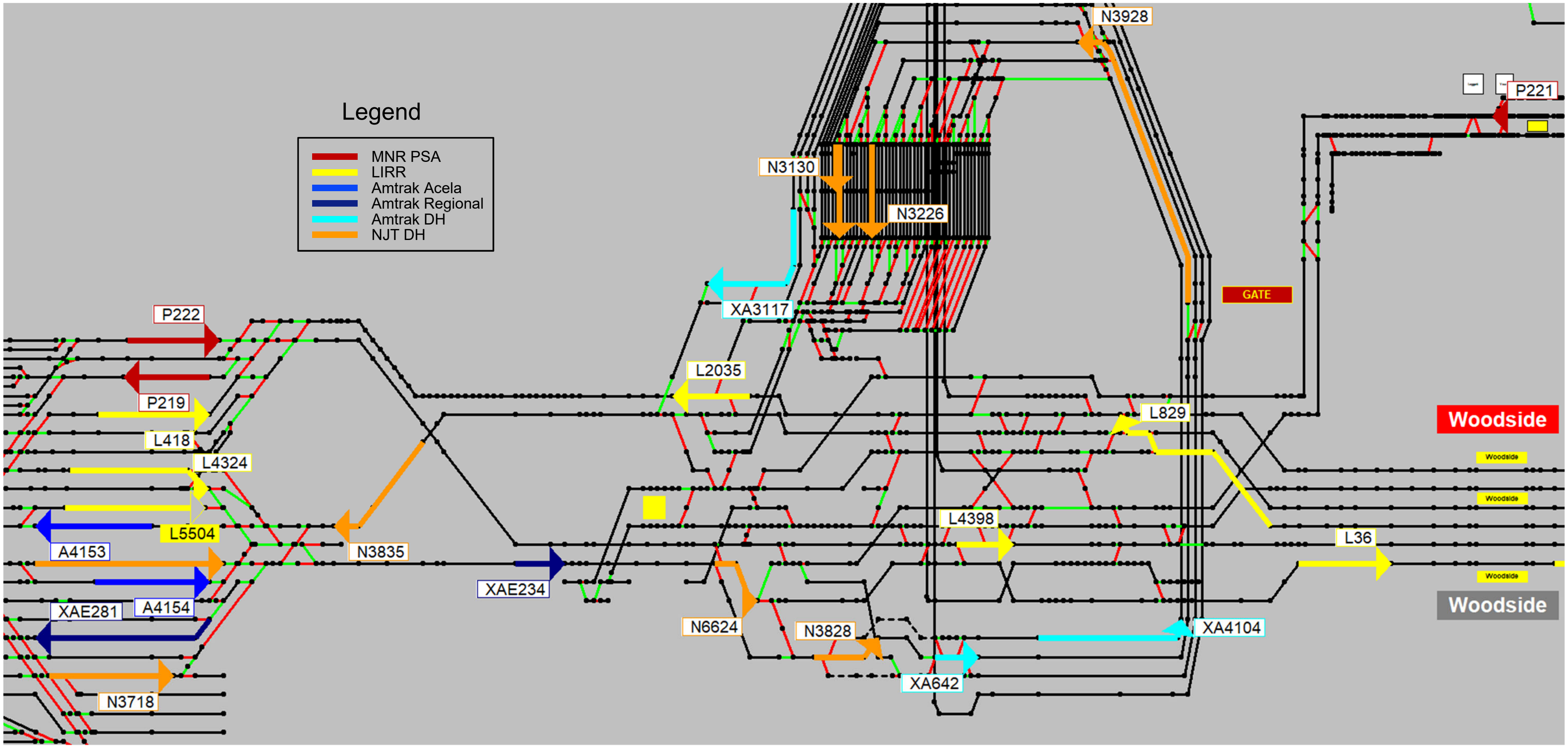

Figure 8 – NY Terminal in RTC Simulation – 0947h (9:47 AM)

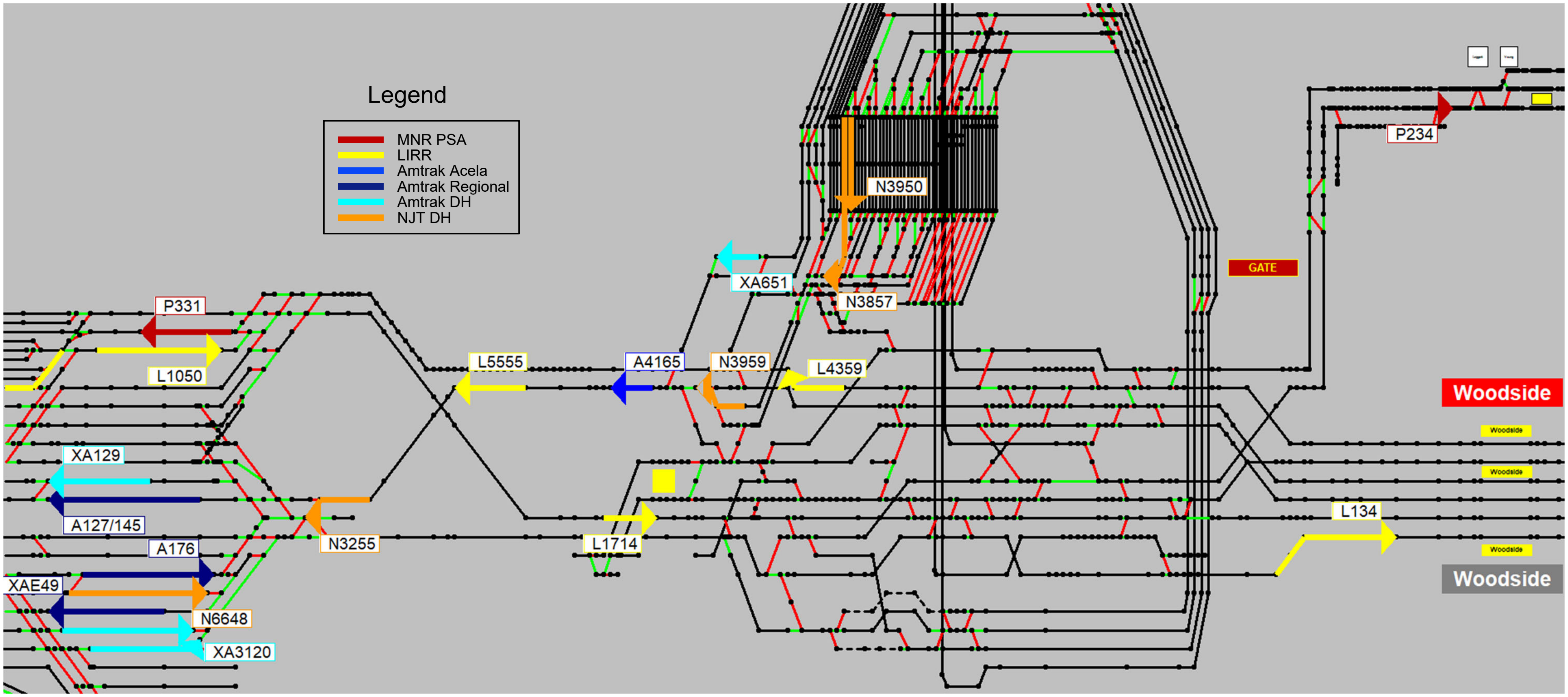

Figure 9 – NY Terminal in RTC Simulation – 1532h (3:32 PM)

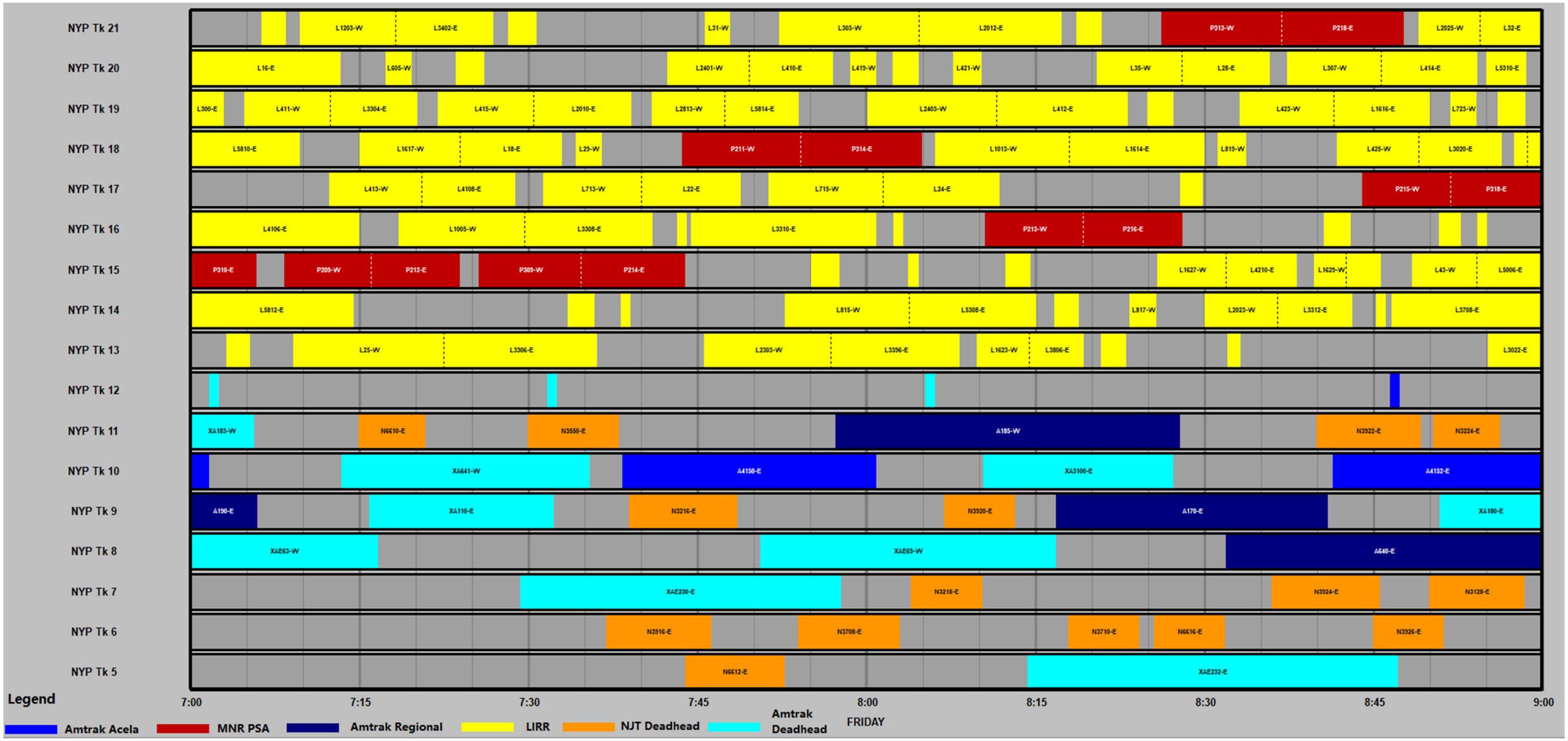

Figure 10 – Example PSNY Track Occupancy Chart (TOC) 7:00 AM to 9:00 AM

C. *Option J1 Results – Hell Gate Line*

Table 5 provides the results of the Option J1 simulation with a focus on the Hell Gate Line only. On-time performance was not measured on the Hell Gate Line because OTP is only measured at terminal stations and at stations jointly served by both MNR and Amtrak trains.

Table 5 – Deterministic Results – Option J1 – Hell Gate Line – 24 hours

Operator & Service	No. of Trains	Avg. Speed w/ Dwell (mph)	Delay (min/100 train-miles)	OTP (3m)	OTP (6m)	No. of Late Trains (>3m)	No. of Late Trains (>6m)
Amtrak Acela	28	64.0	3.7	-	-	-	-
Amtrak Regional	32	56.9	5.5	-	-	-	-
MNR PSA	101	40.7	2.5	-	-	-	-
Overall Amtrak & MNR	**161**	**46.3**	**3.3**	**-**	**-**	**-**	**-**

From observing the simulation, it was noted that delay was accrued by Amtrak trains operating on the HGL in the eastbound direction as they prepared to merge onto the New Haven Line at CP 216 and received a cab signal downgrade.[8] These delays are included in Table 5 because it would be difficult to "tease" them out of the delay statistics. However, three Amtrak Regional trains were stopped at CP 216 while preparing to merge onto the New Haven Line. Because the "stop delay" could be quantified, it was attributed to the New Haven Line (and not to the HGL). Table 6 identifies those trains and the stop delay attributed to the New Haven Line.

Table 6 – Amtrak Regional Trains Delayed at CP216 on HGL

Train ID [9]	Stop Delay (m:ss)
A136	0:16
A140	2:00
A174	1:29
Total Stop Delay	3:45

Eastbound Amtrak trains were also observed in simulation to incur delay (cab signal downgrade) while following PSA trains at Gate Interlocking or after a PSA train stopped at Hunts Point. In one instance, an eastbound Amtrak Regional train received a signal downgrade following in the "wake" of an Acela train. This type of "following move" delay is the final contributor to the relatively minor Amtrak delay seen in Table 5.

For reference, Figure 11 shows the limits of the HGL territory in simulation (shown in yellow).

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[8] A cab signal downgrade occurs when a cab signal aspect displayed to the locomotive engineer (operator) in the locomotive or the train's control cabin (as applicable) has changed from the most favorable aspect available on that track at that location in that direction of travel over the particular route that the train is or will be traversing to an aspect that requires the operator to reduce speed whereas the operator would not otherwise have needed to take that action.

[9] No PSA trains in simulation accrued any stop delay at CP 216 while merging onto the New Haven Line.

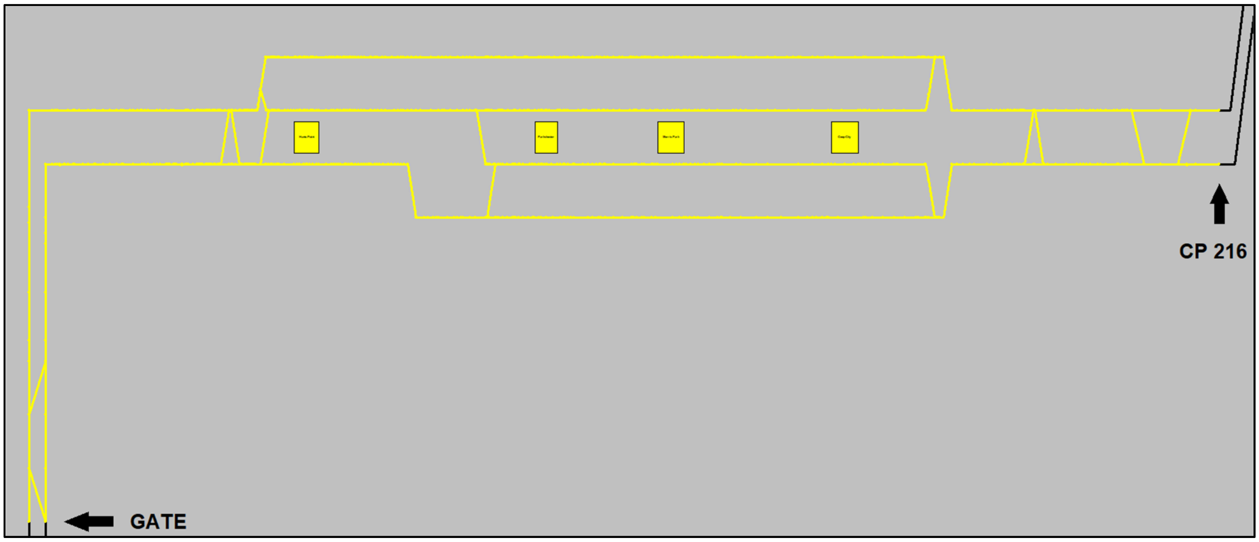

Figure 11 – Hell Gate Line Limits

Operationally, it is understood that Amtrak trains will have priority over PSA trains on the HGL. Therefore, PSA trains were held for same-direction Amtrak trains in simulation when merging from three and four-track territory onto two-track territory in simulation if the overtaking Amtrak train was already in the vicinity and the timetabling implied that an overtake is intended.

Time/distance "string" charts are useful tools for visualizing train operations. Figure 12 below shows an example of an HGL string chart. This string chart presents the HGL territory from 8:00 AM to 12:00 noon. The string chart is annotated to show an overtake at the east end of the HGL where PSA Train P324 is held so that Amtrak Acela train A4156 can overtake it. The solid black arrow indicates the point where train P324 holds for the overtake. Figure 13 shows the same overtake as it would be seen in simulation.

Figure 17 through Figure 22 in the Appendix provide 24 hours' worth of string charts for the Hell Gate Line. The string charts are split into six sheets displaying four hours per sheet. Figure 23 though Figure 28 are the same string charts color-coded by track number. It was noted by observation of the simulation and review of the string charts that no more than five trains were operating on the HGL simultaneously at any given time during simulation.

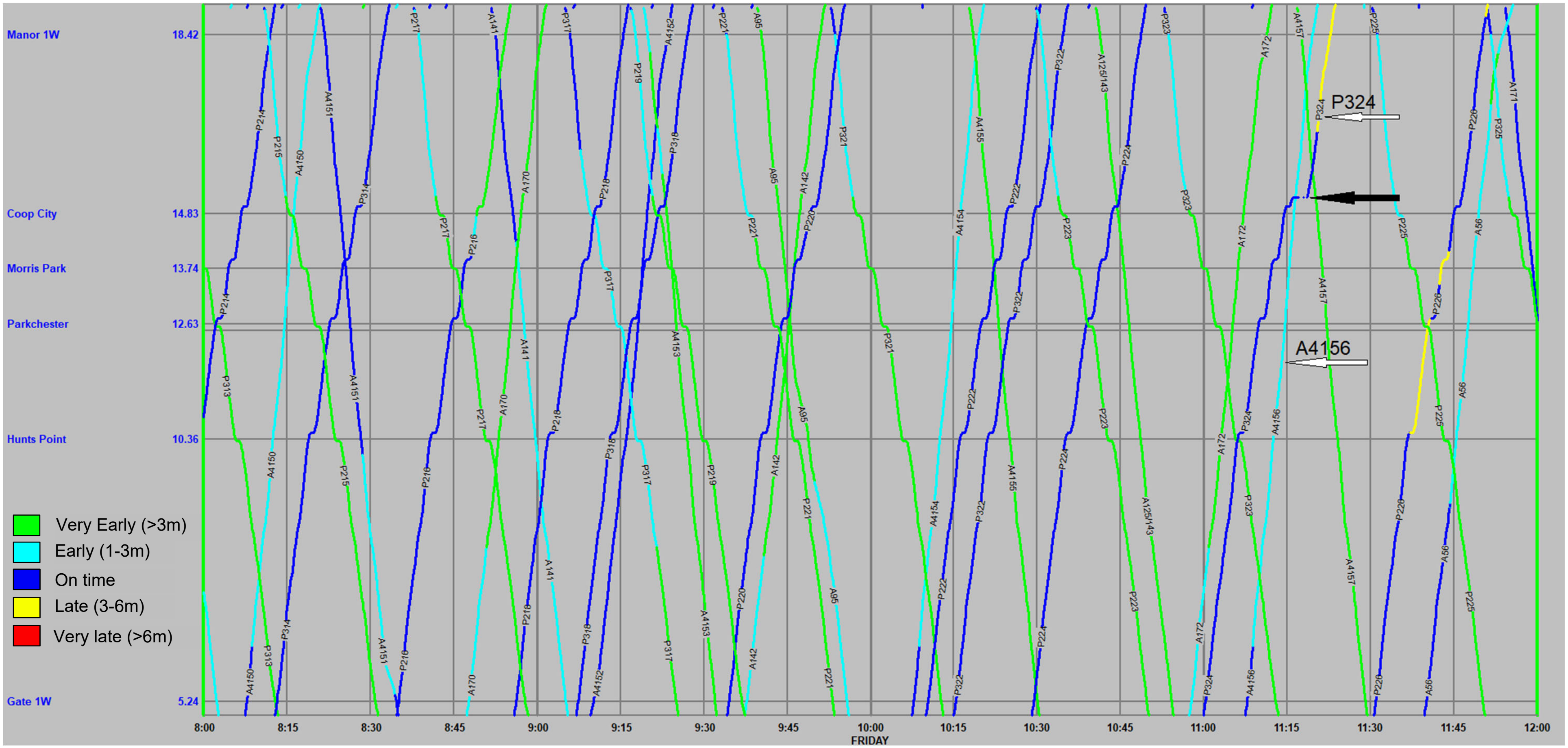

Figure 12 – HGL String Chart – Example of PSA Train Held for Overtaking Amtrak Train

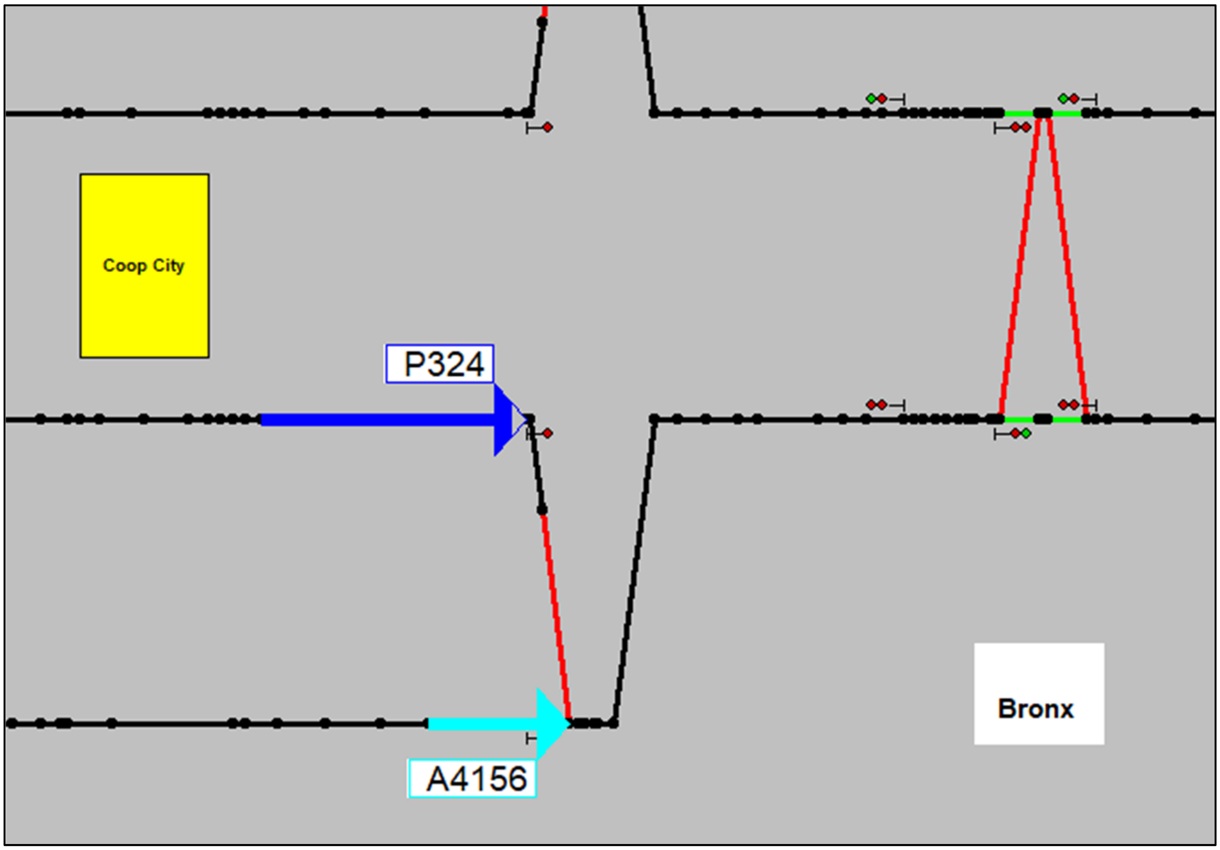

Figure 13 – Simulation Image of PSA Train P324 Held for Amtrak Acela 4156 Overtake

D. Option J1 Results – New Haven Line

This section presents the Option J1 analysis results with a focus on the New Haven Line. Table 7 shows the 24-hour simulation results for the New Haven Line only. OTP on the New Haven Line is very good, and the overall indication from this table is that operations are running smoothly.

Table 7 – Deterministic Results – Option J1 – New Haven Line – 24 hours

Operator & Service	No. of Trains	Avg. Speed w/ Dwell (mph)	Delay (min/100 train-miles)	OTP (3m)	OTP (6m)	No. of Late Trains (>3m)	No. of Late Trains (>6m)
Amtrak Acela	28	48.8	0.5	100.0%	100.0%	0	0
Amtrak Regional (1)	46	44.5	1.4	100.0%	100.0%	0	0
MNR PSA	101	29.3	2.9	100.0%	100.0%	0	0
MNR GCT	252	36.2	1.3	97.2%	100.0%	7	0
MNR Diesel	45	31.0	2.7	93.3%	97.8%	3	1
Overall Amtrak & MNR	**472**	**37.6**	**1.4**	**97.9%**	**99.8%**	**10**	**1**

Note 1: Includes Springfield Line trains in simulation. Springfield-Hartford-NHV shuttles not included in OTP calculation.

Operationally, CP 216 is a busy interlocking and it is busier with the addition of 101 PSA trains. However, the infrastructure at CP 216 and CP217, paired with coordination of Amtrak and MNR operating plans appears to be adequate. The proposed update to the conceptual design of the New Rochelle Yard is essential – especially if up to six PSA trains will stable there simultaneously.

Figure 14 demonstrates how the location of yard leads allows for parallel moves to and from the Yard (see white (eastbound) and dark blue (westbound) arrows.

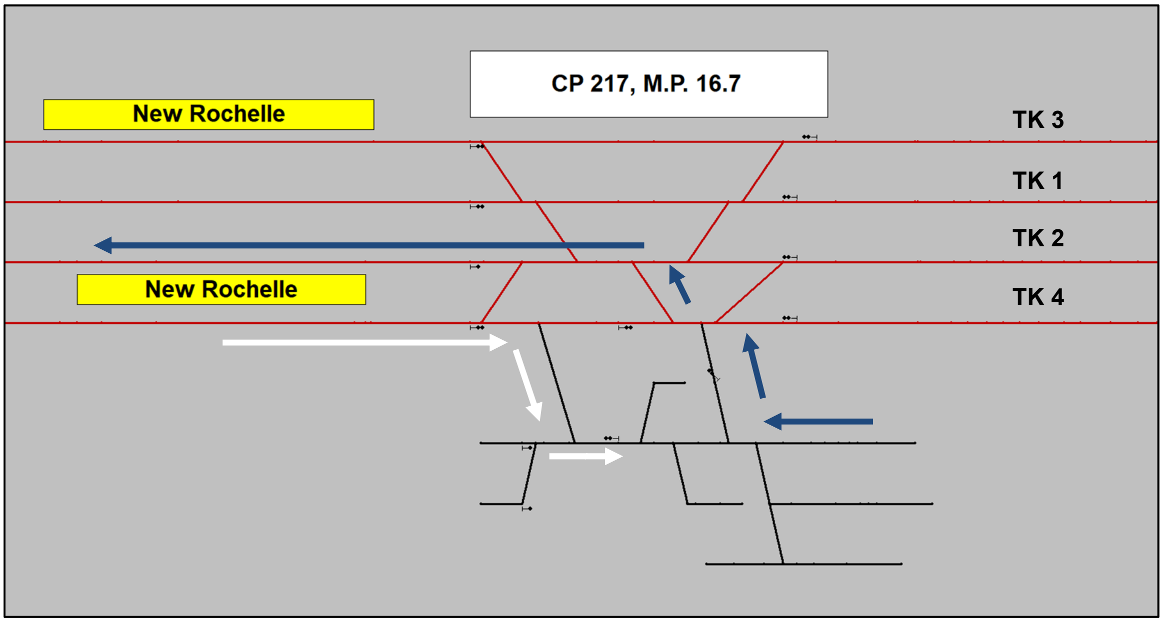

Figure 14 – Traffic Flow In/Out of New Rochelle Yard

Because all equipment terminating at the proposed New Rochelle layover yard leaves Track 4 immediately east of the station, Track 4 is made available to the next eastbound train movement as quickly as practicable. Because westbound trains departing the yard also take the first westbound opportunity to access main track from the yard, their route is separated from the eastbound trains' route to the yard. This minimizes delays.

As discussed in the Hell Gate Line section of this report, some delay is incurred by trains on the Hell Gate Line as they prepare to merge onto the New Haven Line. Re-routing local MNR trains to from Track 4 to Track 2 at CP 215 when possible would alleviate some delay of trains merging from the HGL. Figure 15 shows an example where Train 1334 could have been routed to Track 2 at CP 215, avoiding delay to Train A174.

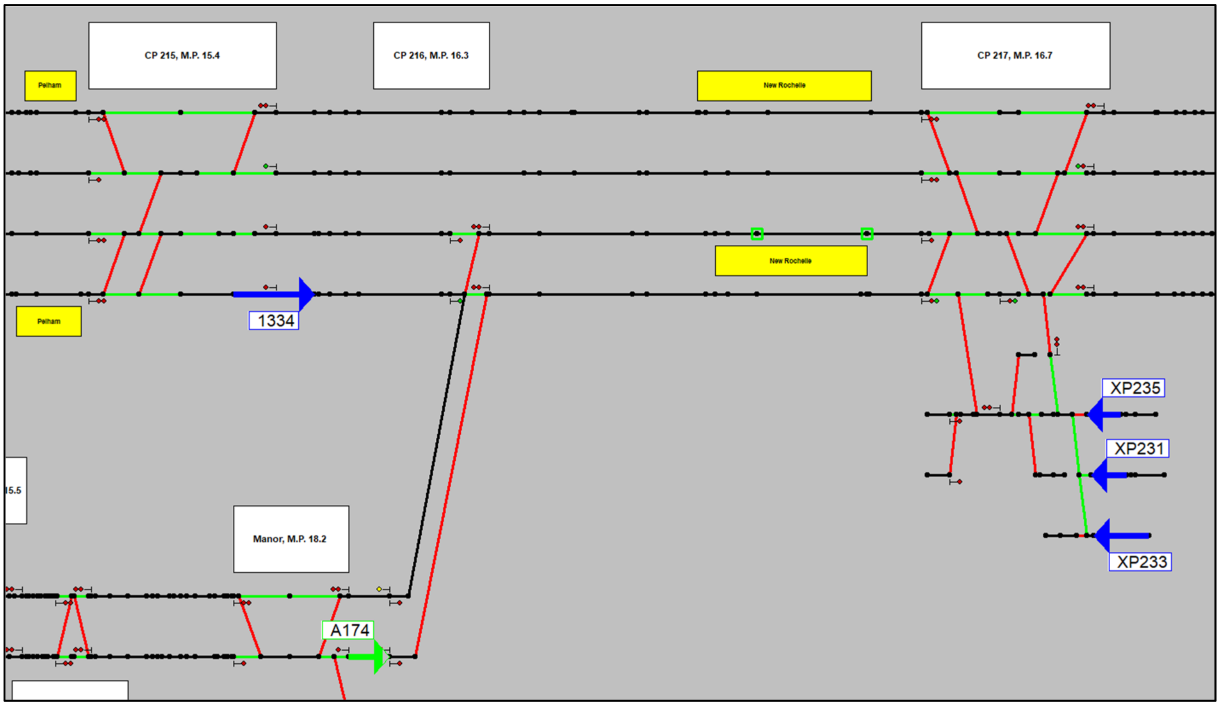

Figure 15 – Signal Delay at CP 216

Another example is shown below in Figure 16. Train A86 was routed to Track 1 at Manor, accessing New Rochelle on Track 2 and allowing MNR Train 1330 to access New Rochelle Station in parallel on Track 4. This is the most efficient solution even if Train 1330 receives a cab signal downgrade at CP 215. It is going to stop at New Rochelle anyway.

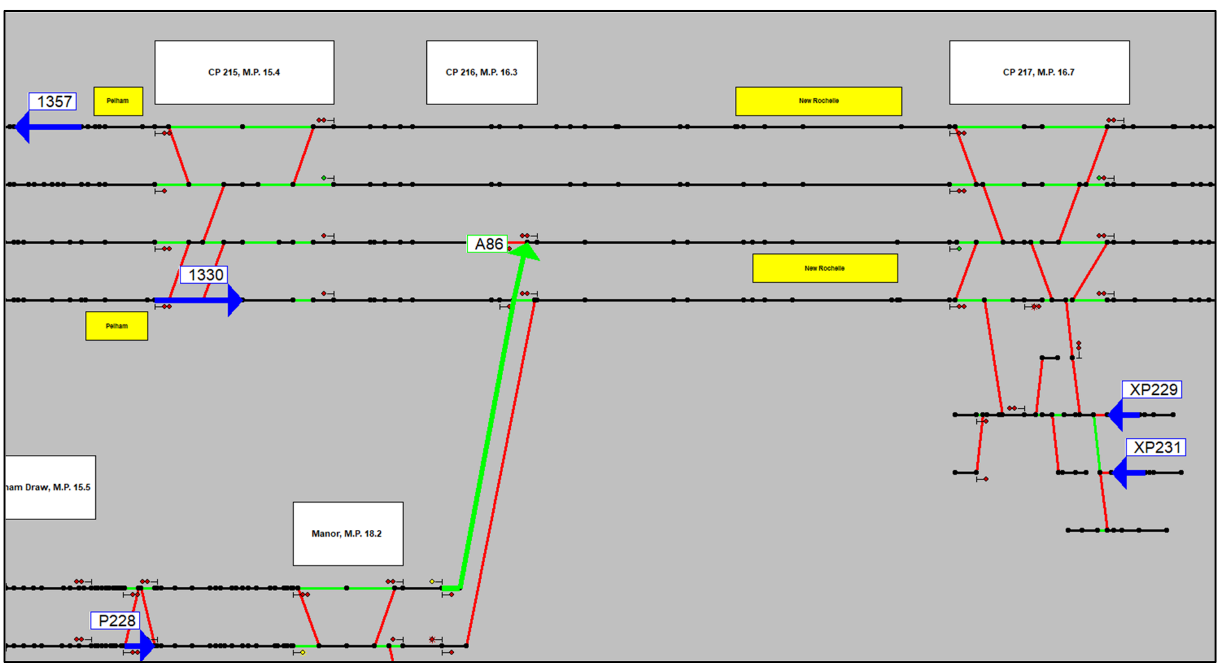

Figure 16 – Train Reroute at Manor to Avoid CP 216 Delay

Minor scheduling adjustments would be a better way to resolve what could otherwise be a repetitive conflict in real-world operations, but a key element of methodology throughout the PSA operations simulation process was to maintain the scheduled Amtrak departure and arrival times at PSNY.

Table 8 provides a comparison of delay metrics between the three segments that comprise the study territory.

Table 8 – Option J1 Deterministic Simulation – Delay Comparison (lower is better)

Operator & Service	West of Gate		Hell Gate Line		New Haven Line	
	No. of Trains	Delay Min/100 train-miles	No. of Trains	Delay Min/100 train-miles	No. of Trains	Delay Min/100 train-miles
Amtrak Acela	28	6.6	28	3.7	28	0.5
Amtrak Regional	32	18.5	32	5.5	46	1.4
MNR PSA	101	14.7	101	2.5	101	2.9
MNR GCT	0	-	0	-	252	1.3
MNR Diesel	0	-	0	-	45	2.7
LIRR	518	10.1	0	-	0	-

3. CONCLUSIONS

Option J1 performed well under deterministic conditions and revealed no Amtrak Stop Delay on the Hell Gate Line and low delay minutes per 100 train miles. Amtrak Acela incurred 3.7 minutes per 100 train miles and Amtrak Regional trains incurred 5.5 minutes per 100 train miles of delay on the HGL.

The signal delays that were recorded were caused by cab signal downgrades received by certain trains approaching the limits of CP 216 (New Rochelle) and receiving less-than-best-aspect due to same-direction traffic ahead or approaching and the route already established and cleared for the conflicting train. Some signal delay was also experienced when Amtrak trains were scheduled such that they followed behind PSA trains at Gate Interlocking in 2-track territory.

These delays could be mitigated by shifting schedules slightly to reduce instances of Amtrak trains following PSA trains entering the HGL at Gate Interlocking, and by modifying schedules slightly at CP 216 to avoid conflicts with existing MNR New Haven Line trains at the merge point.

Trains operating in the NY Terminal territory 'West of Gate' experienced the greatest amount of delay. This is to be expected due to the high volume of trains operating within this densely trafficked territory including at Penn Station itself. Despite the incurred delay, trains still achieved 100% OTP due to "pad" in their scheduled running times. Because PSA trains are replacing certain LIRR trains otherwise berthed at Penn Station, it is expected there will be little difference from what is currently experienced 'West of Gate'.

The simulation indicates that the New Haven Line absorbs the increased traffic from PSA trains and from the proposed increase in Amtrak traffic without causing excessive delay in deterministic simulation. However, the proposed expansion of the New Rochelle Yard to accommodate six trainsets is essential given that the provided operating plan calls for the yard to be fully subscribed.

Table 9 provides a comparison of delay incurred by each operator in each of the three territories comprising the PSA study territory.

Table 9 – Option J1 Deterministic Simulation – Delay Comparison

Operator & Service	West of Gate		Hell Gate Line		New Haven Line	
	No. of Trains	Delay Min/100 train-miles	No. of Trains	Delay Min/100 train-miles	No. of Trains	Delay Min/100 train-miles
Amtrak Acela	28	6.6	28	3.7	28	0.5
Amtrak Regional	32	18.5	32	5.5	46	1.4
MNR PSA	101	14.7	101	2.5	101	2.9
MNR GCT	0	-	0	-	252	1.3
MNR Diesel	0	-	0	-	45	2.7
LIRR	518	10.1	0	-	0	-

Deterministic simulation means that no variability is introduced into the model. The simulation was reviewed to verify that it was operating all trains in "timetable order" as closely as possible according to their actual timetabled departure times and normal or nominal routings.

In overall conclusion, the simulation results indicate that Option J1 offers a viable infrastructure configuration to support the proposed increase in Amtrak service on the HGL while also providing Metro-North with access to Penn Station with a service consisting of 100+/- trains each day.

4. APPENDICES

A. List of Assumptions

Table 10 – List of Assumptions – Option J1 Year 2025 'Build' Model Case

Item	Type	Line/Route or Agency	Description	Remarks
1	Track/ Other	LIRR	Assume East Side Access (ESA) has been completed	Key over-arching assumption.
1a	Track/ Other	LIRR	Eastbound Re-Route and Westbound Bypass	Assumed completed and in service. Elements of ESA Project.
2	Track	HGL	Option J1 configuration	Track schematic and civil design supplied by HNTB; see for example "PSA J1 Alignment Schamtic_5-26-20.PDF" drawing RWA-CT-600. Segments of HGL east and west of design limits are assumed to remain as-existing except for signal control-line "cut ins" and potential new Phase Gaps.
3	Track	NHL	Existing track configuration except Items 3a, 3b & 3c	Option J1 will mimic same assumptions for NHL track configuration as previous 'Build' models except Items 3a, 3b and 3c below.
3a	Track	NHL	New Rochelle Layover Yard (proposed)	Will be emulated per "New Rochelle Yard - Alternative 6 Yard Concept" dated 10/25/19 (VHB); equipment manipulations within yard to be included.
3b	Track	NHL	CP-215 & CP-216	Per MNR sketch received 3/1/19 "MNR Scan.pdf" showing hand markups of track schematic CP-215-CP-216-CP-217. Only one crossover is to be added: #20 Left-Hand marked E42A&B" at CP-215. No modifications to CP-216 except signal Control Lines as needed to support E42A&B. *All other hand markups on this sketch are to be ignored*.
3c	Track	NHL	CP-217	Modify as needed to emulate New Rochelle Layover Yard connections to main tracks per VHB concept sketch plan dated 10/25/20 listed above.
4	Signals	HGL	Upgraded, higher-capacity dual-frequency ATC signal system	Emulate "Existing/Proposed J1/H1 Road Diagram", HNTB/GF, print dated 5/27/20. (Furnished.)
5	Signals	NHL	Upgraded 3-block, 4-aspect ATC/CS configuration	Use "final configuration" NHL signal block layout and control line configuration that supports 270-Code (Limited Speed) as emulated for MNR PTC Impact Study
6	PTC	HGL	ACSES II PTC commissioned & operational	Completed by Amtrak as an independent project unrelated to PSA.
7	PTC	NHL	ACSES II PTC commissioned & operational	Completed or to-be-completed by MNR as an independent project unrelated to PSA.
8	Rolling Stock	Amtrak	Acela 2 vehicles assumed	Currently undergoing testing and assumed to be deployed by 2025. Assume complete replacement of existing Acela fleet.
9	Rolling Stock	Amtrak	ACS-64 locomotives and Amfleet cars for Regional trains	Same as Existing (Base Case) and Future No-Build.
10	Rolling Stock	MNR-GCT	Rolling stock types and number of cars as actually assigned	As of 4/2016. This assumption remains consistent with Base Case, Future No-Build ("Do Minimum") Case and all previous 'Build' cases
11	Rolling Stock	MNR-PSA	M-8 EMUs	10-car trains in simulation for conservatism of track circuit clearing times; in reality, 8-car trains are planned.
12	Civil Speeds	HGL	"Tiered" MAS: Type A; Type B; Type C Equipment as defined or approved by Amtrak	Amtrak intends to adopt "tiered" civil speeds and speed restrictions along entire HGL consistent with other NEC territories as an independent action unrelated to PSA. Importantly, tiered civil speeds are also applicable to HGL territory east and west of PSA design limits, per Amtrak guidance for "Future No-Build" model case.

Item	Type	Line/Route or Agency	Description	Remarks
13	Civil Speeds	NHL	As per 2016-existing	This assumption remains consistent with Future No-Build ("Do Minimum") Case and Base Case.
14	Facilities	HGL	Existing Pelham Bay moveable bridge (no new bridge)	Static assumption common to all PSA model cases. Typical bridge unlock/open/close/lock cycle time is 18 minutes per previous Amtrak guidance.
15	Station Stops	HGL	Per MNR-PSA train timteable (furnished)	Pertains to PSA trains only. Amtrak will not make any scheduled station stops along the HGL.
16	Station Stops	NHL	Existing as of 2016.	All existing stations per 4/2016 NHL Timetable. No station stops have been added to the NHL for this exercise.
17	Operations	LIRR	LIRR G.O. 504 as furnished	Per file: '*PSA Opening Day Plan 200609.xlsx*' furnished to the Consultant via MNR/MTA.
18	Operations	MNR-GCT	Train schedules and equipment turns	NHL GCT trains per 4/2016 Employee Timetable and related documents.
19	Operations	MNR-PSA	Train schedules and equipment turns	Per "PSA Opening Day Plan 200609.xlsx" furnished by MNR via MTA
20	Operations	MNR	DTOBO temp. speed restrictions & outages as applicable	
21	Operations	Amtrak	Year 2025 NYP-BOS train schedules	"*Metro North Revised Timings 170217 Rhodes 2025 Weekday Service Plan*.xlsx". Adjust running times on NHL to match existing. (Same Amtrak train timetabling, numbers and kinds of trains as all previous PSA operations models except Base Case.)
22a	Operations	NJT	NJT PSNY-SSYD deadhead train movements	Per PSNY Capacity Study "Option 6" timetable, but referencing "X1-X2" spreadsheet from MNR via Amtrak for scheduled running times
22b	Operations	Amtrak	Amtrak PSNY-SSYD deadhead train movements	Per PSNY Capacity Study "Option 6" and Item 21, but referencing "X1-X2" spreadsheet from Amtrak via MNR for scheduled running times. Amtrak PSNY-SSYD DHs associated with proposed incremental 2025 services NYP-BOS not available. Leverage available resources for guidance.

Additional remarks:

Note 1 – Model assumes that the existing HGL signal block layout & supported code rates (aspects) will be replaced with an upgraded Automatic Train Control (ATC) system compatible with Amtrak's existing dual-frequency ATC/CS systems such as the High Line HDIS between NYP and Hudson (Newark).

Note 2 – Amtrak and HNTB have furnished proposed tiered civil speeds and speed restrictions for HGL which will be input to the model for Types A, B and C, where Type A is Acela Express.

Note 3 – Any increase of Amtrak level of service on the New Haven Line will require approval from MTA Metro-North Railroad. Any simulation scenario that includes such an increase of service does not imply such approval.

Note 4 – Acela 2 rolling stock is currently under construction as an independent funded action. Model reflects anticipated Acela 2 physical and performance characteristics.

Note 5 – The simulation assumes that Amtrak intends to operate the Inland Route NYP-BOS via Springfield MA such that the relevant aspirational train services listed in its proforma 2025 timetable are included in simulation. This is consistent with all previous PSA 'Build' simulations.

Note 6 – The MTA continues to reserve rights to all existing available slots at PSNY.

Note 7 – Potential added service to LGA AirTrain is not included.

B. *Source Documents*

Table 11 – List of Source Documents

Document or File Name	Portion of Document Used/Type of Data	Date/Version
Amtrak/Gannett Fleming Harold to CP-216 Signal Aspects – Conceptual Design	Signal Block Layout and Control Line configuration	10/10/2014
PSA SE Signal Plans	Revised Concept Design with adjusted block boundaries for Option J1	5/26/2020
New York Penn Station Operations Study	Option 6 operating plan and operating assumptions for NJT DH trains	6/2015
NHL Contract Drawings 12-16-08 – Routings-CWA	Block Plan, Signal Block Layout and Control Line configuration for NHL CP212 – CP230	12/5/2008
NHL_S1_DWGs_REVISED 100%-Gannett Fleming/CWA	Block Plan, Signal Block Layout and Control Line configuration for NHL CP229 – CP244	1/29/2016
NHL - Section 2 - 100%-Gannett Fleming/CWA	Block Plan, Signal Block Layout and Control Line configuration for NHL CP240 – CP261	9/15/2014
NHL S3_100% Submission Drawings-Gannett Fleming/CWA	Block Plan, Signal Block Layout and Control Line configuration for NHL CP261 – CP271	11/7/2014
Waterbury Branch Routings-Gannett Fleming	Signal Block Layout and Control Line configuration	11/28/2011
Metro-North Penn Station Access Project Amtrak Preferred Configuration/ Alignments for Simulation	Train service assumptions, planning principles and proposed configuration/ alignment alternatives for simulation	2/27/2017
Hell Gate Speed Calc of MN A1 Alignment_REVISED 20170517.xlsx	Amtrak supplied source data for curve limits and speed restrictions for Type A, B and C within design territory (superseded 'Hell Gate Line Speed Calculation for MN' within design territory)	5/17/2017
Re: MNR PENN STATION ACCESS CER - ALIGNMENT OPTION A1	Email with Amtrak instructions for speed restrictions	5/15/2017
Metro North Revised timing 170217-Rhodes.xlsx	Amtrak 2025 Train Schedule	2/23/2017

Document or File Name	Portion of Document Used/Type of Data	Date/Version
Alstom - 01- Trainset Schedule 1 Part B - Technical Description - 160129 - Correction (Redline) (2).pdf	Acela 2 trainset technical data including car length, average car tare weight & cross-sectional area provided by Amtrak	3/29/2017
Gate OTP 3302016 to 3302017.xlsx	Amtrak historical lateness data	12/7/2017
Pelham Bay OTP 3302016 to 3302017.xlsx	Amtrak historical lateness data	12/7/2017
TPAS Operating Plan Data	Operating Plan, equipment assignments, track assignments at interlockings and stations	Effective April 2016
Metro-North Railroad Operating Schedule Booklet A	Operating plan in Excel™ format for Hudson and Harlem Lines	4/3/2016
Metro-North Railroad Operating Schedule Booklet B	Operating plan in Excel™ format for New Haven Line and branch lines	4/3/2016
Metro-North Railroad Operating Rules	Rules governing train operations	2/27/2011 (GO-302 1/22/17)
Metro-North Employee Timetable No 3	Civil Speed Restrictions, Maximum Authorized Speeds, and miscellaneous rules governing train operations	5/15/2016
Daily Train Operations Bulletin Order (DTOBO) speed restrictions	Temporary Speed Restrictions and planned track outages on MNR NHL	6/3/2016 7/15/2016
MNR Employee Timetable General Order No 302	Metro-North Operating Rules	1/22/2017
NY2022 2015 baseline.zip	RTC Model of Future Harold Interlocking and Penn Station (from Amtrak)	5/11/2017
CP 215-217 Data Detail Durousseau 171026 all dates correct.xlsx	Train Lateness field data from CP 215, 216, and 217 on NHL	6/3/2016 to 9/23/2016
PSA AM and PM Peak Ridership Train by Train Forecast 180711.xlsx	Draft NHL Operating plan with PSA trains and ridership forecast	7/11/2018
Amtrak Northeast Corridor Consist Book	Amtrak train consist assignments	4/8/2017
New Rochelle Yard concept 26936 - Sheets Alt 6_10-25-2019.pdf	Conceptual yard layout and schematic	10/25/2019
J1 Sim Data for Civil Restrictions_v2.xlsx	J1 curve locations and Type A, B, C speeds. Interlocking and platform limits	6/3/2020
PSA J1 Alignment Schematic_5-26-20.pdf	Schematic for J1 alignment	5/26/20

Document or File Name	Portion of Document Used/Type of Data	Date/Version
PSA Opening Day Plan 200609.xlsx	Opening Day plan for Metro-North integrated with GO 504 Weekday Master Plan	6/9/2020
NYP DWELL_STANDARDS 131206 DG 200526.pdf	Reference for minimum dwells in NYP	12/6/2013
LIRR GO 504 HPA Times 20200618.xlsx	Timings at Hunterspoint Ave	7/13/2020
50401 Weekday East.xls.xlsx	LIRR eastbound routing into NYP	6/4/2020
50401 Weekday West.xls.xlsx	LIRR westbound routing from NYP	6/4/2020
X1-X2 7MAY17 BB200526.xlsx	TIMACS timings for NYP May 2017	5/2017

C. Hell Gate Line Time/Distance "String" Charts (Color-Coded by Lateness)

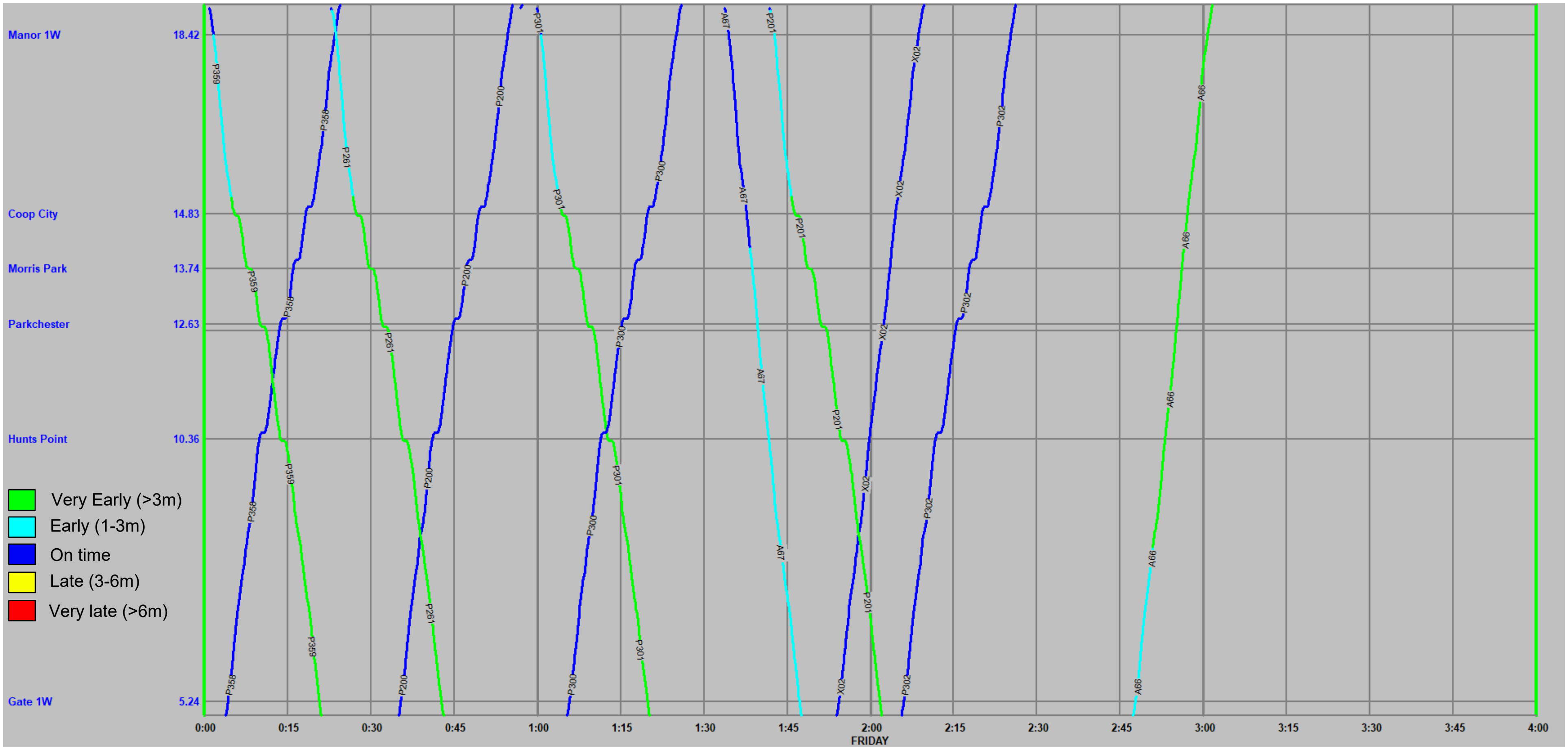

Figure 17 – Hell Gate Line String Chart (by Lateness) 0000h-0400h

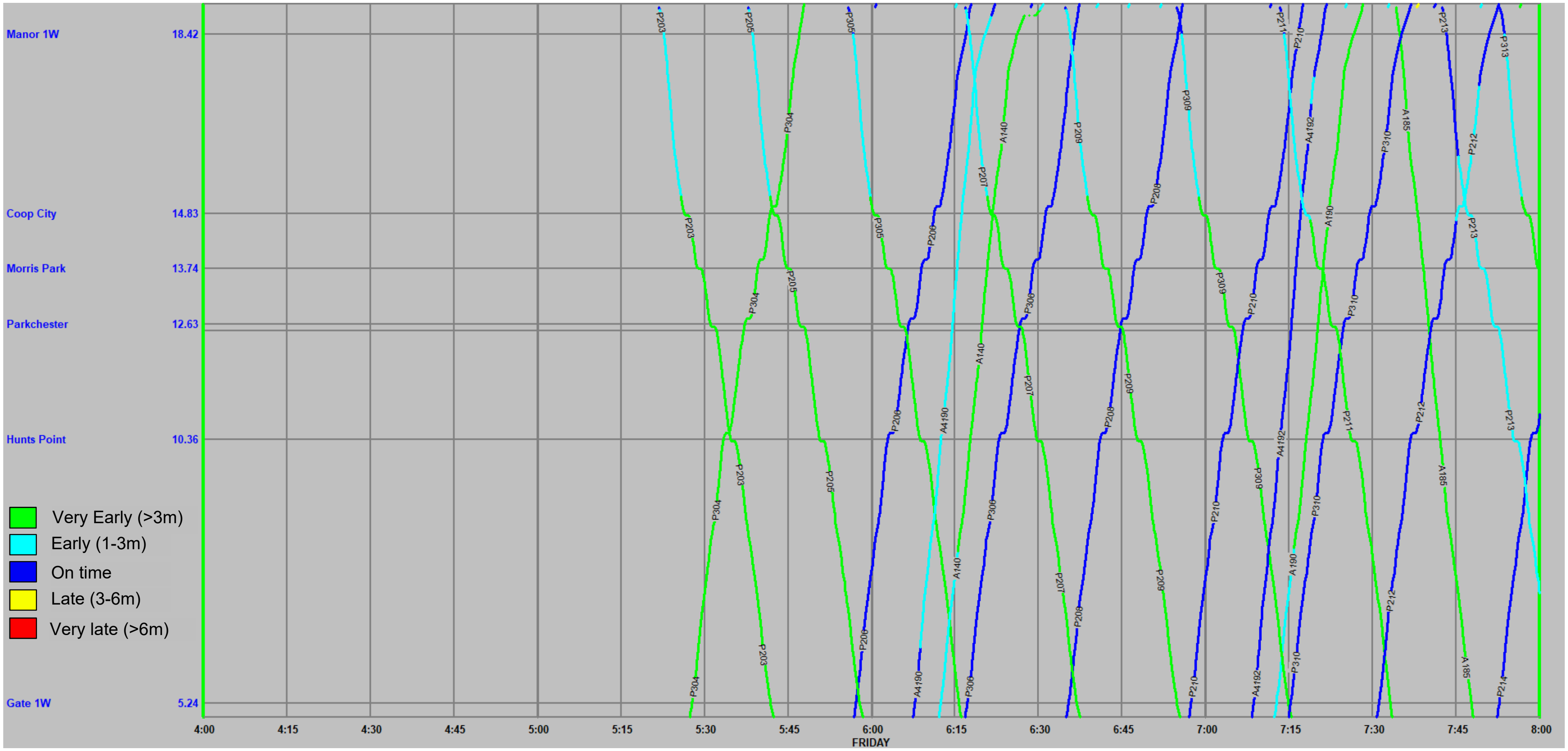

Figure 18 – Hell Gate Line String Chart (by Lateness) 0400h-0800h

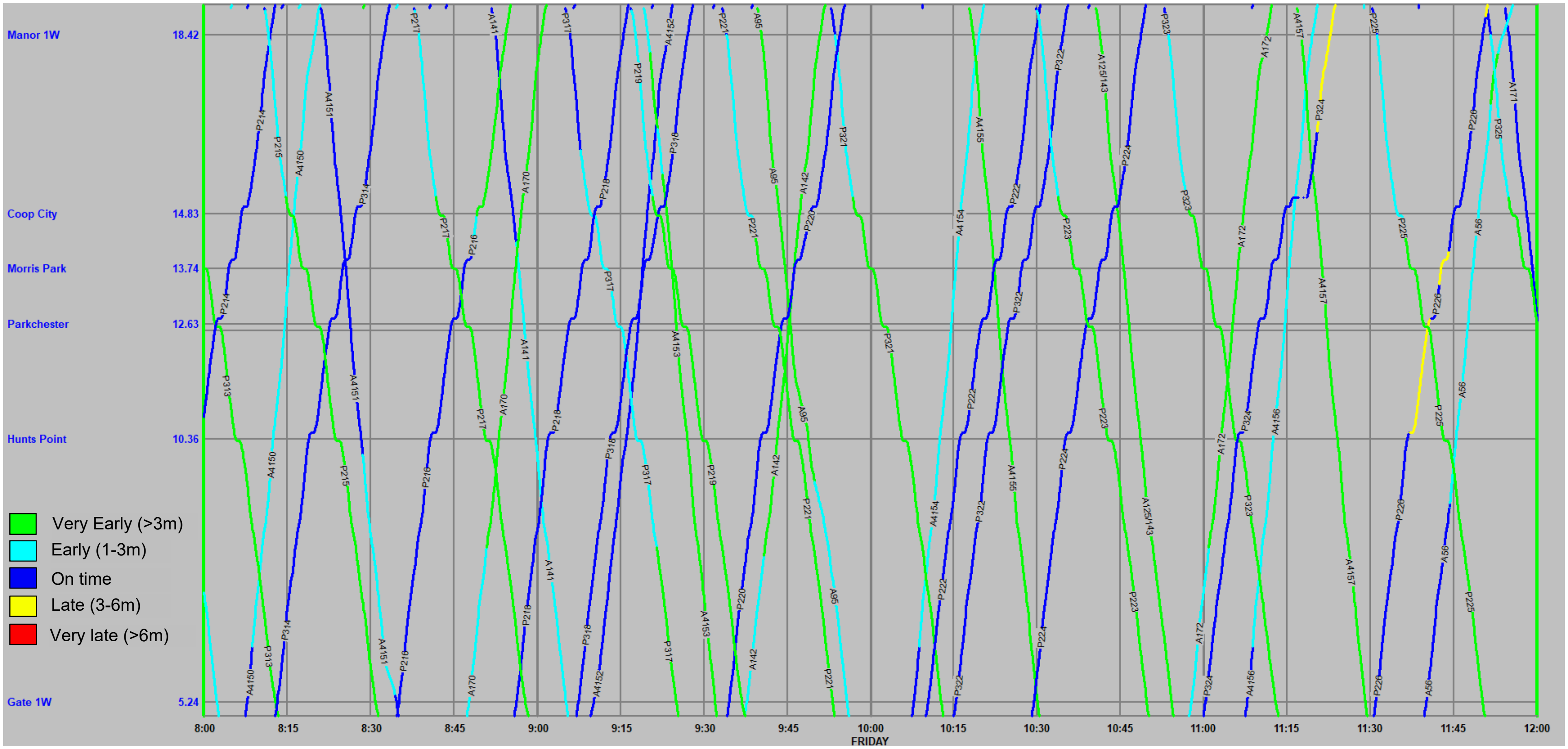

Figure 19 – Hell Gate Line String Chart (by Lateness) 0800h-1200h

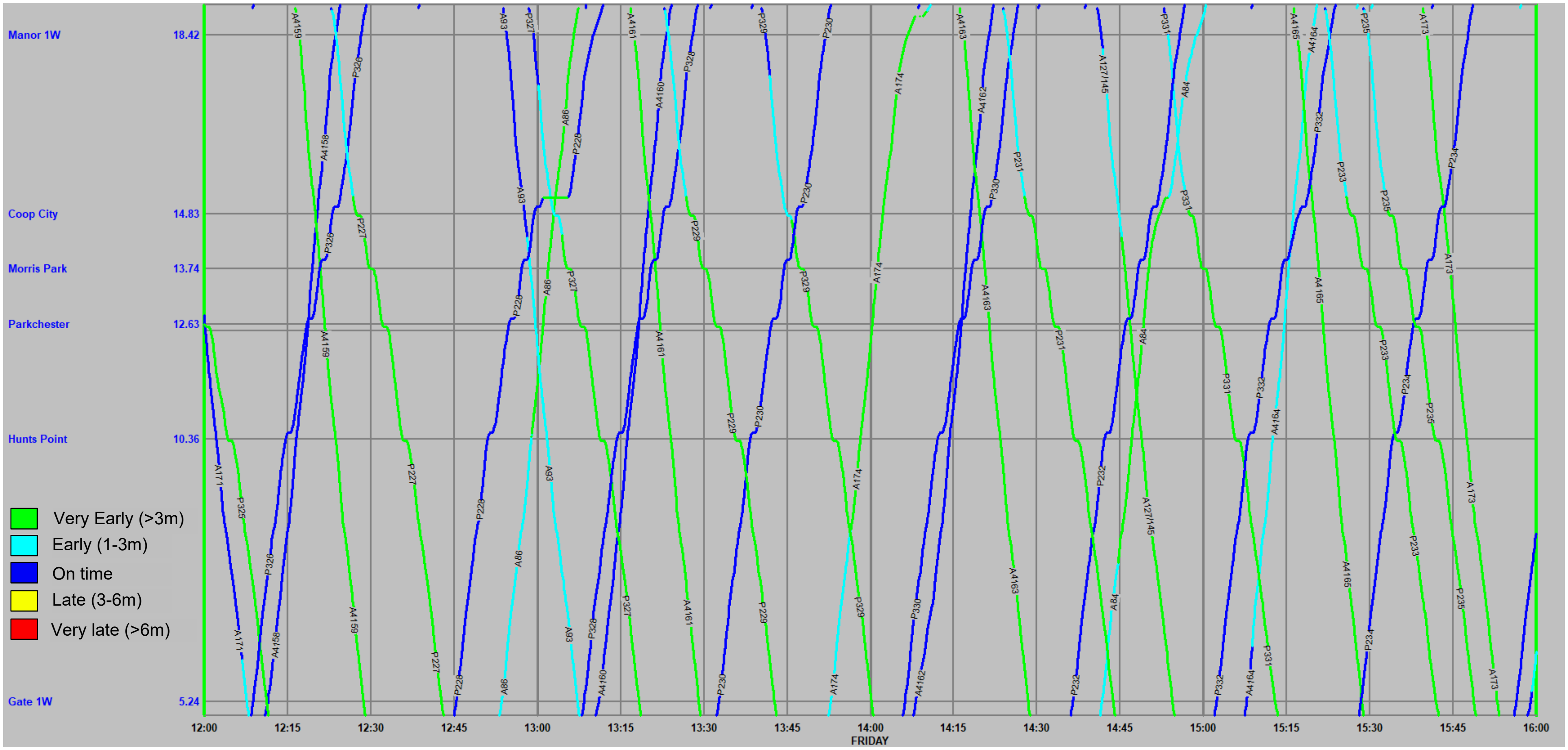

Figure 20 – Hell Gate Line String Chart (by Lateness) 1200h-1600h

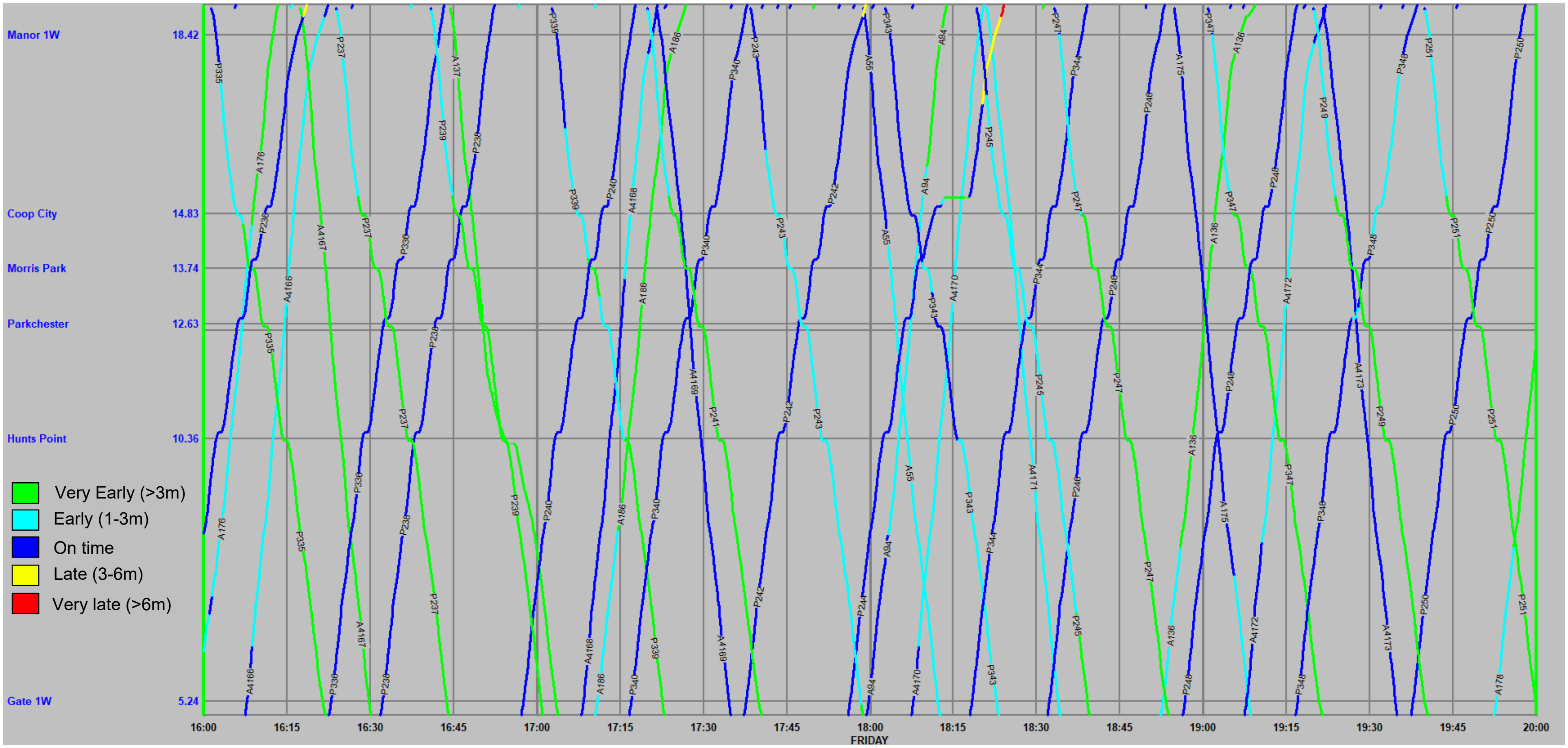

Figure 21 – Hell Gate Line String Chart (by Lateness) 1600h-2000h

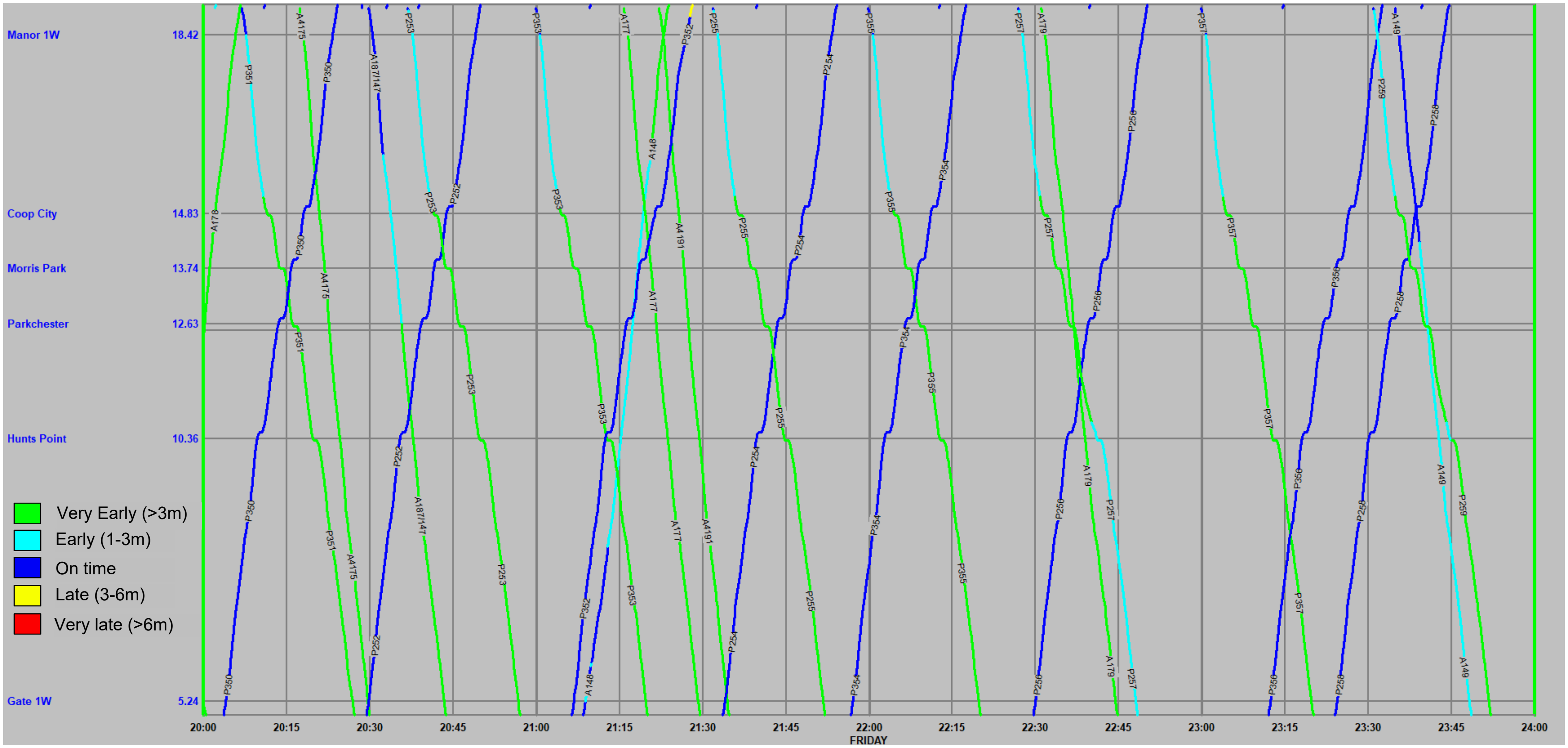

Figure 22 – Hell Gate Line String Chart (by Lateness) 2000h-2400h

D. Hell Gate Line Time/Distance "String" Charts (Color-Coded by Track)

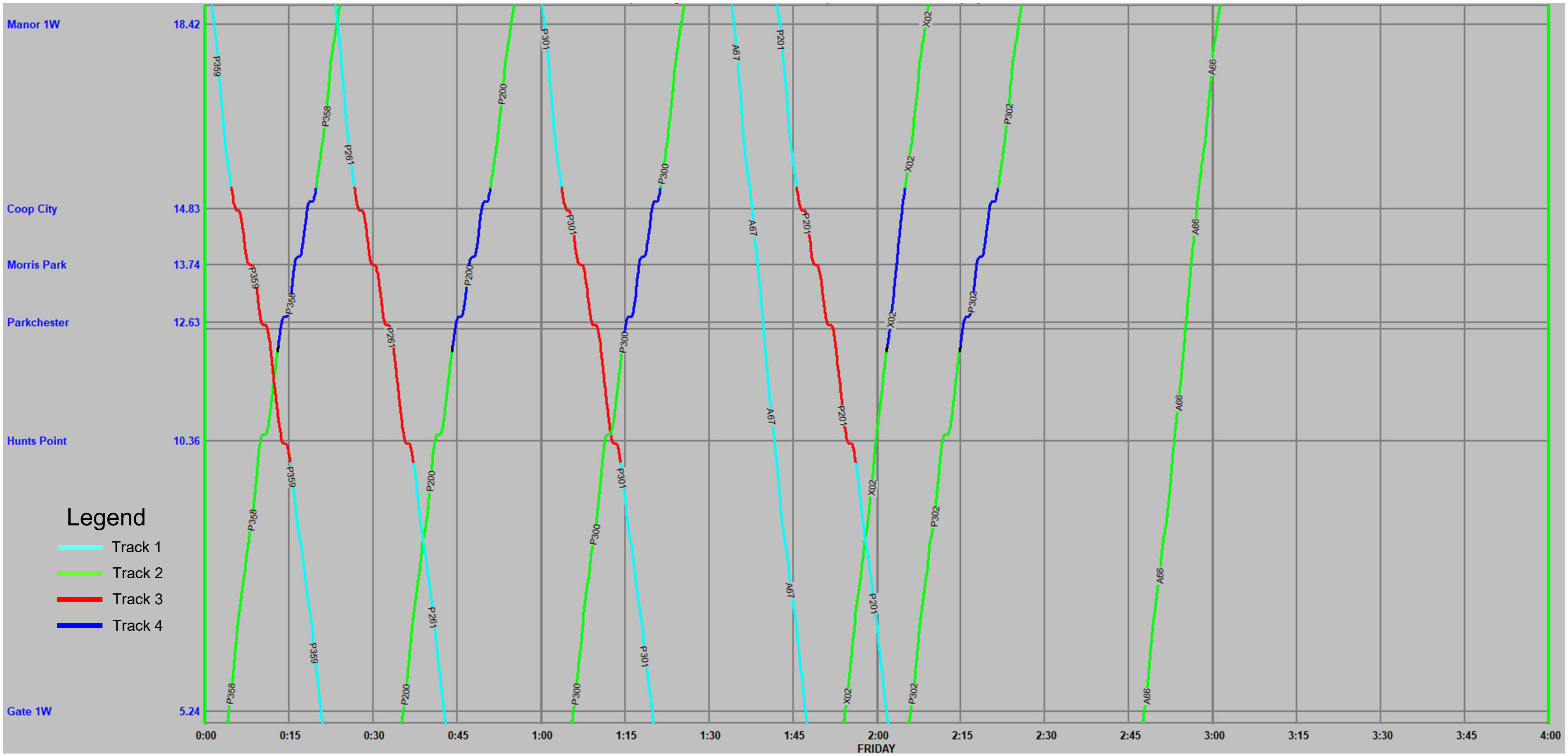

Figure 23 – Hell Gate Line String Charts (by Track) 0000h-0400h

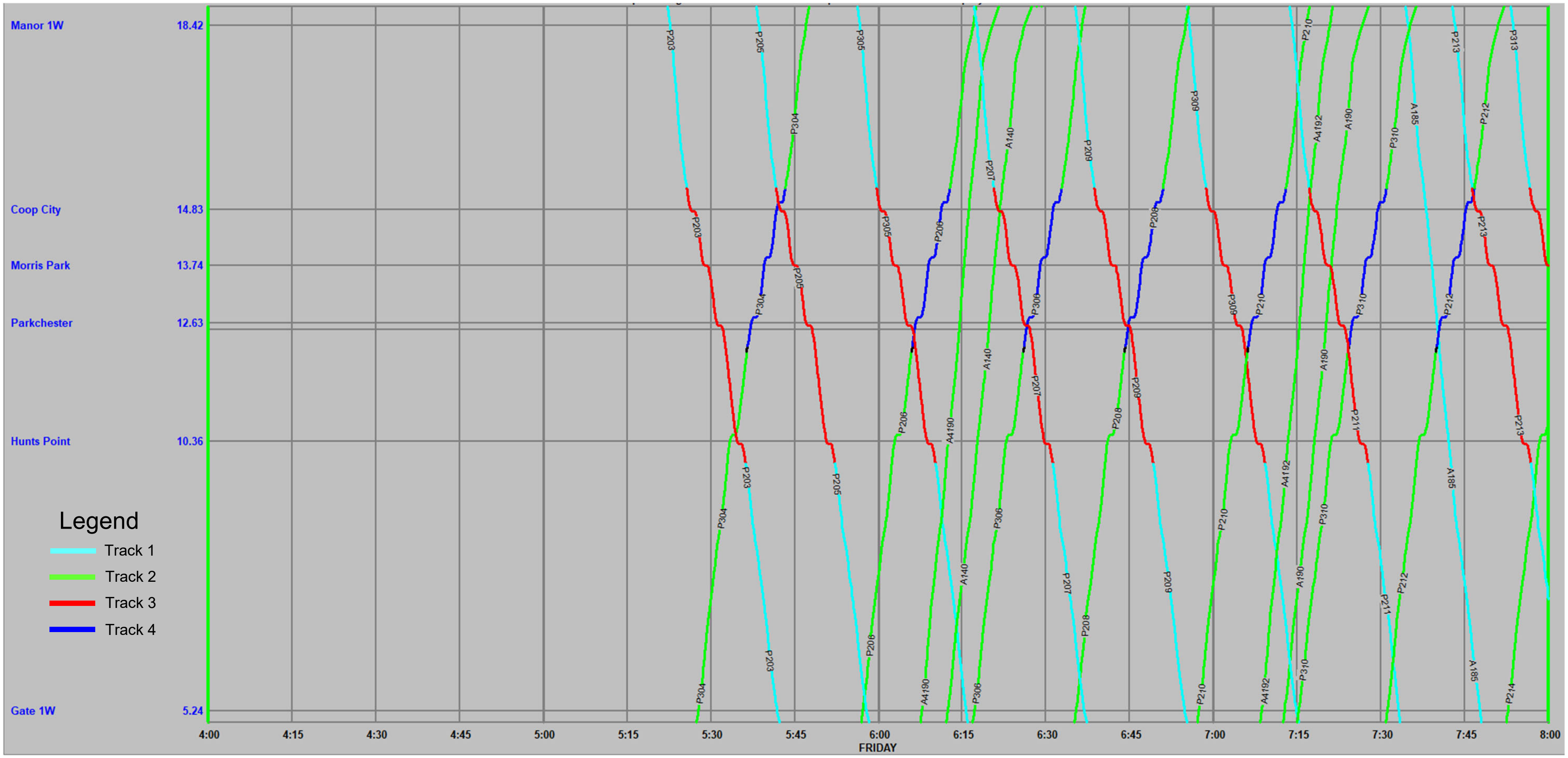

Figure 24 – Hell Gate Line String Charts (by Track) 0400h-0800h

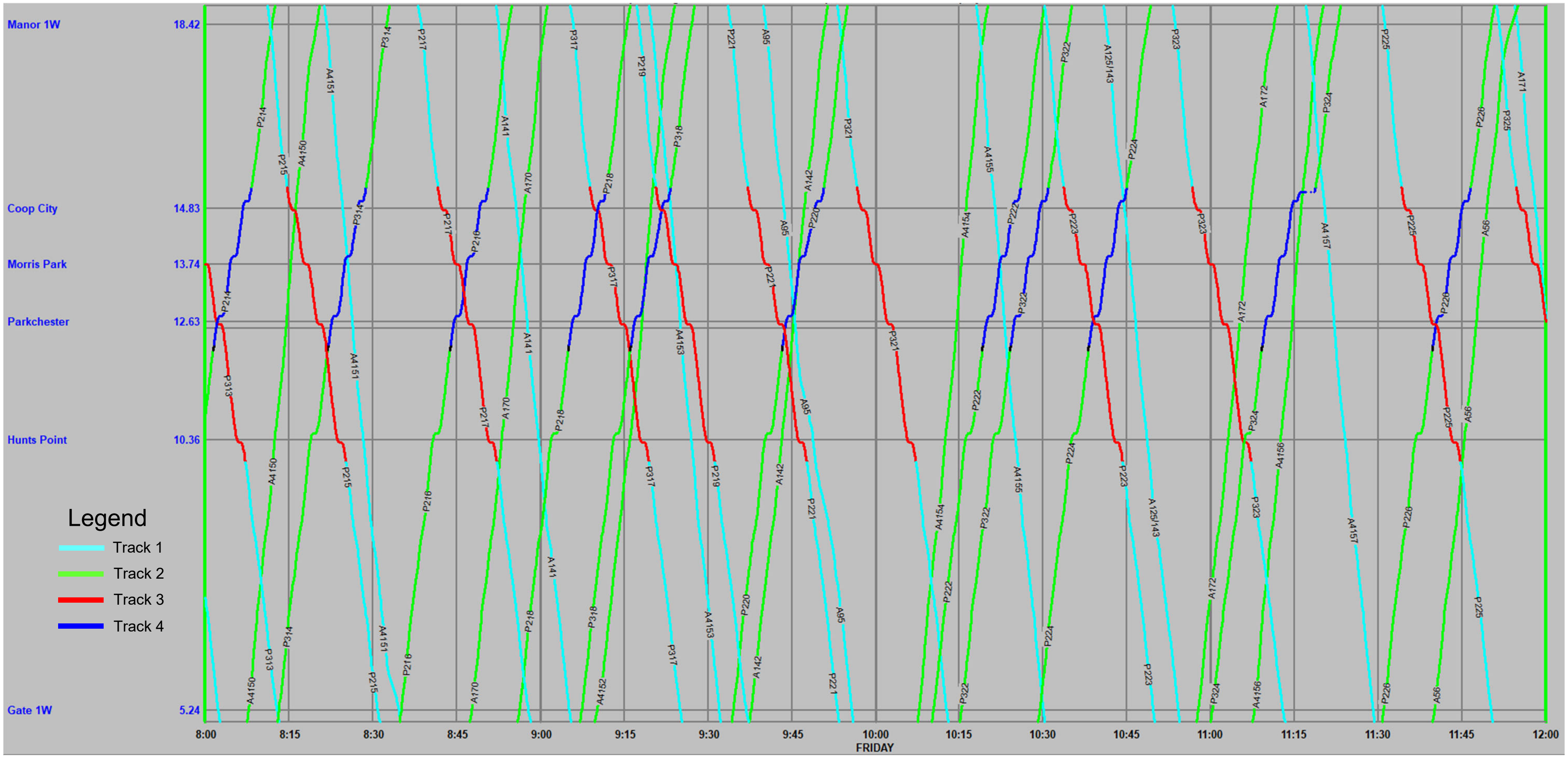

Figure 25 – Hell Gate Line String Charts (by Track) 0800h-1200h

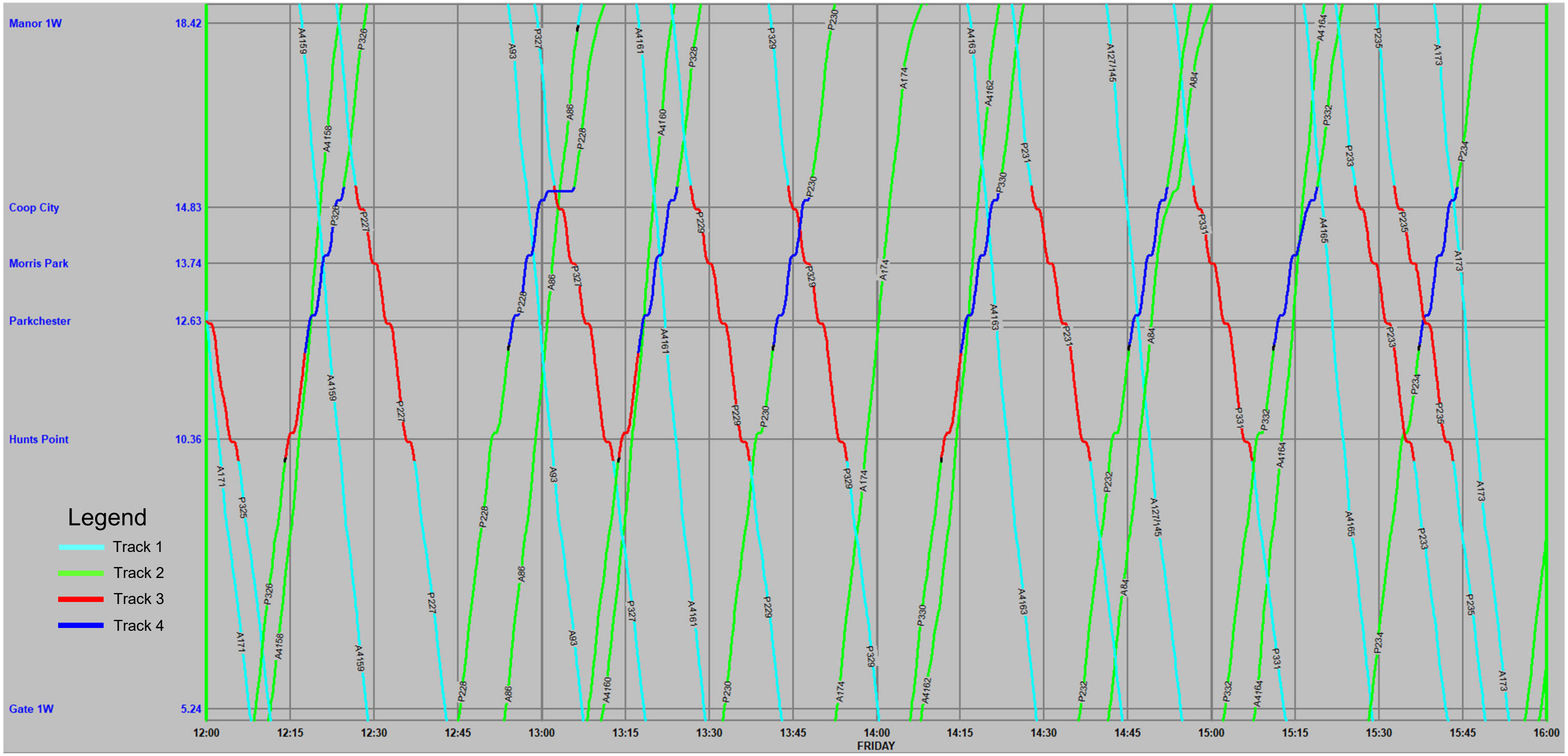

Figure 26 – Hell Gate Line String Charts (by Track) 1200h-1600h

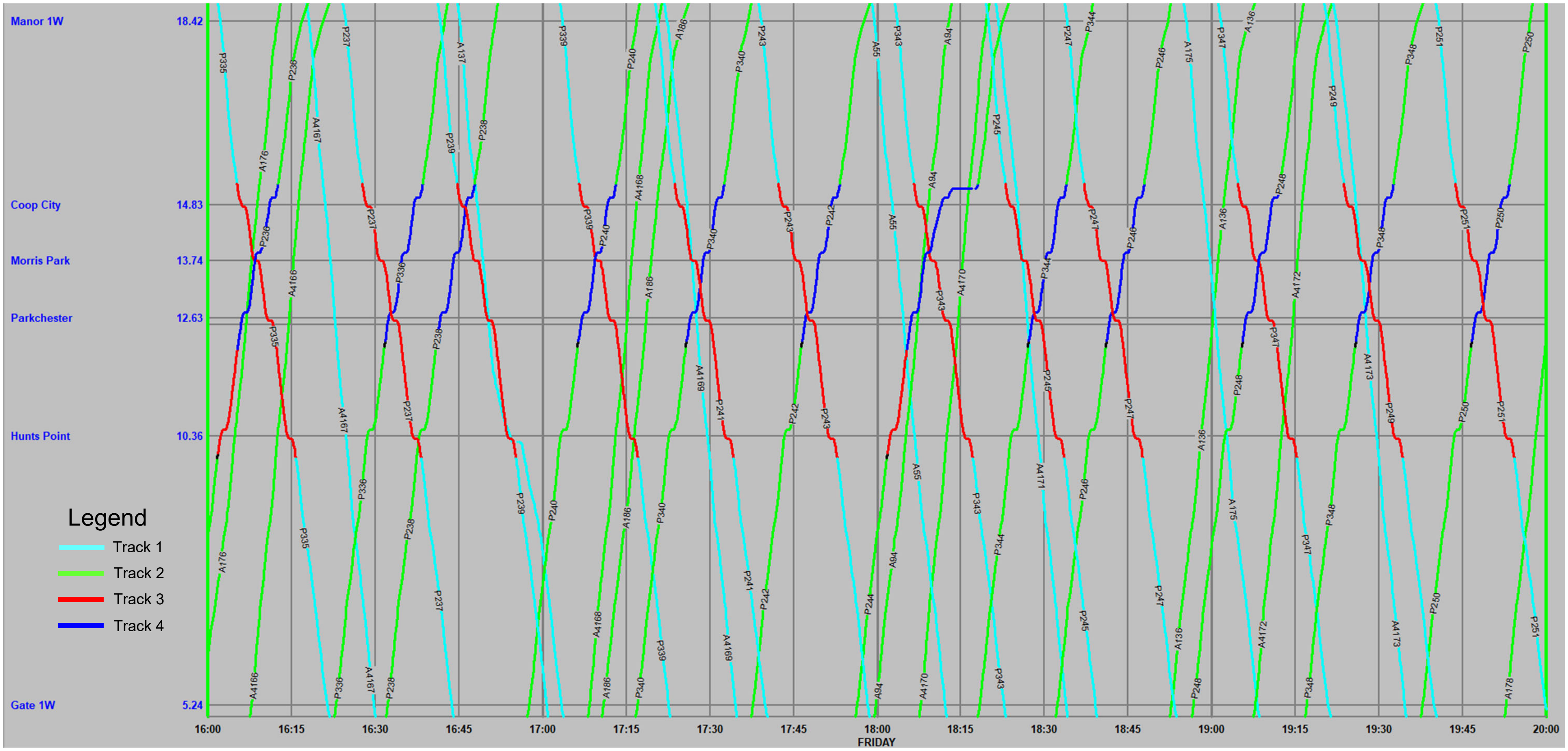

Figure 27 – Hell Gate Line String Charts (by Track) 1600h-2000h

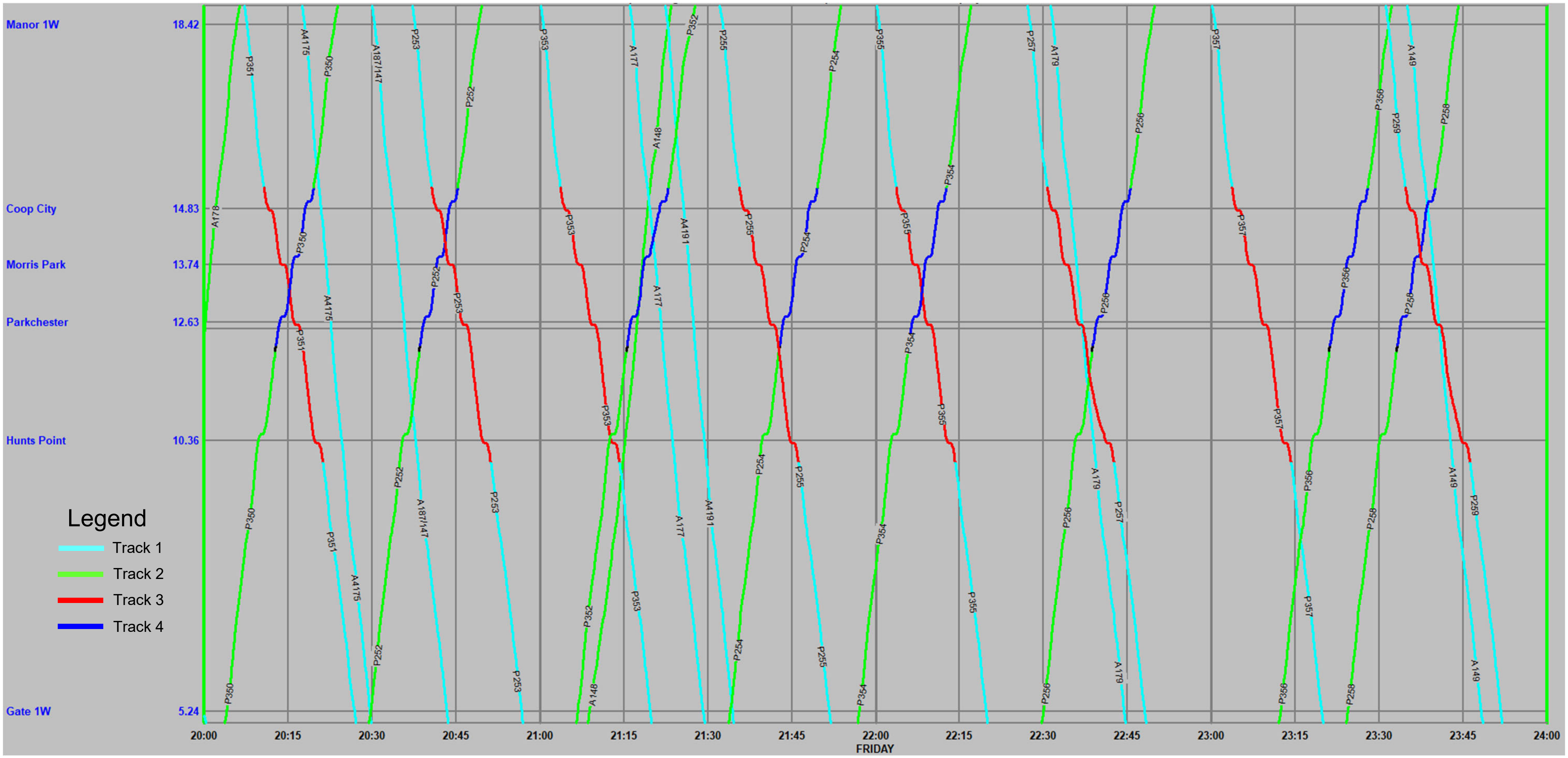

Figure 28 – Hell Gate Line String Charts (by Track) 2000h-2400h

E. New Haven Line Time/Distance "String" Charts

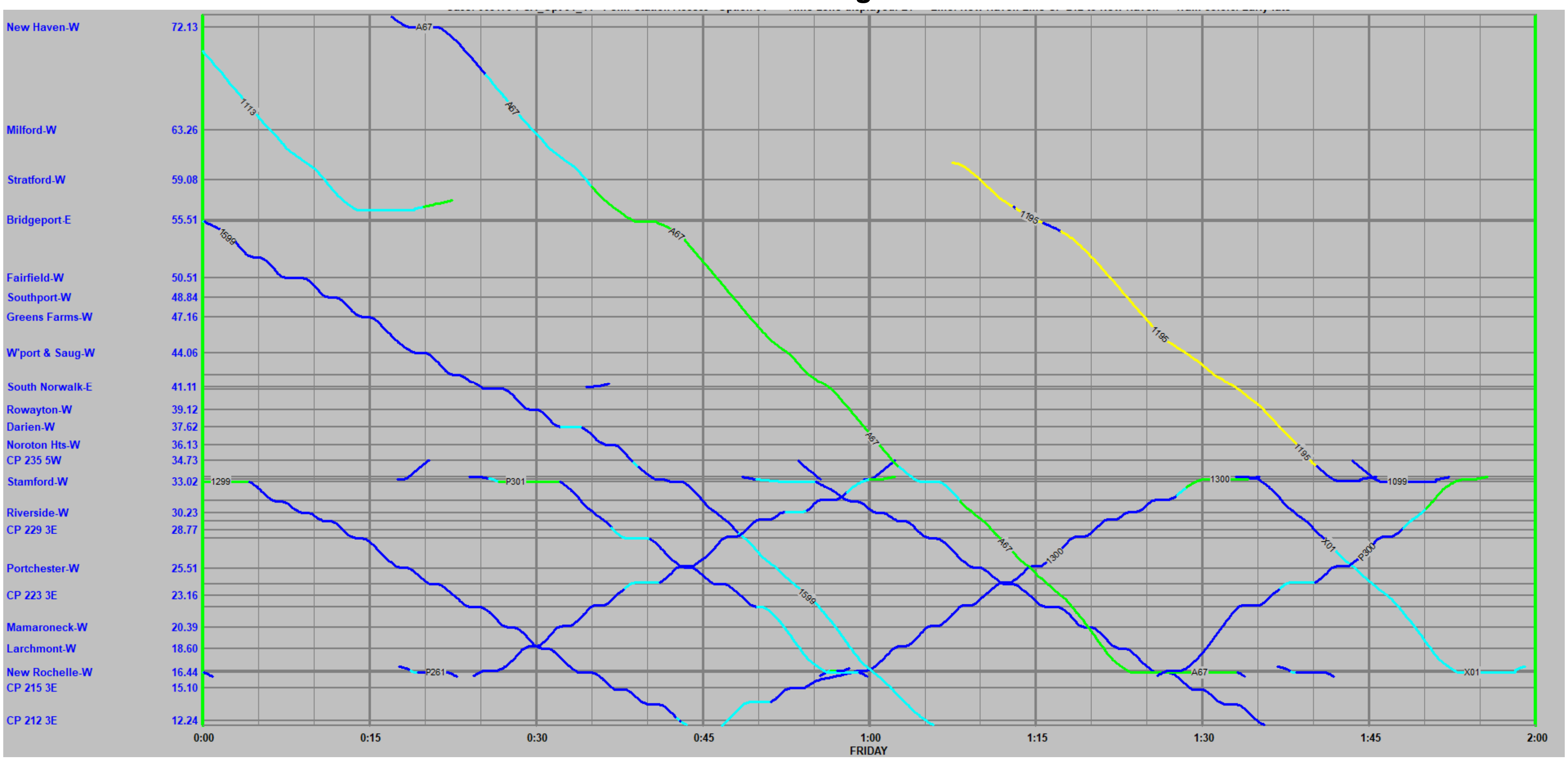

Figure 29 – New Haven Line String Chart 0000h-0200h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

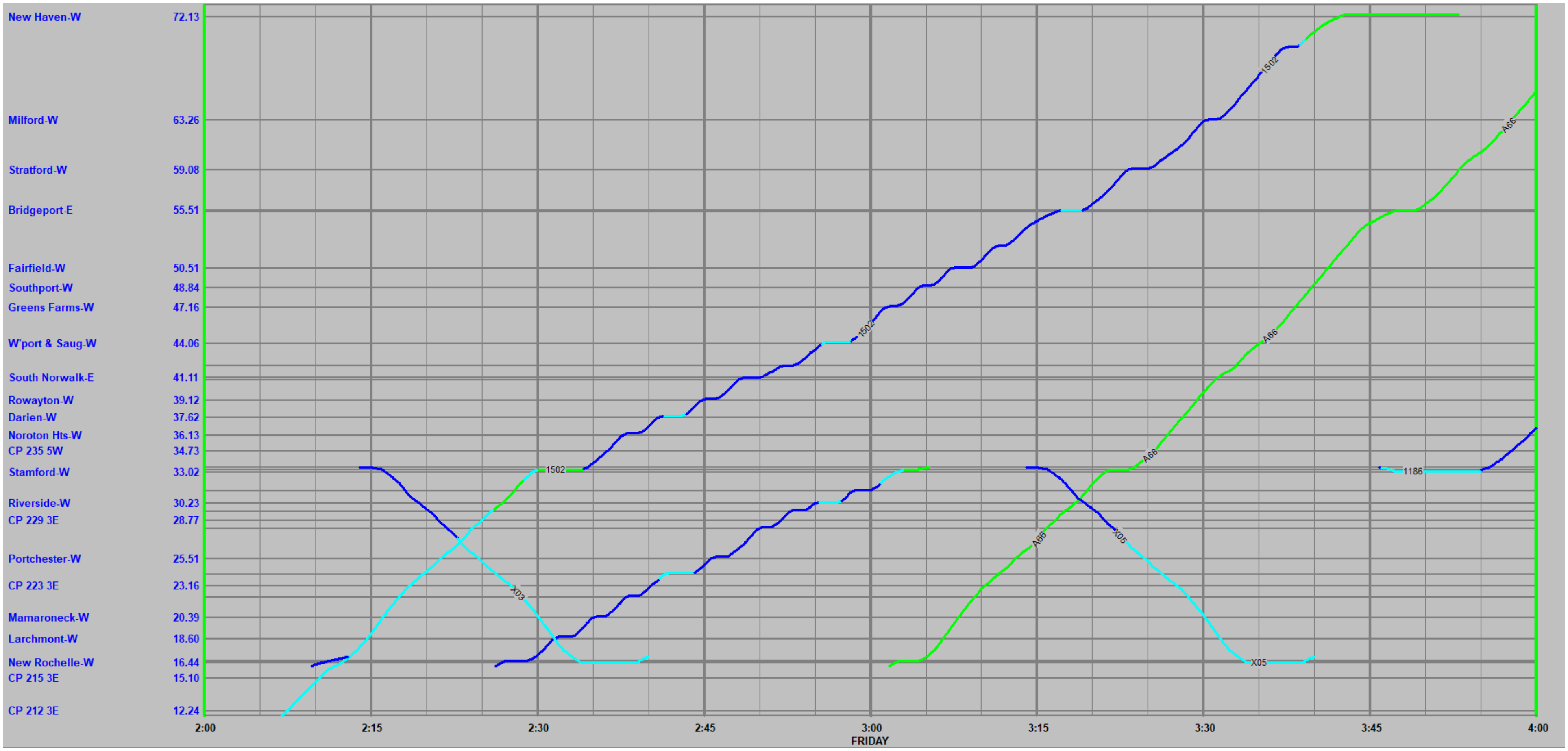

Figure 30 – New Haven Line String Chart 0200h-0400h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

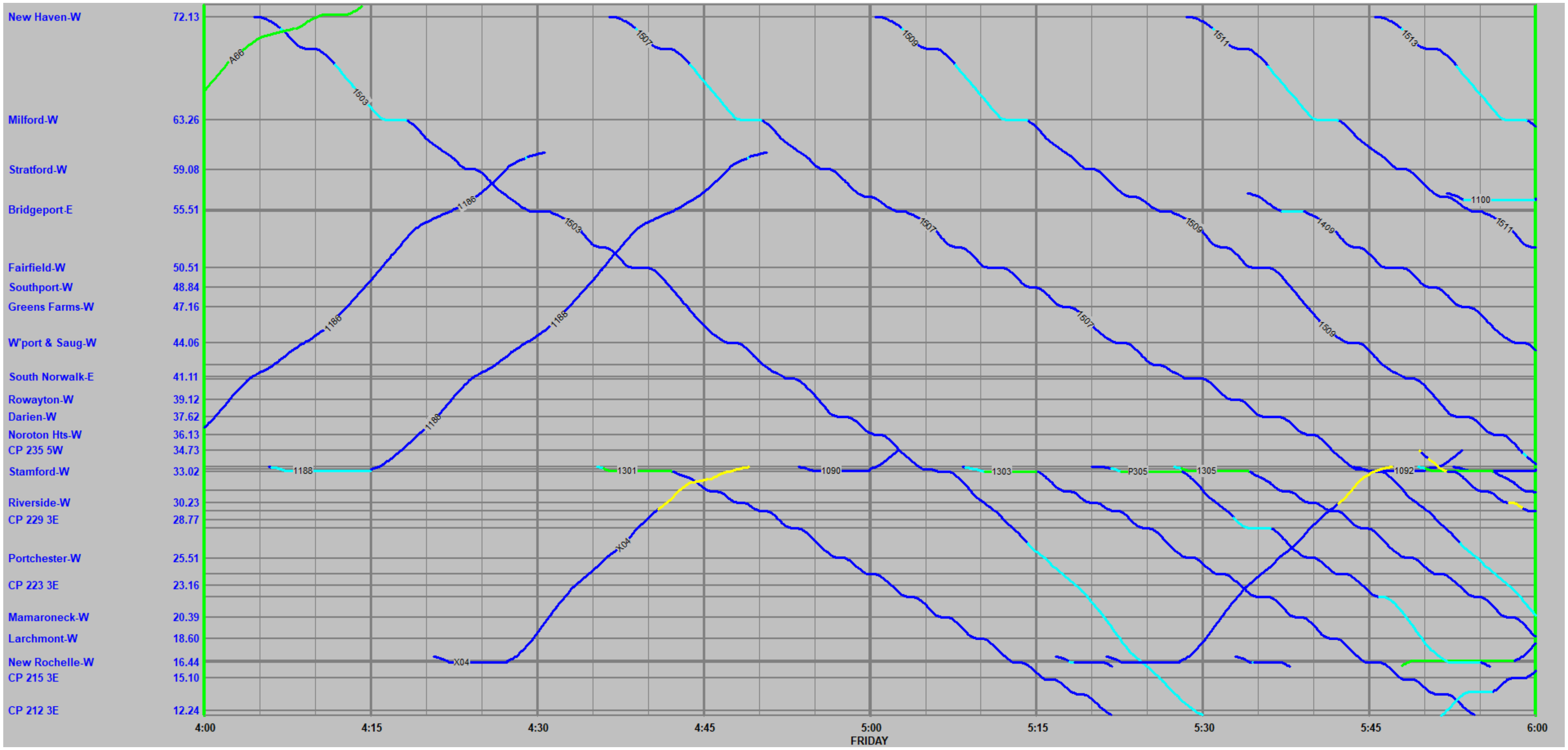

Figure 31 – New Haven Line String Chart 0400h-0600h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

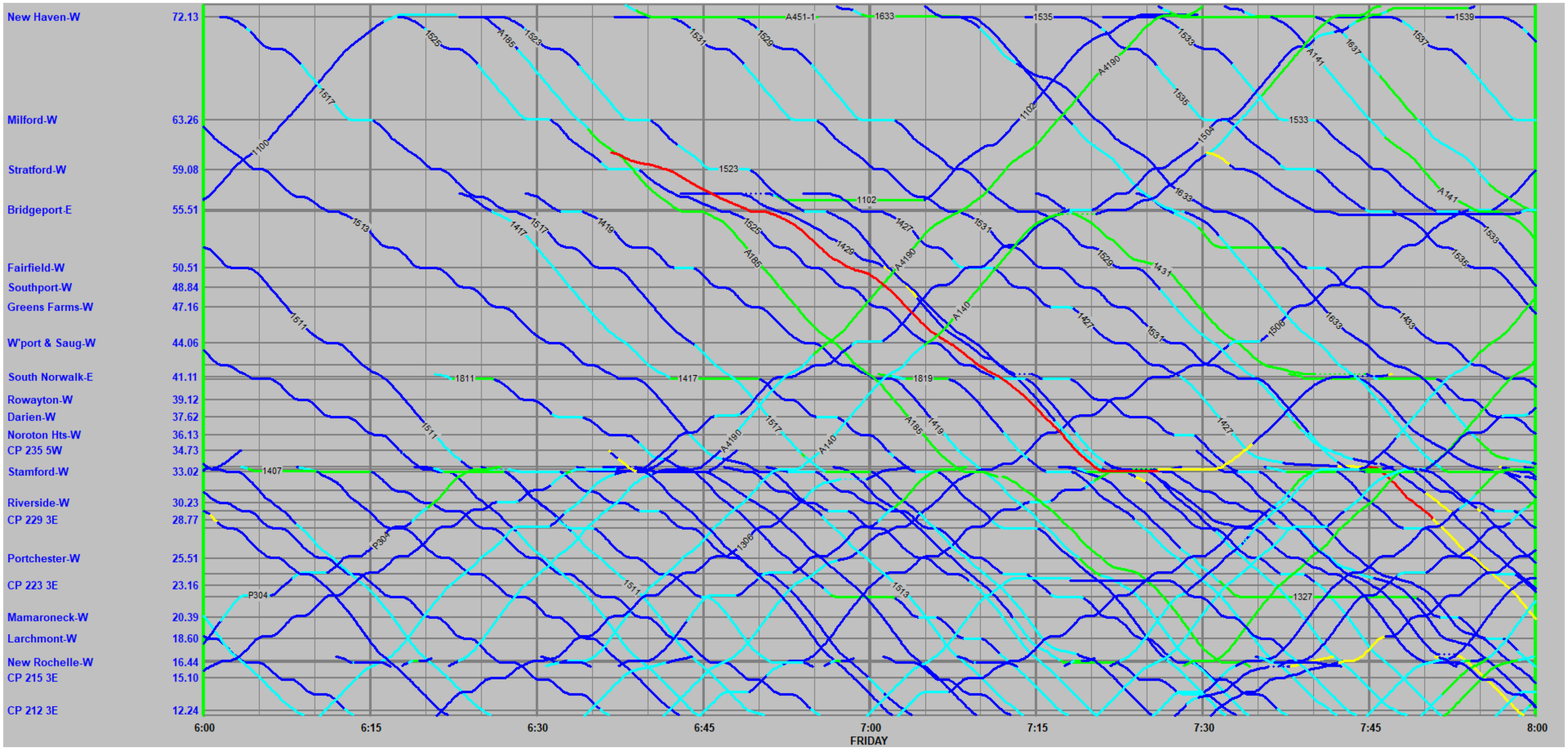

Figure 32 – New Haven Line String Chart 0600h-0800h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

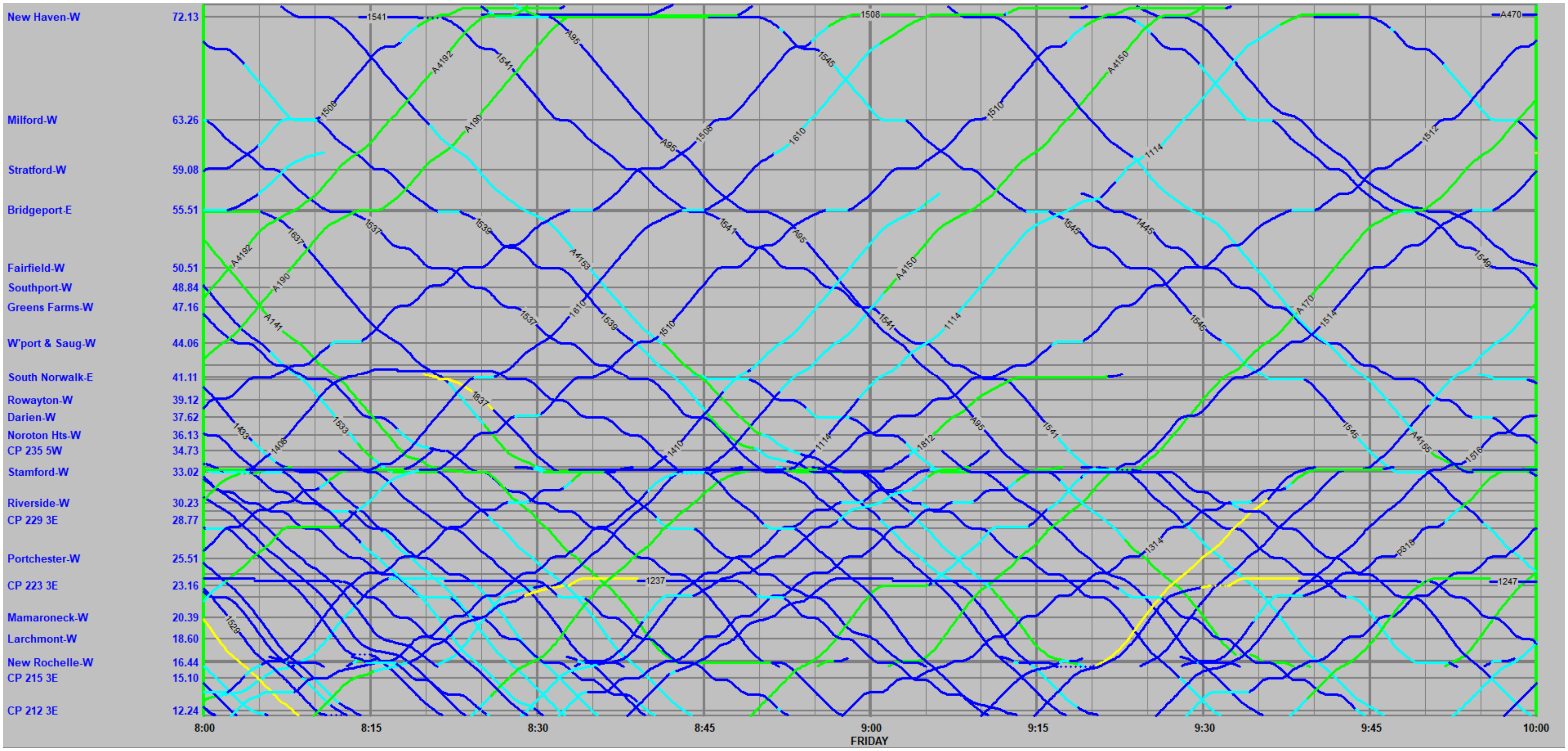

Figure 33 – New Haven Line String Chart 0800h-1000h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

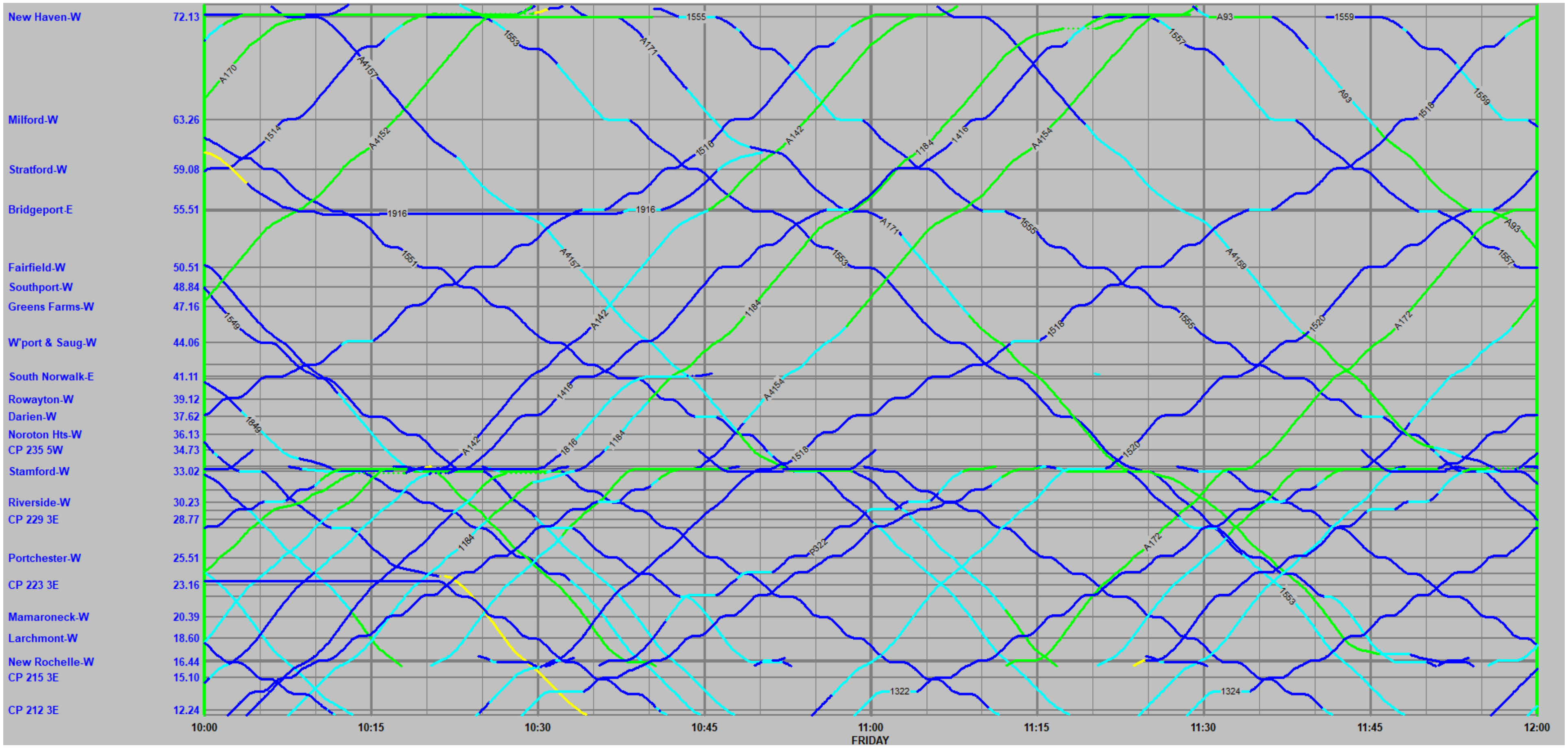

Figure 34 – New Haven Line String Chart 1000h-1200h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

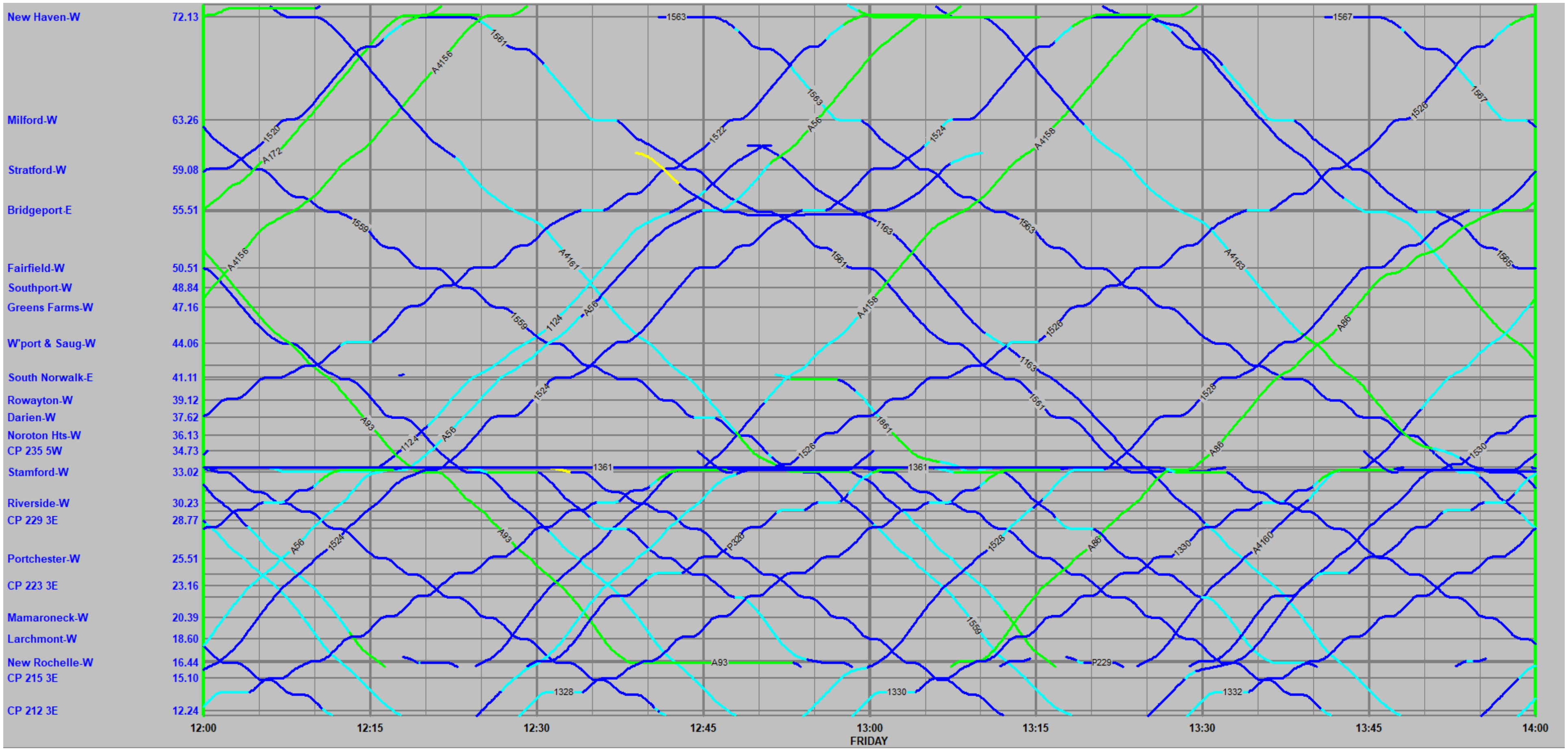

Figure 35 – New Haven Line String Chart 1200h-1400h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

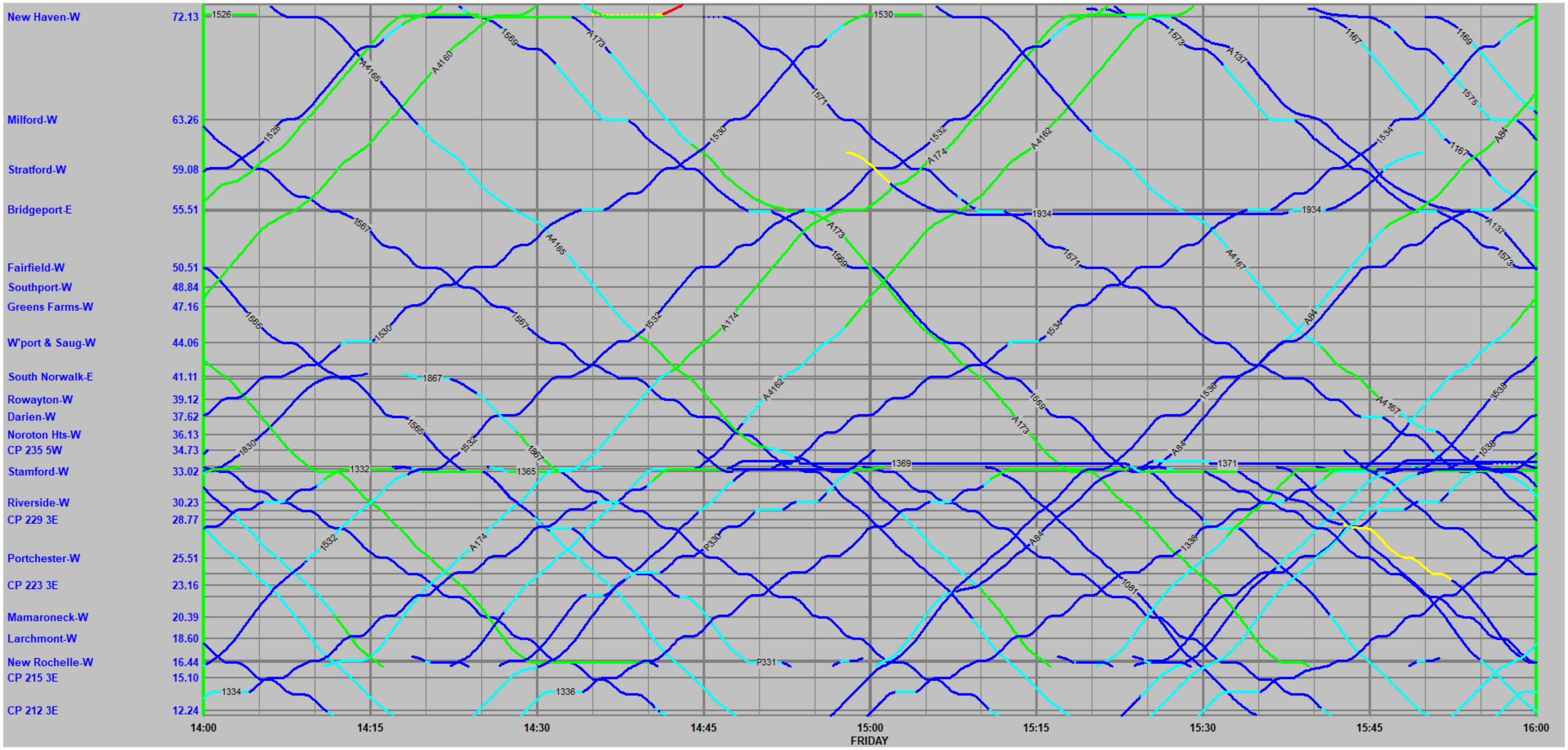

Figure 36 – New Haven Line String Chart 1400h-1600h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

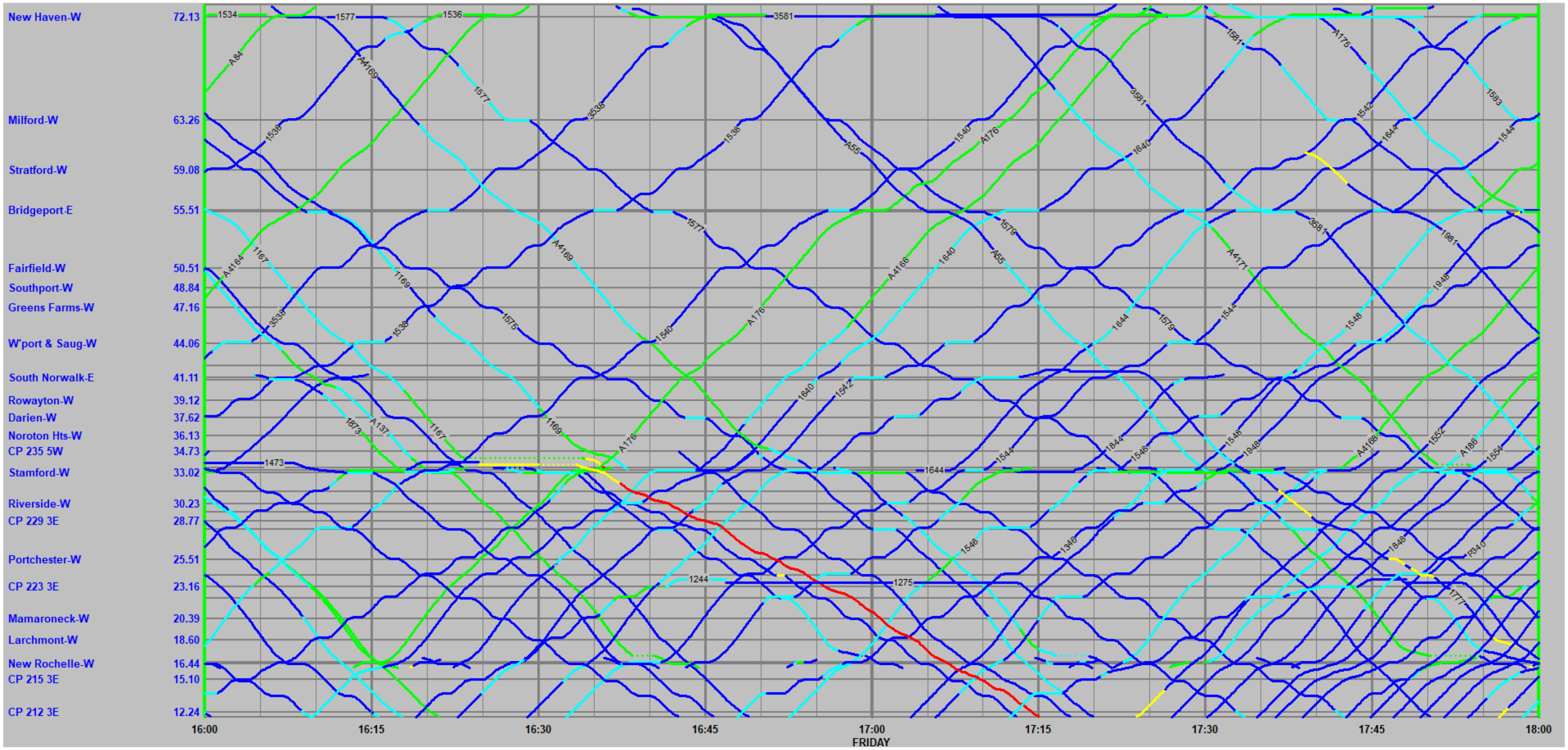

Figure 37 – New Haven Line String Chart 1600h-1800h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

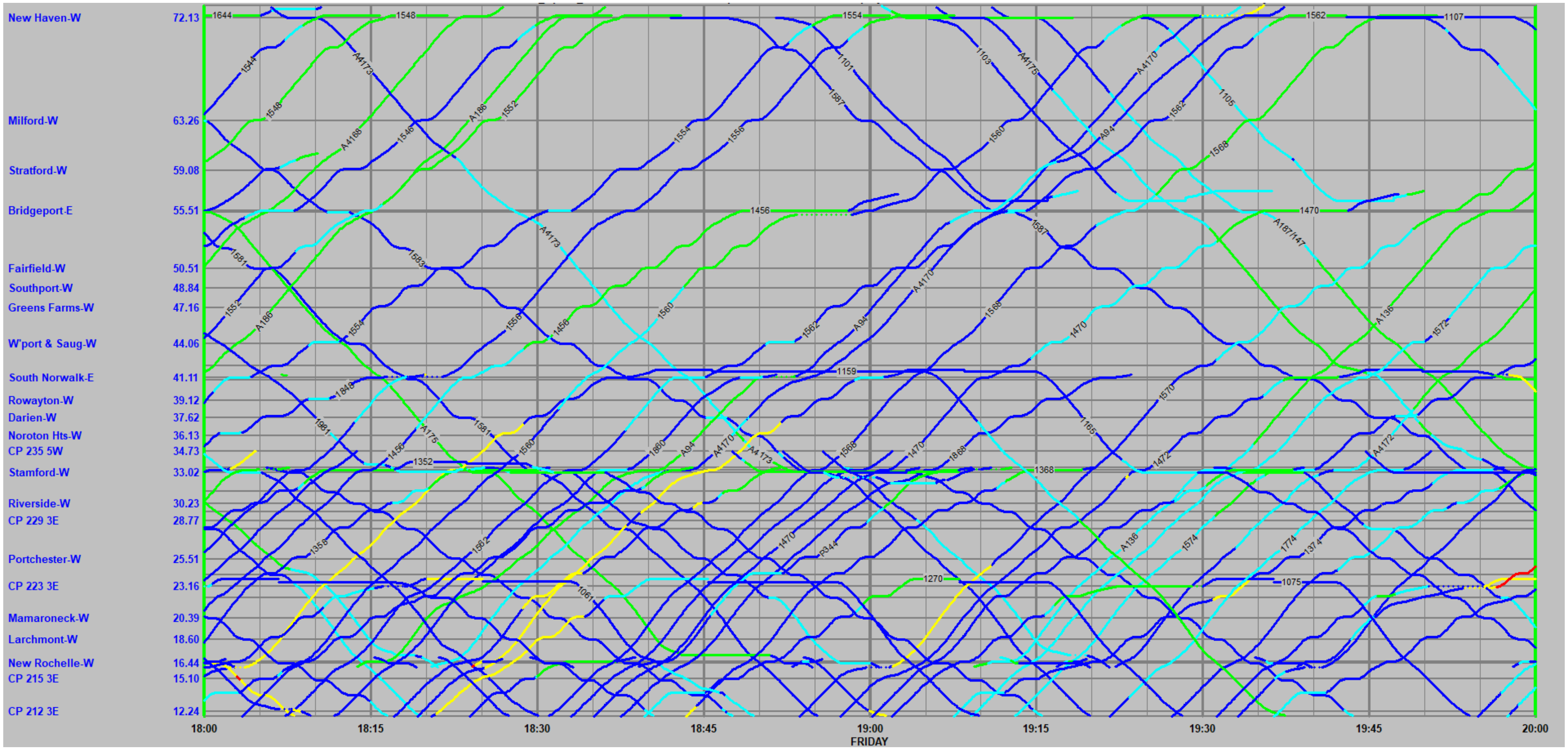

Figure 38 – New Haven Line String Chart 1800h-2000h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

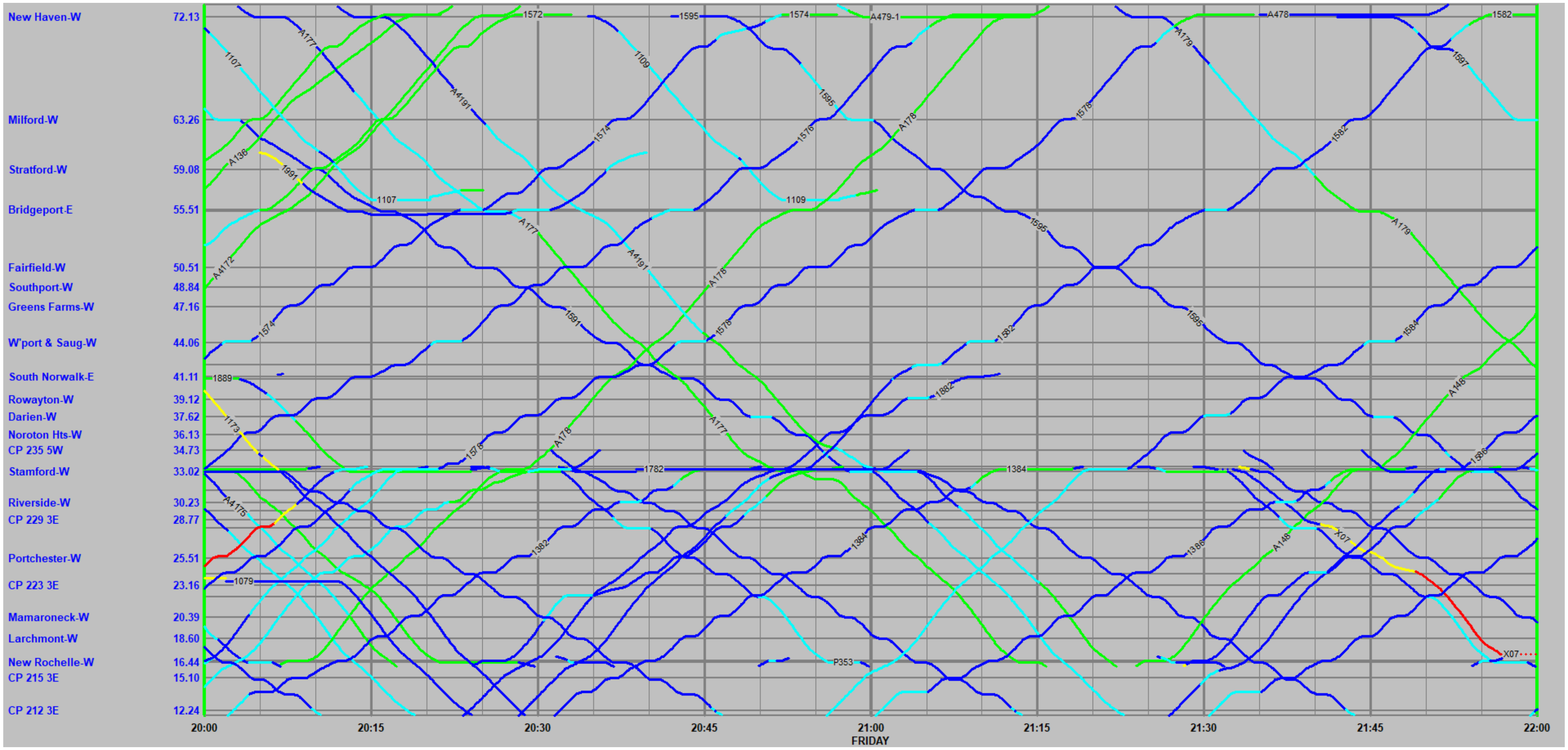

Figure 39 – New Haven Line String Chart 2000h-2200h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

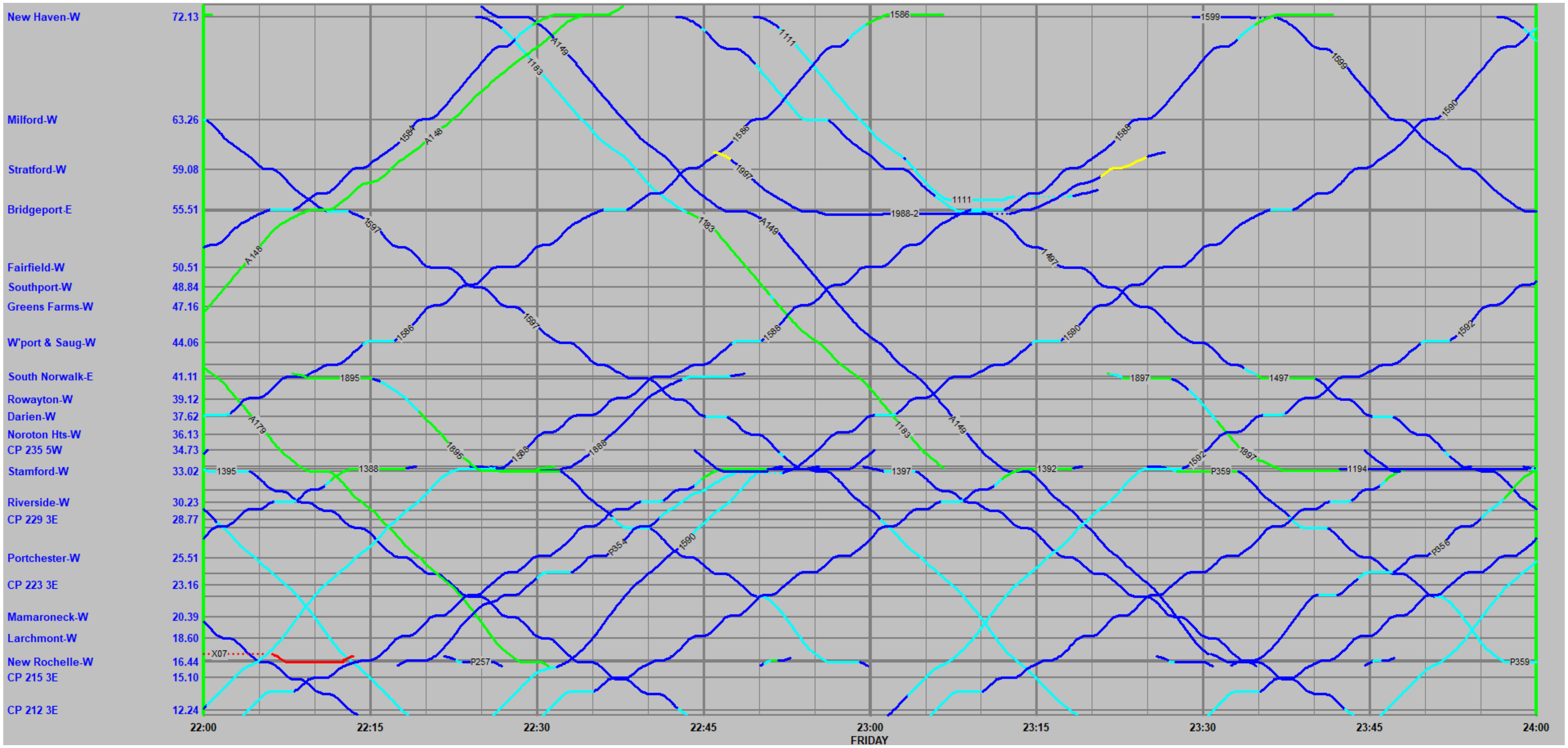

Figure 40 – New Haven Line String Chart 2200h-2400h

- Very Early (>3m)
- Early (1-3m)
- On time
- Late (3-6m)
- Very late (>6m)

A.2 RAIL NETWORK OPERATIONS DISCRETE DELAY EVENTS OPTION J1

Prepared for:

MTA/Metro-North Railroad

Rail Network Operations Discrete Delay Events Option J1

Penn Station Access
Future Build – Option J1 Discrete Delay Analyses
Technical Memorandum

December 14, 2020

MNR Contract No. 75108

Prepared by: Gannett Fleming Transit & Rail Systems

Excellence Delivered As Promised

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REVISION HISTORY

Revision	Date	Comments
1.0	December 14, 2020	Initial Release as Draft

1. INTRODUCTION

This technical memorandum presents findings of "discrete delay event" analysis emulated on the Hell Gate Line (HGL) with proposed Option J1 infrastructure modifications. A discrete delay is an isolated incident that occurs (or may occur) occasionally in the field and could be a variation of normal operations or may be abnormal. The Option J1 HGL infrastructure configuration and proposed Year 2025 Metro-North Railroad (MNR) infrastructure and operations are discussed in detail in the ***Penn Station Access Future Build – Option J1 Network Simulation DRAFT Report*** dated August 20, 2020. The report was produced as part of MTA-CC Contract No. PS864 and HNTB Project No. 65816.

Discrete delay events are unexpected, extended delays that may occur, for example, due to a medical emergency or an equipment malfunction. The events discussed in this memorandum are isolated incidents. Consistent with previous simulations performed in support of the Penn Station Access (PSA) Study Project, it was assumed that each emulated incident occurs individually, in isolation, and not concurrently). They include: 30-minute duration "delay events" at proposed Hunts Point and Morris Park stations during morning and evening peak periods; and peak-period (AM and PM) 18-minute Pelham Bay Bridge openings.

These same discrete events were previously analyzed in rail network operations simulation for earlier proposed HGL infrastructure design configurations that have since been deemed superseded and therefore obsolete. The previous analyses reflected a proposed operating plan that included scheduled 152 weekday PSA trains. By contrast, the Option J1 simulation model reflects a revised PSA operating plan with 108 scheduled trains – a reduction of nearly one-third.

The significant revision of the proposed PSA train schedules meant that the specific trains that were identified as the ones that would be stopped for 30 minutes at Hunts Point and at Morris Park were no longer present the proposed timetable and instead had been replaced with a revised schedule and stopping pattern. Train numbers were also revised. To mimic train timings from previous analyses and to ensure that the results were not sensitive to exact schedule timings, two trains were (separately) delayed in the Option J1 model to "bracket" the schedule of each of the trains from the previous 152-train timetable. For example, PSA Train M5015 is in the former 152-train timetable and was scheduled to stop at Hunts Point Station at 8:21 AM. But M5051 is not in the latest (108-train) proposed MNR PSA schedule. However, Trains P313 and P215 are scheduled to stop at Hunts Point at 8:06 and 8:24 AM respectively. These two trains have schedule timings that bracket Train M5015. Therefore, each of these trains was used to analyze discrete delay for the morning peak period.

Note that the discrete analyses conducted for this study were analyzed under deterministic (non-randomized) conditions.

2. METHODOLOGY AND ASSUMPTIONS

A. Computer Simulation Software

The Option J1 discrete delay simulations were processed using Version 74K of Rail Traffic Controller (RTC) software dated March 20, 2019. RTC is licensed by Berkeley Simulation Software based in California. This is the same version of the RTC software that was used to process the Option J1 "Build" simulation. That separate report is dated August 11, 2020. For additional information concerning over-arching simulation methodology and assumptions, readers may wish to consult that report.

B. Hell Gate Line Infrastructure

Figure 1 below provides a schematic image of the proposed Option J1 HGL configuration. Note that Bronx Interlocking is shown in the schematic and was likewise modeled in RTC. During the discrete analyses, the proposed Bronx Interlocking crossovers were never used nor were they necessary to alleviate delays and would not have been effective to address the specific delay circumstances that were tested.

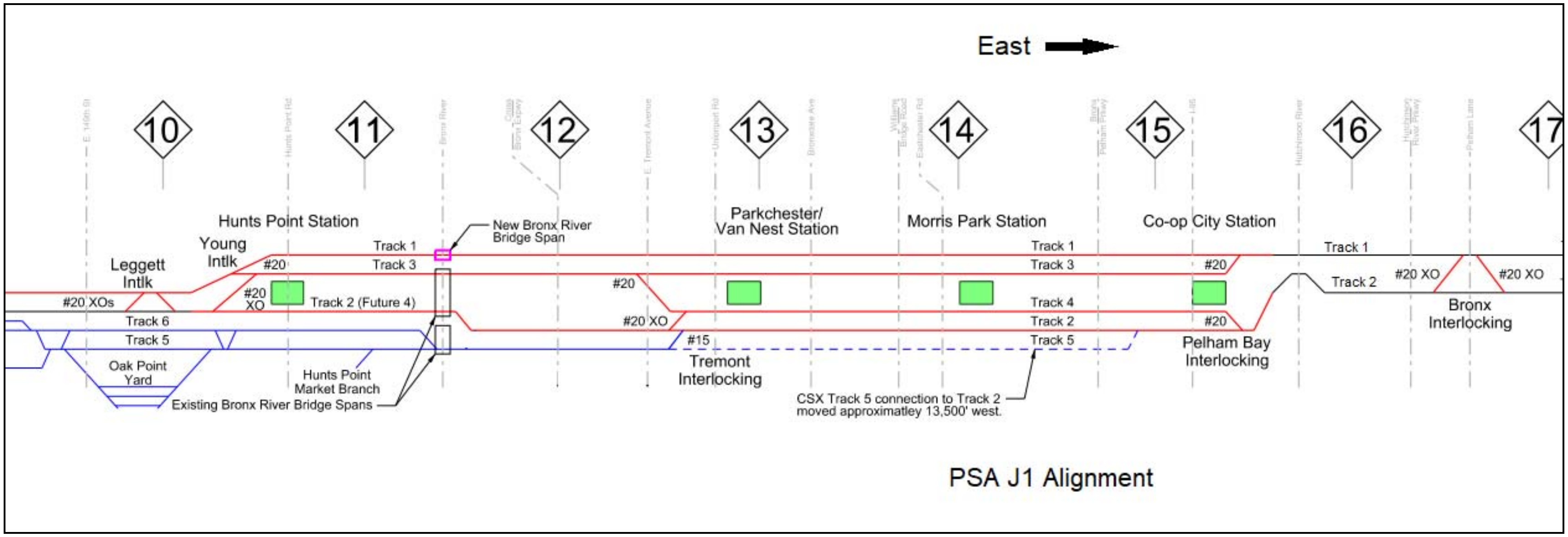

Figure 1 – PSA Option J1 Track Configuration Schematic

3. SIMULATION RESULTS AND FINDINGS

A. Discrete Event Simulations

Discrete delay event emulation is used as a "stress test" for a rail network. Delay events help to determine how a system will react to a singular, unplanned delay or mishap that might occur on the railroad. Amtrak, with MNR's concurrence, requested the following tests:

- 30-minute peak-direction delay event at Hunts Point Station during the morning and evening peak periods;
- 30-minute peak-direction delay event at Morris Park Station during the morning and evening peak periods;
- 18-minute Pelham Bay Bridge opening during the morning and evening peak periods.

1. "Incident" Delay Events

Two morning peak and two evening peak trains were selected to emulate unscheduled delay events at Hunts Point and at Morris Park stations. These trains bracket the timing of trains M5015 (AM) and M3032 (PM) that were used to analyze previous iterations of the Hell Gate Line infrastructure and proposed PSA Operations. Train delay and service recovery time[1] was evaluated for each "incident". Each delay was tested separately and not concurrently.

Trains P313 and P215 (AM westbound/inbound) were intentionally delayed on the HGL in simulation during the morning peak period and similarly Trains P240 and P340 (PM eastbound/outbound) were delayed during the evening peak. In all cases, the delay lasted for 30 simulated minutes.

Table 1 provides a summary of the morning and evening peak simulation results. The "total stop delay" metric is a sum of the delay to each of the indicated number of delayed trains including the train that was directly involved in the 30-minute station platform delay. Note that time is expressed in hours and minutes, not minutes and seconds.

Table 1 – Train Stop Delay Results – Summary

Time Period	Initial Delayed Train	Hunts Point Station Delay					Morris Park Station Delay				
		Stopped Trains MNR/ATK	Total Stop Delay (h:mm)	Slowed Trains MNR/ATK	Stopped & Slowed Trains MNR/ATK	Recovery Time (h:mm)	Stopped Trains MNR/ATK	Total Stop Delay (h:mm)	Slowed Trains MNR/ATK	Stopped & Slowed Trains MNR/ATK	Recovery Time (h:mm)
Morning Peak	P313	2/0	0:39	0/0	2/0	0:07	2/0	0:40	0/0	2/0	0:05
	P215	2/0	0:30	0/0	2/0	0:12	2/0	0:31	0/0	2/0	0:18
Evening Peak	P240	3/0	0:36	1/0	4/0	0:00	2/0	0:39	0/0	2/0	0:06
	P340	1/0	0:30	1/0	2/0	0:00	2/0	0:37	0/0	2/0	0:07

The data in Table 1 shows that no Amtrak trains were impacted by the 30-minute station delays. This is not surprising at Morris Park Station because the station is within the proposed four-track

[1] "Recovery time" is the elapsed time from the time the incipient delay ends until trains are once again operating on schedule.

territory on the HGL. Trains delayed at Hunts Point Station have more *potential* to delay Amtrak trains because of the three-track configuration at that site. However, with the lower volume of PSA trains in the operating plan, Amtrak trains were not impacted because they could easily navigate around the outage. Overall, the number of trains affected by the delay events is minimal in simulation and the delay recovery time is brief except for delays involving Train P215, which are discussed below.

The recovery time for the morning delay events involving Train P215 at Hunts Point and Morris Park is significantly longer in comparison to the delays involving Train P313. The reason for this is that the following train (P217) is delayed behind P215. Train P217 is stopped behind P215 for only 10 seconds during the Hunts Point delay event and for just over 1 minute during the Morris Park delay event (shown in Figure 2 below)

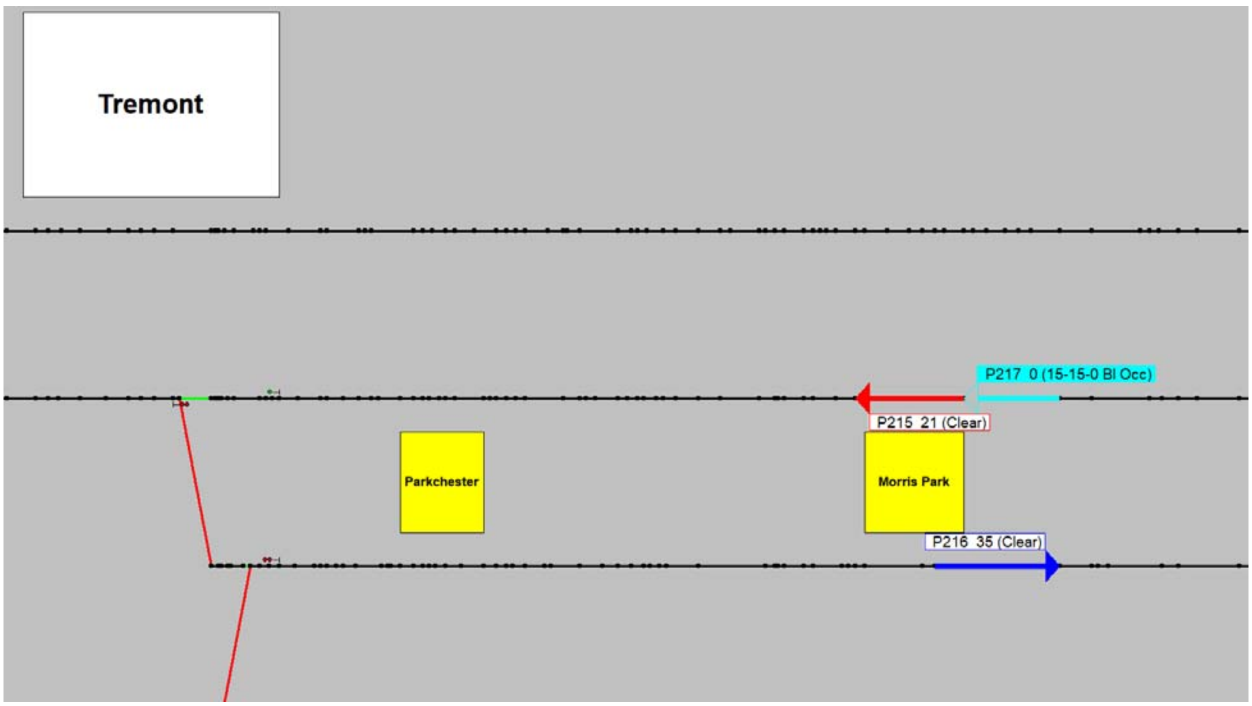

Figure 2 – Train P217 Delayed at Morris Park

Train P217 experiences a subsequent and more significant delay at Young Interlocking, where it is held for an overtake by Train A141 (see Figure 3 below). The delay at Young Interlocking is not reflected in the *stop delay* metrics in Table 1, but the delay is captured in the *delay recovery* metrics instead. Note in Figure 3 that P217 is not yet considered late as it arrives at Young Interlocking and is therefore shown "blue" in the image.

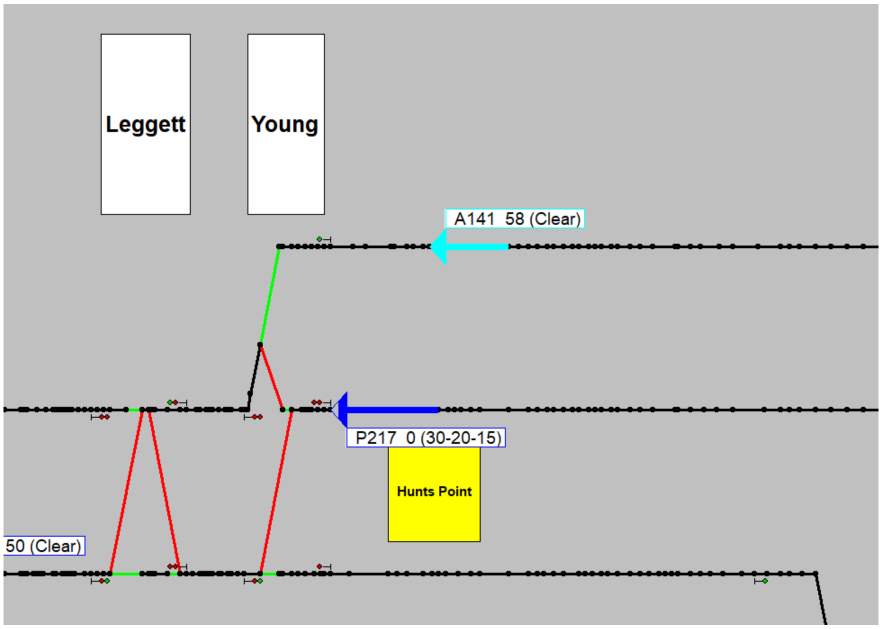

Figure 3 – Train P217 Delayed at Young Interlocking

The decision to hold P217 at 'YOUNG' to allow A141 to overtake it is a judgment call. Over-arching direction to the simulation effort is to allow same-direction Amtrak trains to overtake PSA trains when indicated by the timetabling and a reasonable train dispatcher. In this case, the delay at Morris Park has just concluded and there would be reasonable doubt as to whether A141 might be delayed if P217 is permitted to proceed ahead of it. Moreover, there might have been an unusual level of passenger/pedestrian activity on the Hunts Point Station platform because of the very recent 30-minute interruption to morning peak PSA service. The decision was made to hold A141 by the simulator. This represents a collateral delay secondary to the incipient 30-minute platform delay at Morris Park. However, it also demonstrates that Amtrak service was not disrupted.

It is also noteworthy that the evening peak delay of Train P240 at Hunts Point Station resulted in three stopped trains (including P240 itself), and yet the system recovered immediately following the conclusion of the delay. To explain, westbound (reverse-peak) Train P339 holds for just under 6 minutes at 'TREMONT', to allow Train A4168 and following Train A186 to overtake (circumvent) delayed Train P240 at Hunts Point (see Figure 4 below).

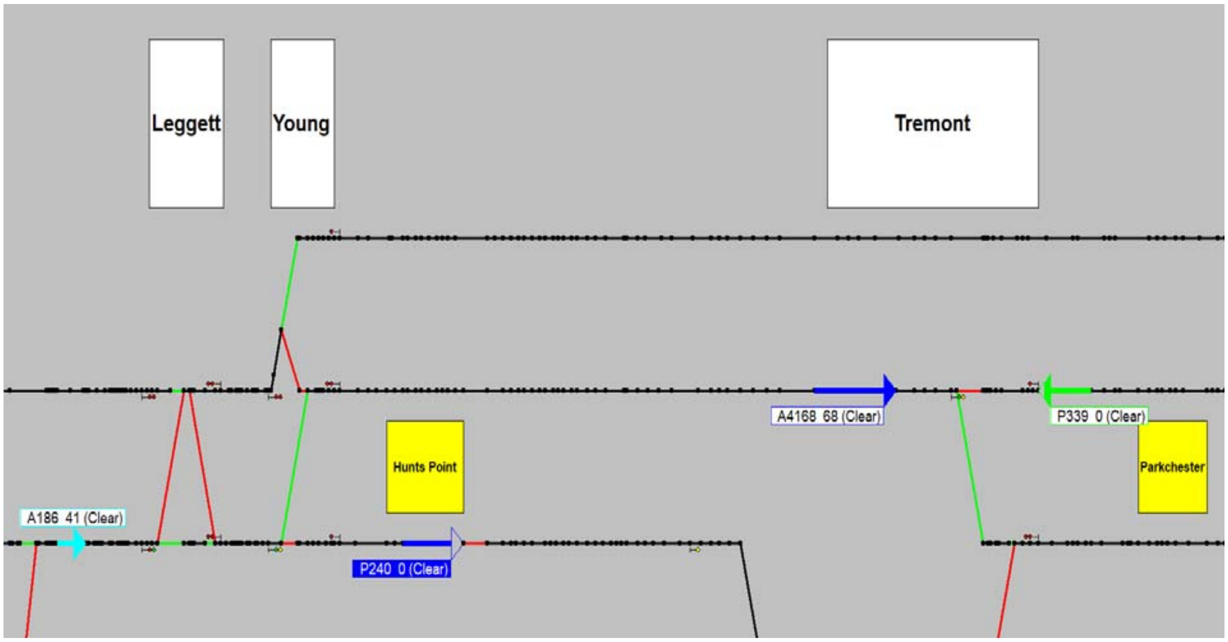

Figure 4 – Train Delay at Tremont During Hunts Point Incident

Figure 4 shows Amtrak Train A4168 has diverged from its normal Track 2 route at 'YOUNG' to Track 3 and is about to diverge from Track 3 (which is a detour route) onto Track 4 (continuing a detour route), this circumventing the delay caused by Train P240 at Hunts Point (at lower left). There is a small time penalty to A4168 due to the two crossover moves but the train never stops moving. Train A186 will make the same diverging movements while westbound Train P339 is held at Tremont.

P339 then proceeds westward and delays Train P340 briefly at Young Interlocking (see Figure 5 below). After Young Interlocking is clear, P340 similarly circumvents the delay, accessing Hunts Point via Track 3. Because P340 is not stopped behind P240 at Hunts Point, recovery is immediate after the delay to P240 concludes.

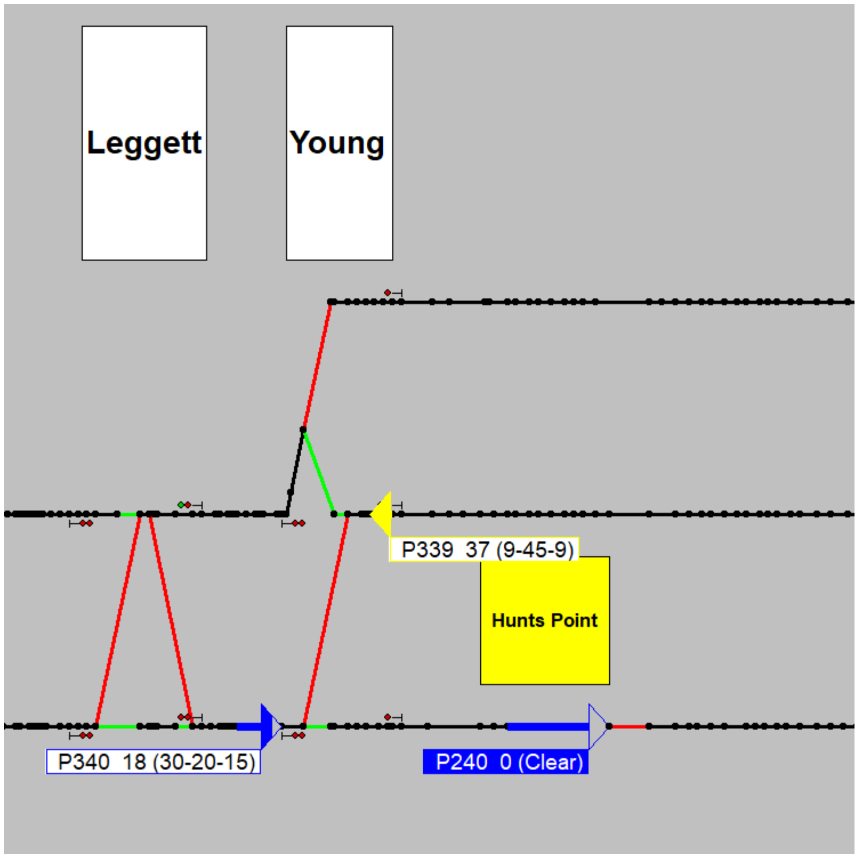

Figure 5 – Train Delay at 'Young' During Hunts Point Incident

In Figure 5, eastbound Train P340 has reduced speed to 18 mph and is waiting for opposing Train P339 to vacate Track 3. P340 will access Hunts Point Station via Track 3 (the center track), thereby overtaking delayed Train P240. This causes only a small delay to Train P340 and isolates the delay to P240 that has been involved in the protracted delay at Hunts Point station. When Train P240 proceeds, recovery is immediate. Moreover, from the standpoint of passenger convenience, passengers affected by the delayed P240 have a cross-platform option to take P340 instead and be on their way. Amtrak train operations are unaffected except for the small time penalty due to making two crossover moves that are not part of their normal route via Track 2.

2. Bridge Opening Delay Events

Metro-North previously directed that Pelham Bay bridge openings be simulated from 8:00 – 8:18 AM (morning peak) and from 5:50 – 6:08 PM (evening peak)[2]. After review and analysis of bridge tender logs and consultation with Amtrak, including advice from same, it was determined that an 18-minute opening was typical and reasonable for simulation.

[2] It should be noted that Amtrak's bridge tender logs indicate that bridge openings occur primarily during off-peak hours.

Table 2 presents the bridge opening delay results. The total stop delay is an aggregate of all trains that were stopped due to the bridge opening. Recovery Time is the elapsed time for operations to restore to normal after the delay event ends. The results in Table 2 show minimal impact to rail traffic and brief system recovery time.

Table 2 – Bridge Opening Delay Results – Summary

Time Period	Stopped Trains MNR/ATK	Total Stop Delay (h:mm)	Slowed Trains MNR/ATK	Stopped & Slowed Trains MNR/ATK	Recovery Time (h:mm)
Morning Peak	2/1	0:16	0/0	2/1	0:06
Evening Peak	2/1	0:21	1/1	3/2	0:09

a) Morning Bridge Opening

The first train delayed by the morning bridge opening is P214, which arrives at the Pelham Bridge interlocking signals almost 10 minutes after the 8 AM opening. Amtrak Train A4150 arrives next and is stopped at the interlocking signals at approximately 8:17 AM. When the bridge opens, A4150 proceeds ahead of P214 (see Figure 6) and is therefore unaffected by the PSA trains.

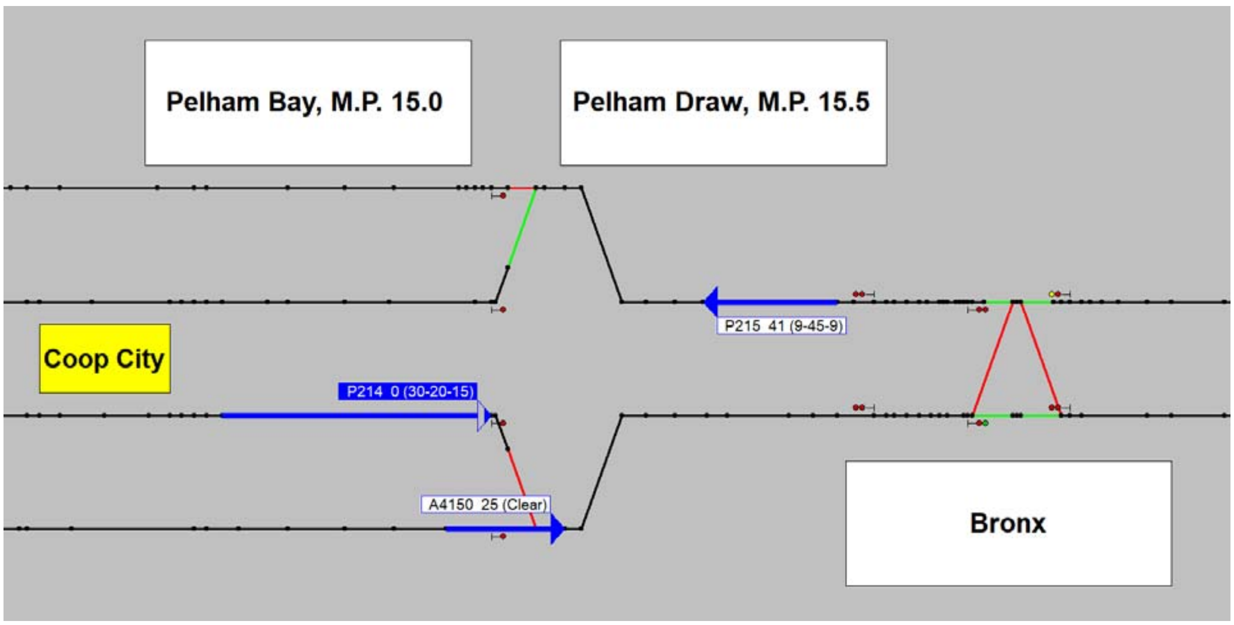

Figure 6 – Recovery from Pelham Bay Bridge Opening – AM Peak

b) Evening Bridge Opening

The first train to arrive during the evening peak bridge opening is P242, which reaches proposed new Pelham Bay Interlocking more than three minutes after the 5:50 PM bridge opening has commenced. Amtrak Train 55 arrives next, approximately 12 minutes after the bridge has opened. Train A55 is unaffected by the presence of PSA trains on the line because it is running ahead of the closest westbound PSA train which is P343. Figure 7 below shows train movement after the evening bridge opening event has concluded and trains begin to proceed.[3]

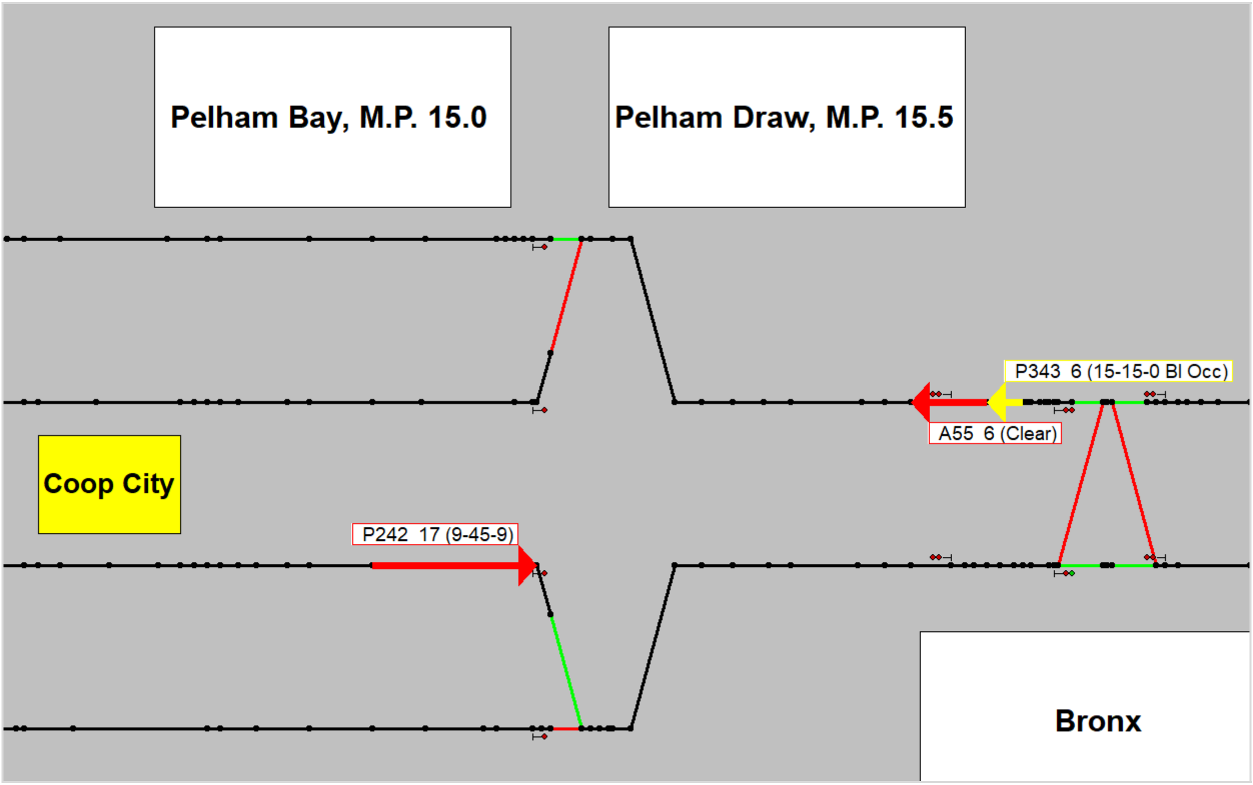

Figure 7 – Recovery from Pelham Bay Bridge Opening – PM Peak

During the evening peak period bridge opening emulation which interrupts train traffic on both main tracks, one Amtrak train and two PSA trains are directly affected. However, the presence of proposed PSA trains did not have any impact on Amtrak in this case. Amtrak Train 55 would still have been impacted by the bridge opening and to the same degree.

It is important to note that the Amtrak bridge tender has ten minutes' latitude to allow an imminently approaching train to cross the bridge after an opening request has been made by mariners. In the example above, Train P242 might have been permitted to cross the bridge and be on its way because it arrived only 3 minutes after the presumed opening began. Amtrak Train 55 having arrived approximately 12 minutes after the presumed raise would have been stopped in any case.

[3] The RTC simulation software color-codes a segment of track -- such as a signal block -- as occupied when any part of it is occupied. This creates the usually incorrect illusion that trains are stopped with no separation from the train ahead, as in Figure 7.

If the bridge tender delayed the bridge opening to allow P242 to cross, the bridge opening event would be shifted by 3 to 4 minutes. Under this scenario, westbound Trains A55 and P343 would experience 3 to 4 minutes of *additional* delay. Also, eastbound Train A94, which is the next scheduled train after P242, would be delayed 2-3 minutes due to the shift in bridge opening time. So, unless it would have been imperative to expedite Train P242, the bridge tender was better off raising the bridge immediately in this case. This also illuminates that had the bridge tender waited for P242, the avoided delay to that train would've been replaced one-for-one with a delay to A94 instead.

4. CONCLUSIONS

The simulated discrete events reveal track infrastructure and PSA train operations that are very resilient to the unexpected peak-period “discrete delay” events that were tested, including routine (normal) openings of the existing Pelham Bay moveable bridge.