Association Of American Railroads

RTC Modeling Simulation of CREATE P2 Project

Chicago, Illinois
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1 Introduction

The Association of American Railroads (AAR), as directed by the Chicago Transportation Coordination Office (CTCO), asked HDR to conduct computer-based rail simulation modeling of the Chicago Terminal District to compare train performance in the terminal with and without CREATE Project P2, the Rock Island Connection project. The rail simulation modeling was performed to support AAR's preparation of a grant application requesting funding from the U.S. DOT's FY 2024-2025 Federal-State Partnership for Intercity Passenger Rail program to construct the P2 project.

The P2 project, also known as the Rock Island Connection project, will construct a two-track flyover structure to connect the Metra SouthWest Service line near 75th Street and Halstead to the Rock Island District in the vicinity of 75th Street and Parnell, allowing Metra SouthWest Service trains to access Chicago's LaSalle Street Station instead of Union Station, which will increase capacity for the Metra SouthWest Service and free capacity at Union Station for future increased Amtrak service.

The P2 project is one component of the 75th Street Corridor Improvement Project, which is a group of four infrastructure improvement projects to eliminate the most congested rail chokepoint in the Chicago Terminal, Belt Junction, where 30 Metra Southwest Service trains and 90 freight trains per day cross each other's paths.

To conduct the rail simulations, HDR used the Chicago Terminal District's Rail Traffic Controller (RTC) model. This version of the model, originally created in 2015, was subsequently updated with more recent traffic data provided by Railinc for passenger and freight trains operating through the terminal in late 2021. In addition, the model incorporates rail infrastructure as of 2023, which includes speeds, track configuration, traffic flow direction, sidings, etc. This model is known as the "Current Build" version of the model (the "Base 2023 Case"), as it includes all CREATE fully budgeted or constructed rail infrastructure as of 2023. The model software was reverted to operate with the previous RTC release (76Z, dated December 14, 2023) to keep consistent with previous studies.

AAR requested technical assistance to run the rail simulations using the updated RTC model to compare how train operations in Chicago would differ between two scenarios:

- If the Rock Island Connection flyover (project P2) is not constructed and
- If the Rock Island Connection flyover (project P2) is constructed.

Both scenarios assume that an adjacent CREATE project has also been built and is in service, the 80th Street Junction Replacements project Segment A (project EW2A). This assumption was made to calculate the incremental benefits of the P2 project without including benefits from other planned 75th Street Corridor improvements. This assumption also acknowledges that the EW2A project must be completed to start building the P2 project. The EW2A project will reconfigure track segments and signals at Belt Junction; add a third track to the NS line; replace and restore 14 aging grade separation bridges; and implement mobility improvements on surface streets along a 3-mile elevated rail corridor on Chicago's South Side. Project EW2A runs through Belt Junction, along W 75th Street, bordering NS Landers Yard to the west (at S Maplewood Ave), and splitting at the Emerald Wye to the east (east of S Union Ave). The Project's northeast limits terminate at West 72nd Street, and its southeast limits terminate at West 79th Street, near 80th St Junction. The area within the EW2A project limits sees 90 freight trains per day, in addition to 30 Metra SouthWest Service trains per day, and 3 Amtrak Cardinal trains per week in each direction.

Figure 1-1 depicts the project area.

Figure 1-1 Project Area Map Showing Rock Island Connection Flyover

RTC train performance outputs from the two models were compared in five year increments up to 25 years from 2023.

Figure 1-2 depicts the RTC Model in the Current Build configuration ("Base 2023 Case") incorporating all current and planned CREATE rail infrastructure improvements in the Chicago Terminal District.

Figure 1-2 RTC Model Current Build configuration incorporating all current and planned CREATE rail infrastructure improvements as of 2023

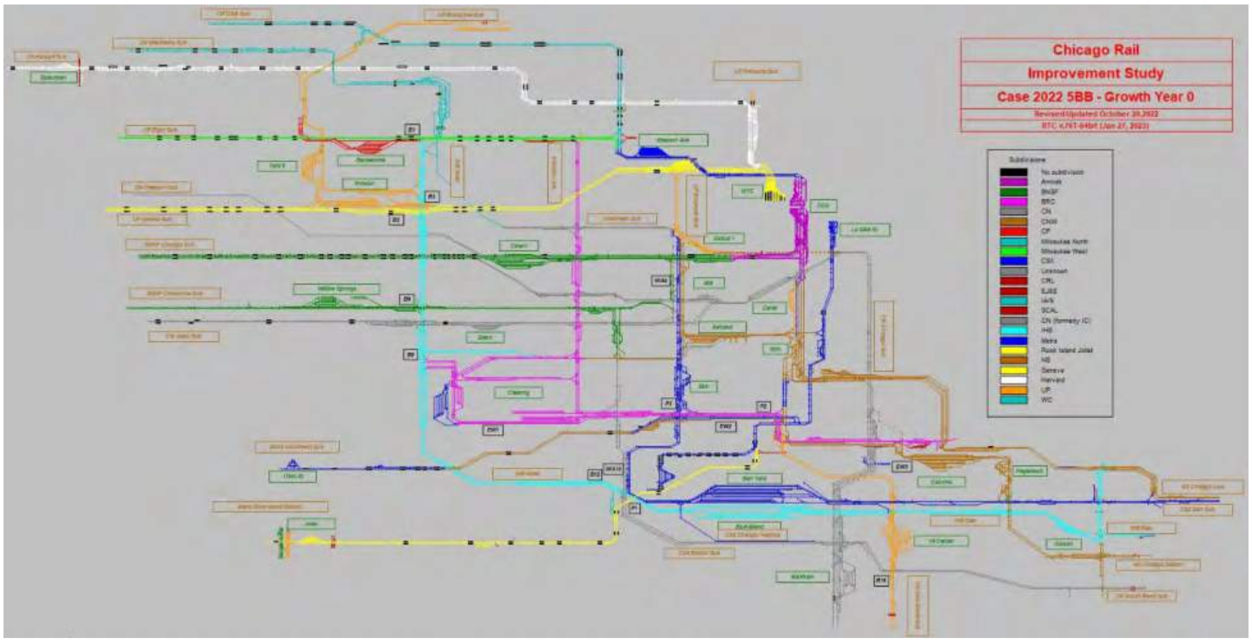


Figure 1-3 depicts the RTC Model in the vicinity of the 75th Street Corridor, showing all current and planned CREATE rail infrastructure improvements in the Current Build version of the model (the "Base 2023 Case"), plus the addition of the 80th Street Junction Replacements project Segent A (project EW2A). For the purposes of this RTC rail simulation modeling study, the track configuration shown in Figure 1-3 represents the EW2A case, which is the No Build condition (further described in Section 2), wherein the Rock Island Connection flyover is not constructed yet, but the adjacent Belt Railway of Chicago tracks have been shifted and reconfigured.

Figure 1-3 RTC Model Infrastructure in the 75th Street Corridor with Project EW2A

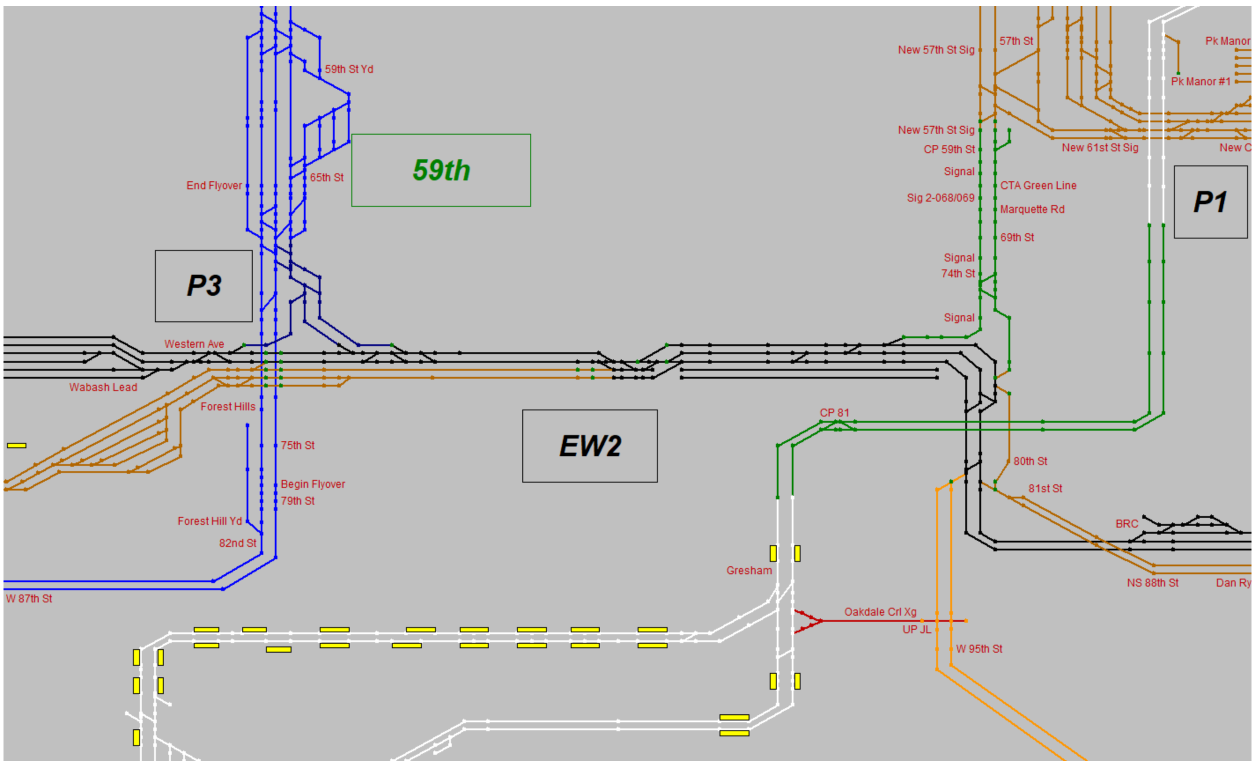
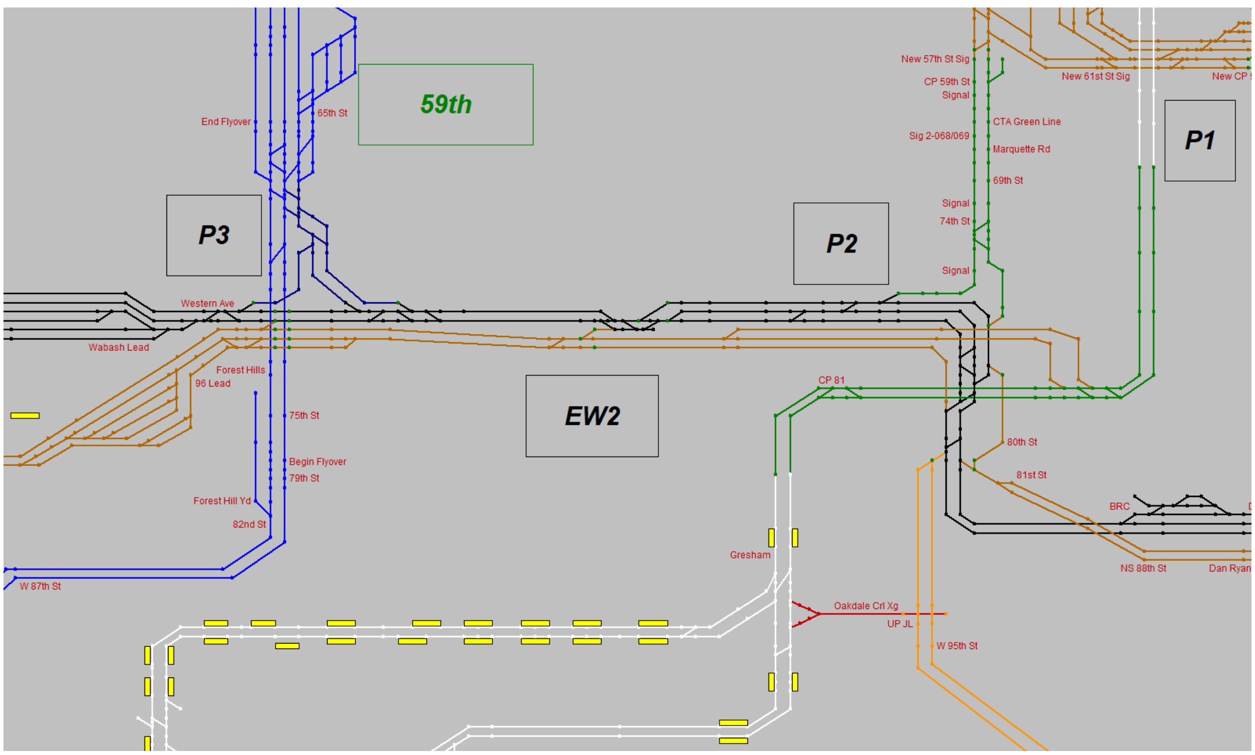


Figure 1-4 depicts the RTC Model RTC Model in the vicinity of the 75th Street Corridor, showing all current and planned CREATE rail infrastructure improvements in the in the Current Build version of the model (the "Base Case"), plus the addition of the 80th Street Junction Replacements project Segent A (project EW2A) and the addition of project P2, the Rock Island Connection flyover for Metra SouthWest Service trains. For the purposes of this RTC rail simulation modeling study, the track configuration shown in Figure 1-4 represents the EW2B-1 case, which is the Build condition (further described in Section 2), wherein the Rock Island Connection flyover is constructed. In addition to the Rock Island Connection flyover, the EW2B-1 case includes the extension of an adjacent single main track for Norfolk Southern, the NS Landers Main track, extending from Belt Junction eastward to the 80th Street interlocking. The combination of the Rock Island Connection flyover and the NS Landers Main track extension represent the components of project EW2 Segment B1, which is why the Build case is labeled EW2B-1.

Figure 1-4 RTC Model Infrastructure in the 75th Street Corridor with Project EW2A and Project P2



2 RTC Modeling Methodology

For this task, HDR developed the following RTC models:

- **EW2A** – This model incorporates the Chicago Terminal infrastructure in the Current Build version of the model (Base 2023 Case) and also assumes that Segment A of Project EW2 has been completed. The Base 2023 Case defines the existing freight and passenger operations in the model and includes all constructed or funded CREATE rail infrastructure improvements as of 2023, with future year cases at 5-year increments (up to 25 years); the Base 2023 Case includes completion of the CREATE P3, EW3 and WA11 projects. In this model, Metra SouthWest Service trains operate to and from Chicago Union Station. For purposes of a grant application, the EW2A case could be considered the "No-Build" case.
- **EW2B-1** – This model incorporates the Chicago Terminal infrastructure in the Current Build version of the model and also assumes that (1) Segment A of project EW2 has been completed and (2) that project P2, the Rock Island Connection flyover, has been completed and that the NS Landers Main track has been extended from Belt Junction to 80th Street (project EW2 segment B1). In this model, Metra SouthWest Service trains use the P2 flyover to access the Rock Island District and operate to and from Chicago LaSalle Street Station. For purposes of a grant application, the EW2B-1 case could be considered the "Build" case.

HDR updated RTC models that were originally developed in 2015. The original models did not include any railroad signal operations, and none were added in the updated models due in part to the time and cost it would take to add functioning signals to the entire CREATE model. The Base 2023 Case only includes track infrastructure changes and does not include any projects related to tower improvements or highway-rail grade separations.

CREATE projects that are in the Base 2023 Case include all completed and funded projects as of 2023:

- B1: Canadian Pacific Crossover Upgrades
- B2: Union Pacific Third Mainline- Proviso Yard
- B3: Melrose Connection
- B4/B5: La Grange/Broadview Signalization
- B6: McCook Connection
- B8: Summit Signalization
- B9: Argo Connections
- B12: Third Mainline- 123rd Street to Cal Sag Channel
- B15: Signalization of Blue Island Yard Running Tracks
- B16: Thornton Junction Connection
- EW3: Pullman Junction
- EW4: BRC and Norfolk Southern Signalization
- P1: Englewood Flyover
- P3: Forest Hill Flyover
- WA3: Signalization- Ogden Junction to CP 518
- WA4: BNSF Horseshoe
- WA5: Corwith Tower Upgrade
- WA10: Blue Island Junction

- WA11: Dolton Interlocking

In addition, the following CREATE project was added to the EW2A case:

- EW2A: 80th Street Junction Replacements (75th Street CIP) Segment A

In addition, the following CREATE projects were added to the EW2B-1 case:

- EW2A: 80th Street Junction Replacements (75th Street CIP) Segment A
- P2: Rock Island Connection (75th Street CIP)
- NS Landers Main track extension (the additional component of project EW2 Segment B1)

3 Rail Traffic Controller Modeling

3.1 Operations Simulation

3.1.1 Overview

Operations simulation consists of understanding the effects of a proposed or anticipated change in infrastructure, trains, or both on all trains that operate on a selected portion of a railroad. “Changes” typically consist of additional trains, additions, or subtractions to fixed infrastructure (e.g., a new siding), a modification to train characteristics (e.g., longer, or faster trains), or a modification to when trains operate (i.e., a new train schedule). To understand the change’s effects, multiple operations simulation cases are prepared to enable comparisons between alternative future conditions in which the change is and not implemented. Formally, the “No-Build Case” forecasts how all trains would operate over the railroad *without* the proposed change. The “Build Case” forecasts how all trains would operate over the railroad *with* the proposed change.

Operations simulation models seek to replicate “real world” train operations. The model attempts to dispatch trains such that each train obtains its best performance and outcome independently given its priority among all trains, within a set of rules that limit train behavior, such as maximum speed, acceleration and braking rates determined by tonnage and horsepower, and required station and terminal stops. The operations simulation model then delivers metrics that inform the user about train performance in the world that the user defined. To find out how trains would operate in a different world, the user must define the world differently and create a new operations model.

The software used for the operations simulation is the RTC operations simulation model, developed and licensed by Berkeley Simulation Software, LLC. Additional HDR developed data pre-and post-processing tools to automate the input and output of data from the model. These tools do not affect train dispatching or performance within the RTC model itself.

3.2 Modeling Assumptions

3.2.1 Simulation Period

All cases were dispatched for a 3-day weekday period, exclusive of 12-hour warm-up and 12-hour cool-down periods. The purpose of the warm-up and cool-down is to obtain a steady state of operation. During the warm-up period, train volumes and train conflicts taper upward as trains have not yet entered and fully populated the network. During the cool-down period, train volumes and train conflicts decline as trains begin to exit the network without new seed train replacement. In both warm-up and cool-down periods, train volumes and dispatching conflicts are unrealistic; thus, metrics captured from these periods and averaged with the steady state condition would overestimate network performance. The model starts on Tuesday and ends on Friday, with the three-day capture period running from midday Tuesday through midday Friday.

3.2.2 Randomization of Train Delay Events

Since the AAR CREATE model was originally developed, RTC randomization of train delays was never deployed due to the concern that a model of this size would be unable to complete successful dispatch runs with random delay events spread across the simulation.

Actual train performance data was gathered from November 16 to November 21, 2021. Symbol trains entered the model limits at different times. For example, NS train 17V entered the model at the following times during the simulation period:

- 14:09
- 06:12
- 16:38
- 06:39
- 23:36

Randomization attempts to create a simulation representing the random nature of daily railroad operations. With the model using actual train data that shows the variance in daily train operations, it was determined that RTC randomization was not necessary.

3.2.3 Train Priority

The Chicago Terminal Operating Protocol requires that passenger trains have priority over freight trains in the case of a conflict at a control point or major rail / rail crossing. The model is configured to adhere to this protocol. Some rail lines in the Chicago Terminal District have curfews that do not permit freight trains to operate during weekday morning and evening peak commuter hours (totaling 6 hours per weekday). The model is configured to incorporate freight train operating curfews on the rail lines where such curfews are in effect. However, the tracks used by Metra SouthWest Service trains do not have freight curfews and are only dispatched using the train passenger train priority protocol in the model.

3.2.4 Train Performance Metrics

The following train performance metrics were calculated:

- Total Delay Hours: The total number of train delay hours during the 3-day modeling period
- Delay Minutes per 100 Train Miles: The total number of delay minutes per the amount of time it takes a train to operate 100 miles
- Average Train Velocity: Measured in miles per hour, as the sum of all train miles operated during the 3-day modeling period divided by the sum of all hours of train operation accumulated during the 3-day modeling period
- Total Elapsed Hours: The total amount of time that trains spent in the network during the 3-day modeling period

- Total Fuel Gallons: The total amount of diesel fuel in gallons consumed by trains during the 3-day modeling period

A comparison of the EW2A model (the No Build condition), with EW2B-1 model (the Build condition) estimates how the network would perform in the future with the constructed and funded P2 project in service compared to a future in which the P2 project was not constructed and placed into service.

3.2.5 Freight Growth Metrics

HDR used regional forecasted Chicago annual growth rates (CAGR) disaggregated by directionality and traffic type based on the most recent FHWA Freight Analysis Framework (FAF5). The Chicago Department of Transportation (DOT) and Cambridge Systematics provided the growth rates in Table 3-1.

Table 3-1 Recommended Greater Chicagoland Regional Freight Forecasted Annual Growth Rates

Freight Traffic Type (Regional Forecasts)	Thru Traffic CAGR	In/Out/Intra Traffic CAGR	All Traffic CAGR
Intermodal	1.25%	2.41%	1.81%
Carload Rail (Regional, FAF5)	0.80%	2.81%	1.85%
Manifest	2.43%	3.24%	2.86%
Unit (Except Coal)	-0.05%	2.17%	1.49%
Coal Unit	-4.61%	-0.61%	-4.41%
Combined Intermodal/Carload Rail	**1.01%**	**2.64%**	**1.83%**

Source: FHWA FAF5. Intermodal is domestic mode 5-Multiple Modes. Note: CAGR calculated between 2019-2050. See the methodology section of this memorandum for more information.

The model uses compounded annual growth rates in 5-year increments up to 25 years. There was no growth assumed for Metra commuter trains or Amtrak passenger trains. Passenger train schedules are pre-Covid except for Metra SouthWest Service, which used schedules effective January 16, 2023. Pre-Covid schedules were also used for Amtrak trains. Table 3-2 shows these compounded freight growth rates.

Table 3-2 Compounded Freight Growth Rates

	2020	2025	2030	2035	2040	2045
Number of Years from 2020	0	5	10	15	20	25
Compound Annual Growth Rate	**0.000%**	**0.769%**	**0.774%**	**0.793%**	**0.870%**	**0.906%**
% Growth for each 5-year increment	0.00%	3.90%	3.90%	4.20%	5.60%	5.40%
% Growth from 2020	0.00%	3.90%	8.01%	12.57%	18.91%	25.28%

For each growth case, if the length of a train exceeded 10,000 feet the train was split into another train equally so that their individual lengths were less than 10,000 feet. If additional trains were generated, they were spaced into the model at 8-hour increments from the time of the original train.

3.3 Modeling Results

3.3.1 No Build / Build Conditions Comparison

Modeling results are tabulated for Total Delay Hours and Delay Minutes per 100 Train Miles in Table 3-3 and Table 3-4, respectively. Modeling case EW2A represents the No Build Condition, without the P2 project flyover, and modeling case EW2B-1 represents the Build condition, with the P2 project flyover constructed and in service. The train count is the total number of freight and passenger trains operating in the model during the simulation period.

Table 3-3 Total Delay Hours (3 Day Capture) Network Wide Stats

All Trains				
YEAR	Train Count	EW2A	EW2B-1	DIFF
00	2755	232.1	229.0	-1.32%
05	2901	310.7	311.7	0.33%
10	2986	354.4	355.4	0.26%
15	3111	411.3	412.6	0.32%
20	3206	510.3	503.4	-1.37%
25	3301	651.0	628.8	-3.41%

Compared to the No Build scenario (EW2A), the Build scenario (EW2B-1) shows a reduction in delay hours of 1.32% in the Base model and 3.41% (22.2 delay hours avoided) in the Year 25 future model. The five-year increments from Years 0-5, 5-10, and 10-15 experienced slight increases in delay hours as overall freight traffic grew in Chicago. The results in Table 3-3 are the total delays of all trains operating across the entire Chicago Terminal District, many of which do not traverse the 75th Street Corridor.

The freight and passenger trains that are routed via the 75th Street Corridor and on main rail lines north of 75th Street leading to Union Station would be the most likely to benefit from delay reductions and improved reliability, as the conflicts between freight trains and Metra trains would be significantly reduced. The P2 flyover will reroute Metra SouthWest Service trains onto the passenger-only Rock Island District tracks to LaSalle Street Station in downtown Chicago instead of using congested freight and passenger rail tracks to reach Chicago Union Station. The shift of Metra SouthWest Service trains onto the Metra Rock Island District line reduces passenger and freight rail conflicts on the Chicago and Western Indiana line north of the P2 project area where Norfolk Southern operations to its 47th St. intermodal yard and Ashland Avenue yard can block Metra SouthWest Service and Amtrak trains heading north to Chicago Union Station. Freight operations are typically delayed at these conflict points to allow for prioritized Amtrak and Metra movements, although there are also sometimes delays to passenger trains resulting from conflicts.

The project also reduces delays through the 75th Street Corridor for NS freight trains operating to and from the NS Landers intermodal yard, which is located just west of Belt Junction. The P2 project creates a path for Metra's trains to access track additions at Belt Junction constructed as part of the EW2A project, which separates Metra's 30 daily trains from freight traffic with a parallel and dedicated track used by NS trains that exit and enter Landers Yard.

When the scale of the entire Chicago Terminal District is considered, a network-wide performance improvement of 1% to 2% is significant, and demonstrates the importance of the P2 project to improving overall terminal operations.

Table 3-4 Delay Minutes per 100 TM (3 Day Capture) Network Wide Stats

All Trains				
YEAR	**Train Count**	**EW2A**	**EW2B-1**	**DIFF**
00	**2755**	**18.3**	**18.1**	**-1.37%**
05	**2901**	**23.4**	**23.5**	**0.28%**
10	**2986**	**26.0**	**26.0**	**0.21%**
15	**3111**	**29.0**	**29.1**	**0.28%**
20	**3206**	**35.0**	**34.5**	**-1.41%**
25	**3301**	**43.4**	**41.9**	**-3.44%**

Compared to the No Build scenario (EW2A), the Build scenario (EW2B-1) shows a reduction in delay minutes from 1.37% in the Base model to 3.44% (1.5 minutes per 100 train-miles avoided) in the Year 25 future model.

Similar to the results in Table 3–3, when the scale of the entire Chicago Terminal District is considered, a network-wide performance improvement in delay per minutes per 100 train-miles of 3.44% is significant, again demonstrating the importance of the P2 project to improving overall terminal operations.

Table 3-5 shows the change in average train velocity (in miles per hour) between the No Build and Build conditions models.

Table 3-5 Average Train Velocity (3 Day Capture) Network Wide Stats

All Trains				
YEAR	**Train Count**	**EW2A**	**EW2B-1**	**DIFF**
00	**2755**	**26.4**	**26.5**	**0.31%**
05	**2901**	**25.5**	**25.6**	**0.15%**
10	**2986**	**25.1**	**25.1**	**0.14%**
15	**3111**	**24.7**	**24.7**	**0.11%**
20	**3206**	**23.8**	**23.9**	**0.33%**
25	**3301**	**22.8**	**23.0**	**0.71%**

Compared to the No Build scenario (EW2A), the Build scenario (EW2B-1) shows an increase in average train velocity of 0.31% in the Base model and 0.71% in the Year 25 future model. All five-year increments experienced improvements in train velocity ranging between 0.11% and 0.71%. Average train speeds increased from 0.0 to 0.2 mph in each five-year increment with the completion of the P2 project.

Table 3-6 shows the change in total train run time (elapsed hours) between the No Build and Existing Conditions models.

Table 3-6 Total Train Run Time (Elapsed Hours) Network Wide Stats

All Trains				
YEAR	Train Count	EW2A	EW2B-1	DIFF
00	2755	2882.7	2875.2	-0.26%
05	2901	3122.8	3119.5	-0.11%
10	2986	3260.2	3257.2	-0.09%
15	3111	3450.3	3447.9	-0.07%
20	3206	3671.6	3661.0	-0.29%
25	3301	3950.6	3924.3	-0.67%

Compared to the No Build scenario (EW2A), the Build scenario (EW2B-1) shows a decrease in total run time of trains in the network across every five-year increment. Avoided hours of operation with the P2 project over the three-day capture ranges from 7.5 hours in the Base model to as modest as 2.4 hours at Year 15 and as high as 26.3 hours in Year 25. Network operations improved in each five-year increment with the completion of the P3 project. Over the entire 25-year measurement period, with the P2 project in service, train operations across the entire Chicago Terminal District saved an average of 9 train operating-hours every day.

Table 3-7 shows the change in gallons of fuel consumed by trains between the No Build and Build Conditions models.

Table 3-7 Total Fuel Gallons (3 Day Capture) Network Wide Stats

All Trains				
YEAR	Train Count	EW2A	EW2B-1	DIFF
00	2755	324891.9	324905.7	0.00%
05	2901	348911.8	349201.7	0.08%
10	2986	369278.6	369527.4	0.07%
15	3111	395470.9	395349.5	-0.03%
20	3206	421651.1	421536.9	-0.03%
25	3301	451839.2	450845.7	-0.22%

Compared to the No Build scenario (EW2A), the Build scenario (EW2B-1) shows a decrease in total fuel consumption by trains in the network in the later three of the six five-year increments measured. Avoided gallons of fuel consumption with the P2 project over the three-day capture range from as modest as 121.4 gallons at Year 15 and as high as 993.5 gallons in Year 25. The first three five-year increments generated slight increases in fuel consumption in the Build scenario, ranging from 13.8 gallons in the Base model to 289.9 gallons in Year 5. Over the entire 25-year measurement period, with the P2 project in service, train operations across the entire Chicago Terminal District saved an average of 331 fuel gallons every day.

3.3.2 Modeling Summary

The modeling results indicate that the construction of CREATE project P2, the Rock Island Connection flyover, will improve freight and passenger rail operations in Chicago compared to a rail environment where the P2 project is not constructed.

As rail traffic increases during the 25-year modeling period, freight delays increase proportionally, as more trains create more freight and passenger train conflicts. The growth rate varies by 5-year increment, due in a large part to the methodology used where specific trains are duplicated to support growth as they exceed their desired operating length and tonnage limits.

The addition of the P2 project, and the rerouting of Metra SouthWest Service trains onto Rock Island District tracks leading to LaSalle Street Station and away from freight tracks leading to Chicago Union Station, reduces train delays, improves train velocity, and reduces fuel consumption across the Chicago Terminal District when compared to the scenario where the P2 project is not built. Operational benefits increase substantially in years 20 and 25 when traffic volumes at the NS Landers Yard intermodal terminal grow, creating the potential for a significant increase in passenger-freight train conflicts without the P2 project. Trains routed on the Belt Railway of Chicago tracks in the 75th Street Corridor also see significant improvements in years 20 and 25 with the P2 project's completion.