Northstar Commuter Rail Extension Feasibility Assessment

Appendix F – Technical Memorandum on Rail Operations Modeling

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Prepared for

DEPARTMENT OF TRANSPORTATION

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1. Introduction

The purpose of this document is to outline the modeling methodology and assumptions that were used to evaluate the proposed extension of Northstar service to St. Cloud, MN. To facilitate this analysis, Rail Traffic Controller™ (RTC) computer modeling software was employed. RTC is North America's industry standard railroad planning software. RTC is unique among planning tools because it contains n-logic problem solving technology, allowing the user to simulate countless railroad operating scenarios. Using RTC, impacts to a railroad network's performance, due to changes in the network's traffic or infrastructure, can be quantified.

2. Development of Base Case RTC Model

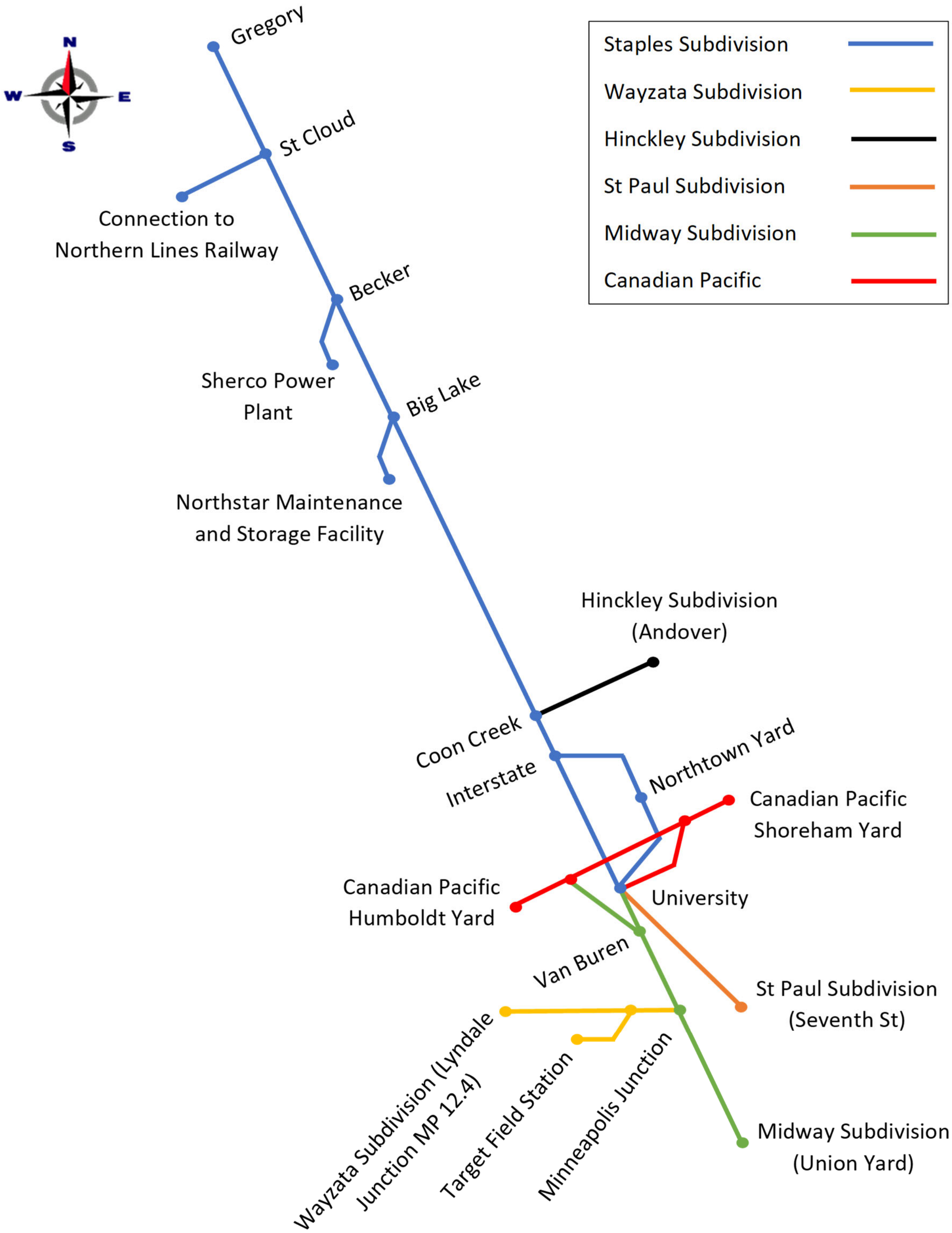
The foundation of this analysis is an RTC model containing the railroad's existing conditions. This RTC model is referred to as the "Base Case" model, which provides a baseline of comparison to operations under 2020 proposed Service Alternative RTC models. In this feasibility assessment, the Base Case model represents 2020 track, signal, and traffic conditions.

2.1. Base Case Network

An RTC network encompasses a railroad's track, signals, and switches and represents the boundary of analysis. Figure 1 depicts the RTC network used to evaluate the extension of Northstar commuter rail service. To achieve meaningful results from the modeling process, the model's network inputs must be as accurate as possible. To ensure the highest level of accuracy, a model provided by BNSF in 2013 was utilized and updated with current track, signals, and switch locations.

The 2020 Base Case RTC network was programmed from Target Field Station (MP 12.5) on the Wayzata Subdivision to Gregory (MP 103.1) on the Staples Subdivision. The network includes the Midway Subdivision, St. Paul Subdivision, Northtown Yard, the junction at Coon Creek, and a connection to the Sherco Coal-Fired Power Plant at Becker (MP 57.2).

Figure 1: RTC Network for Northstar Commuter Rail Service Evaluation



To program the 2020 Base Case, track, signal, and speed limits were gathered from the following files provided by BNSF and input into the 2020 Base Case RTC model:

1. Staples Subdivision Track Chart; 07/30/2019,
2. Midway Subdivision Track Chart; 04/01/2019,
3. Wayzata Subdivision Track Charts; 08/21/2017,
4. Hinckley Subdivision Track Charts; 01/11/2018
5. Twin Cities Division Timetable No. 8; 01/01/2019,
6. System Special Instructions all Subdivisions No. 9; 12/01/2018,
7. Z-Train Transportation Service Plan (TSP) Northtown Dilworth Feb 2020; 02/24/2020

2.1.1. Turnout and Crossover Speeds

To accurately assess trains as they traverse the network, correct speed limits were assigned to the diverging routes of turnouts and crossovers. BNSF publishes each turnout and crossover's speed limits for passenger trains, freight trains over 100 Tons Per Operative Break (TOB), and freight trains under 100 TOB in their timetables. This information was used to program the 2020 Base Case RTC network.

2.1.2. Signals

Movements through much of BNSF's rail network are governed by Centralized Traffic Control (CTC) signals with a Positive Train Control (PTC) overlay. RTC simulates the signal system by defining signal blocks through the network. RTC allows users to program 16 unique signal aspects. Table 1 shows the definition of signal aspects that are programmed into RTC models.

Table 1: Signal Aspects Programmed in RTC

	Signal Imposed Speed Limits (MPH)			
Aspect Name	**Passing**	**Prescribed**	**Target**	**Definition**
Clear	none	none	none	Proceed
Approach Limited	none	none	60	Proceed. Speed passing next signal must not exceed 60 MPH
Advance Approach	none	none	50	Proceed. Speed passing next signal must not exceed 50 MPH
Approach Medium	none	none	40	Proceed. Speed passing next signal must not exceed 40 MPH
Approach Restricting	none	none	15	Proceed. Speed passing next signal at restricted speed
Approach	none	none	40	Proceed. Speed passing next signal must not exceed 40 MPH
Diverging Clear	Turnout Speed	Turnout Speed	Turnou t Speed	Proceed on diverging route not exceeding prescribed speed through turnout
Diverging Approach Diverging	50	50	50	Proceed on diverging route. Speed must not exceed 50 MPH.
Diverging Approach	40	40	40	Proceed on diverging route. Speed must not exceed 40 MPH.
Diverging Approach Medium	35	35	35	Proceed on diverging route. Speed must not exceed 35 MPH.
Restricting	15	15	15	Proceed at restricted speed.
Diverging Lunar	10	10	10	Proceed on diverging route not exceeding 10 MPH through turnout.
Stop and Proceed	0	15	15	Stop before any part of train or engine passes the signal, then proceed at restricted speed.
Stop	0	0	0	Stop before any part of train or engine passes the signal.

Each aspect imposes either a passing, prescribed, or target speed limit. Passing speed limits require trains to operate at, or below, the posted speed limit as the head end of the train passes the signal. Prescribed speed limits instruct the train to begin slowing down to the speed once the head end of the train passes the signal. Target speed limits must be achieved before the head end of the train passes the next signal.

RTC's signal logic is based on a set of trailing aspects which show the cascading sequence of aspects at each signal behind a train as the train proceeds along the railroad. In RTC's logic, and as actually displayed in the field, aspects of signals behind the train ("trailing aspects") become less restrictive as the rear end of the train continues past each signal. The use of trailing aspects enables RTC to accurately simulate the impacts of a train on a railroad's signal system. The trailing aspects prevent a following train from advancing quicker than BNSF’s signal system will allow. Table 2 lists the trailing aspects programmed for each signal aspect.

Table 2: Trailing Signal Aspects

Aspect Name	Permissive Trailing Aspect	Absolute Trailing Aspect	Diverging Trailing Aspect
Clear	Clear	Clear	Diverging Clear
Approach Limited	Clear	Clear	Diverging Clear
Advance Approach	Clear	Clear	Diverging Clear
Approach Medium	Clear	Clear	Diverging Clear
Approach Restricting	Clear	Clear	Approach Limited
Approach	Approach Medium	Approach Medium	Diverging Clear
Diverging Clear	Advance Approach	Advance Approach	
Diverging Approach Diverging	Advance Approach	Advance Approach	Diverging Clear
Diverging Approach	Advance Approach	Advance Approach	Diverging Approach Diverging
Diverging Approach Medium	Approach Limited	Approach Limited	Diverging Approach Diverging
Restricting	Approach Restricting	Approach Restricting	Diverging Approach
Diverging Lunar	Advance Approach	Advance Approach	
Stop and Proceed	Approach	Approach	Diverging Approach
Stop	Approach	Approach	Diverging Approach

The trailing signal aspects remained the same throughout all models in this study.

The signal logic described above is the way that RTC software attempts to replicate CTC. The network also contains a PTC system which enforces prescribed safe following distances between trains, penalizes overspeed train movements, and requires compliance with signal, switch, and work zone restrictions. PTC and cab signaling technologies are rapidly improving and advancements in these technologies will increase network capacity in the future. The currently-in-use CTC signal aspects may eventually become obsolete as PTC advances. Because advancements have not yet been fully defined or approved, speed-restricting signal aspects were used in the models.

2.1.2.1. Signal Types and Locations

The railroad's signal locations were provided by BNSF as shown in Table 3 and were verified using track charts, Google Earth imagery, and photos taken during field visits. The 'Name' column indicates whether the signal is a Control Point (CP) or an intermediate location.

Table 3: Location of Signals on BNSF Staples Subdivision

Signal Location Name	BNSF Staples Subdivision Milepost	Signal Location Name	BNSF Staples Subdivision Milepost
University (CP)	11.4 - 11.88	CP 421 (CP)	42.0 - 42.3
35th (CP)	13.6 - 13.8	Intermediate	43.76
44th (CP)	13.7 - 14.0	Intermediate	45.06
Interstate (CP)	15.1 - 15.3	Big Lake Platform (CP)	46.8
16.3 (CP)	16.3	Intermediate	49.5
Intermediate	18.46	Intermediate	50.87
Coon Creek (CP)	20.66 - 21.31	CP 528 (CP)	52.8
Intermediate	23.24	Intermediate	55.2
Coon Rapids Platform (CP)	25.12 - 25.38	***CP 566 Main 2 only***	***56.59***
Anoka Platform (CP)	27.02 - 27.31	Becker (CP)	57.2
Ramsey Platform (CP)	29.17 - 29.42	Intermediate	59.66
CP 321 (CP)	31.06 - 31.42	Intermediate	61.93
Intermediate	33.2	Intermediate	64.01
Intermediate	34.82	MP 66 (CP)	66.1
Elk River Platform (CP)	36.74 - 36.94	Intermediate	68.09
Intermediate	38.46	Intermediate	71.28
Intermediate	40.4	St Cloud (CP)	73.65

BNSF provided a location for proposed CP 566 (shown in red in Table 3) that is proposed to be constructed in the future. Because there is currently no planned construction date, the control point was not included in any of the models.

2.2. Base Case Traffic

An important element of evaluating a railroad's capacity is existing traffic volumes. Traffic volumes for BNSF, Northstar, and Amtrak Empire Builder were programmed for Base Case 2020.

2.2.1. Weekly 2020 Train Counts

As noted in the Section 2.2 introduction paragraph, three types of train traffic operate over BNSF's Staples, Midway, and Wayzata Subdivisions: freight (including BNSF, Canadian Pacific (CPR), and Union Pacific (UP) trains), Northstar commuter rail, and Amtrak intercity passenger rail services. Figure 2 and Figure 3 depict the Northstar and Empire Builder schedules used in the models.

Figure 2: Base Case Northstar Commuter Rail Schedule (February 2020)

Downtown Minneapolis

route number & letter	Target Field Station (7)	Fridley Station (6)	Coon Rapids-Riverdale Station (5)	Anoka Station (4)	Ramsey Station (3)	Elk River Station (2)	Big Lake (1)
AM							
888	6:15	6:29	6:38	6:42	6:47	6:52	7:07
PM							
888	3:57	4:11	4:20	4:24	4:29	4:34	4:49
888	4:27	4:41	4:50	4:54	4:59	5:04	5:19
888	4:57	5:11	5:20	5:24	5:29	5:34	5:49
888	5:30	5:44	5:53	5:57	6:02	6:07	6:22
888	6:15	6:29	6:38	6:42	6:47	6:52	7:07

Downtown Minneapolis

route number & letter	Big Lake Station (1)	Elk River Station (2)	Ramsey Station (3)	Anoka Station (4)	Coon Rapids-Riverdale Station (5)	Fridley Station (6)	Target Field Station (7)
AM							
888	5:00	5:10	5:16	5:21	5:25	5:33	5:52
888	5:48	5:58	6:04	6:09	6:13	6:21	6:40
888	6:18	6:28	6:34	6:39	6:43	6:51	7:10
888	6:48	6:58	7:04	7:09	7:13	7:21	7:40
888	7:18	7:28	7:34	7:39	7:43	7:51	8:10
PM							
888	5:03	5:13	5:19	5:24	5:28	5:36	5:55

Figure 3: Base Case Empire Builder Schedule (April 2018)

7/27		◂ Train Number ▸			8/28
Daily		◂ Normal Days of Operation ▸			Daily
		◂ On Board Service ▸			
Read Down	Mile	▼		Symbol ▲	Read Up
10 03P 10 20P	410	Ar Dp	St. Paul-Minneapolis, MN Duluth—see page 2 Rochester—see page 2	● Dp Ar	8 00A 7 43A
12 24A	486		St. Cloud, MN	○	5 19A
1 26A	552		Staples, MN	○	4 14A

Because BNSF is a private railroad, BNSF's traffic and train type information is not public record. Traffic counts and train types were provided by BNSF as a representation of the traffic typically operating along the Subdivisions. Table 4 describes the train types and quantity that typically operate over the network in a one-week period in existing conditions.

Table 4: Network Train Traffic in 2020

Train Type	Weekly Train Count in 2020
A-Amtrak (Empire Builder)	14
A-Commuter (NorthStar)	72
B-Bare Table Intermodal	6
C-Coal Loads	34
D-Light Engines	2
E-Empty Unit Coal	32
F-Foreign RR Detour (CPR & UP)	46
G-Grain Loads	20
H-Hi Priority Merchandise	44
L-Local	21
M-Merchandise	4
Q-Guaranteed Intermodal	32
S-Stack Train	39
U-Unit ex Coal/Grain	91
V-Vehicle / Parts	43
X-Empty Grain	16
Z-Trains	37

2.2.2. Origin-Destination

The origin and destination points of freight trains are defined in the RTC network to simulate traffic patterns. Figure 4 presents the network's entry/exit points.

Figure 4: Origin and Destination Points in the Network

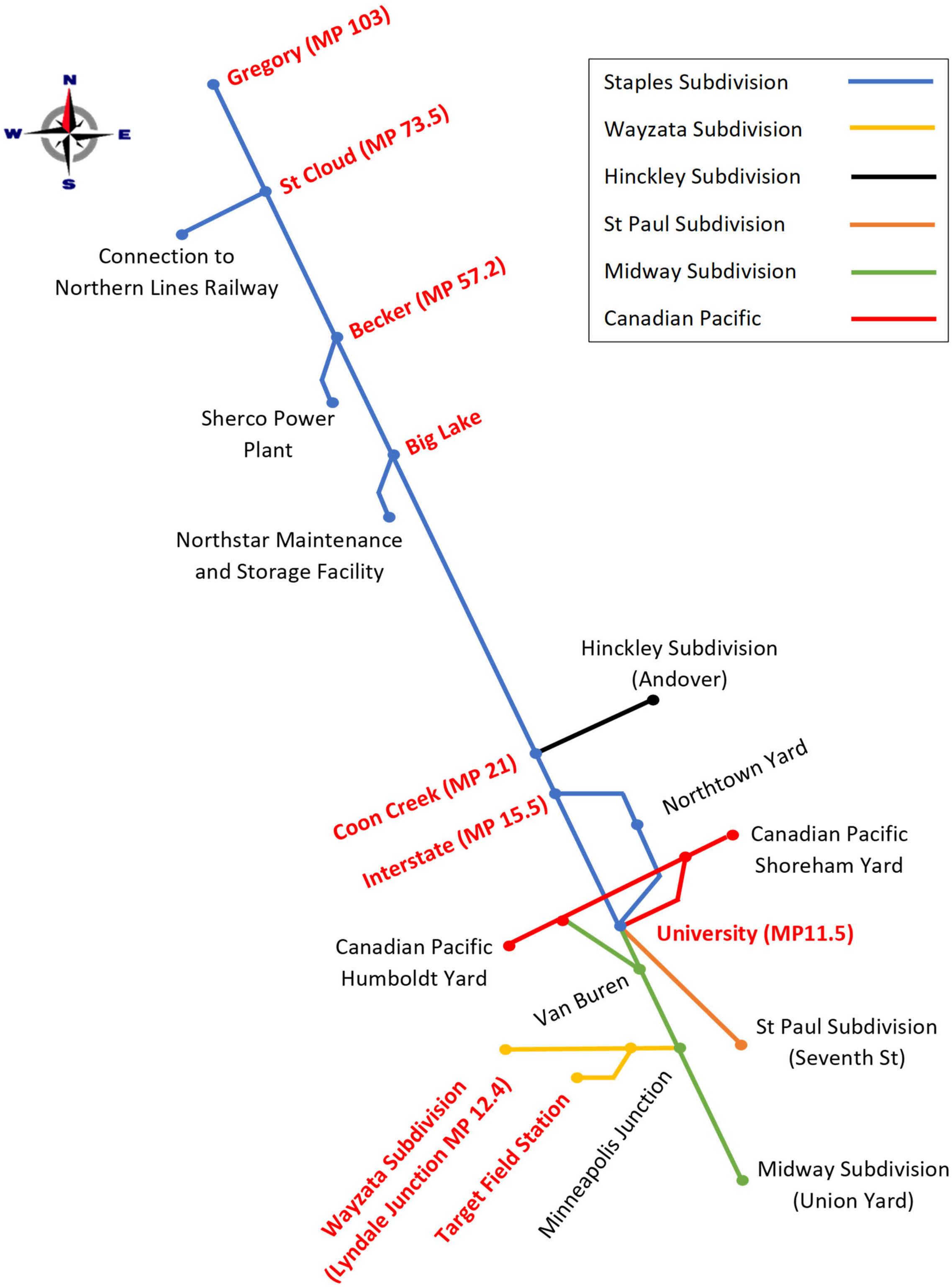


Table 5 lists the number of freight trains operating per week in 2020 by their origin and destination pair.

Table 5: Freight Volumes by Origin and Destination Pair in 2020

Origin-Destination Pair (Subdivision)	Trains per Week (2020)
Gregory - Becker (Staples)	42
Andover (Hinckley) - Northtown Yard (Staples)	2
Andover (Hinckley) - University (Staples)	90
Andover (Hinckley) - Lyndale Junction (Wayzata)	11
Gregory - Northtown Yard (Staples)	44
University - Northtown Yard (Staples)	29
University – CPR Shoreham Yard (CPR Paynesville Sub)	34
Gregory - University (Staples)	186
Gregory (Staples) – Lyndale Junction (Wayzata)	8
Lyndale Junction (Wayzata) – University (Staples)	7

*Local and Passenger trains not included

In addition to the trains listed in Table 5 there are local trains that operate from Northtown and St. Cloud Yards. These trains start and end in the same location (i.e., a train departing from Northtown Yard returns to Northtown Yard). Seven trains per week operate between St. Cloud Yard and Little Falls, MN, seven per week operate between St. Cloud Yard and Northtown Yard, and seven per week operate between Northtown Yard and Hinckley, MN. These local trains were programmed into the RTC models.

2.3. Base Case Train Operations

To achieve a simulated railroad network that closely replicated real-world operations, BNSF's existing operations were reviewed in detail and in coordination with BNSF. Operating and dispatching practices at complex locations in the corridor were refined to more closely match what occurs in the field. Discussions of these issues follow.

2.3.1. Operating and Dispatching Practices

After discussions with BNSF on how trains are dispatched on the Staples Subdivision, the following was programmed into the Base Case:

- Fuel optimizers were added to freight trains (excluding Z-Trains) to limit acceleration to throttle position 5 above 50 MPH
- Freight train minimum stop times were set to five minutes to ensure that freight trains would not operate closer together than BNSF dispatchers allow

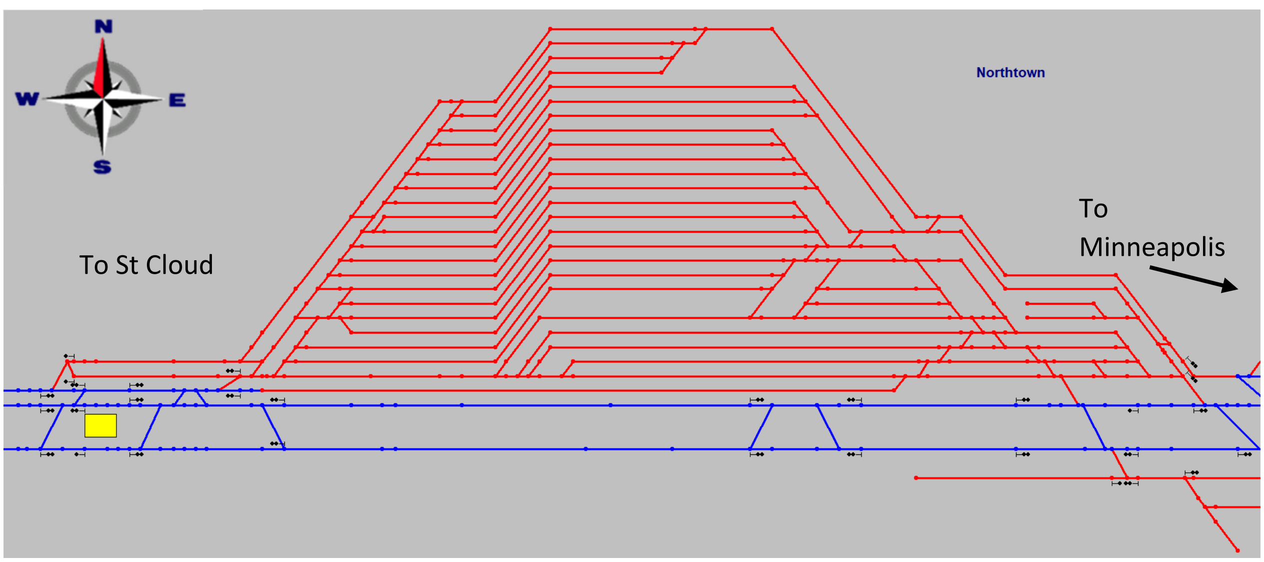
Fuel optimizers limit train acceleration to minimize locomotive fuel consumption and emissions. This has the effect of slowing the train's speed compared to operation at a train's maximum throttle position. The minimum stop time was added to represent the actual time it takes a freight train to restart after it stops. In some cases, the stop may need to be longer to enable trains to properly recharge their air brake system before proceeding. In several instances, freight trains were not permitted to proceed from a stop or waiting point if doing so might have delayed a following passenger train.

2.3.2. Northtown Yard

As discussed in the Technical Memorandum on Existing Constraints (Appendix A), Northtown Yard is located along the Staples Subdivision between railroad control points at University (MP 11.5) and Interstate (MP 15.5). The Yard serves as an origination and termination point for trains moving to and from other major yards on BNSF's network in addition to serving as the origin and terminus of local freight trains and switch runs that service local industries. Northtown Yard also serves as a through-train crew change point and a maintenance point for BNSF locomotives.

A significant number of trains stop and dwell on the main tracks adjacent to Northtown Yard to change crews (see Appendix A for detail). As trains continue to enter, exit, and layover in the Yard, it's entry and exit points become congested, causing a domino effect on the network that results in mainline train delays. The RTC model that BNSF provided in 2013 was pre-programmed with Northtown Yard. For the purposes of this feasibility assessment, it is assumed that the operations were modeled accurately. BNSF confirmed that the Yard is a source of congestion, but no reconfiguration or expansion of the Yard is possible due to its urban location. Figure 5 shows an image of Northtown Yard as it appears in RTC.

Figure 5: RTC Image of Northtown Yard



In addition to congestion within Northtown Yard, BNSF also conducts crew changes on the mainlines paralleling Northtown Yard as described above. Accurately representing these functions in all RTC models is critical to achieving meaningful results.

2.3.3. Passenger Equipment Layover and Storage

Northstar is operated as a commuter rail service with demand southbound to Minneapolis in the morning peak and northbound to the city's suburbs in the afternoon peak. This type of service requires that Northstar trains layover during the midday at Target Field Station in Minneapolis and overnight on storage tracks at the Big Lake Maintenance Facility. To ensure that there would be enough storage tracks available to accommodate the number of trains laying over as proposed in the Service Alternatives, trains were linked in the model. In RTC, trains disappear from the network after completing their programmed trip, making it difficult to assess if there is enough storage capacity. When trains are linked, they do not disappear from the network after finishing their trip; instead they change train numbers to become that trainset's next scheduled trip. By linking the trains, the capacity of Northstar's storage tracks can be assessed.

2.3.4. Operations at Passenger Stations

Northstar serves seven stations along its route between Minneapolis and Big Lake: Target Field, Fridley, Coon Rapids-Riverdale, Anoka, Ramsey, Elk River, and Big Lake. In the RTC models, Northstar trains were programmed to operate on the track corresponding to the platform that passengers use to board and alight their trains. Typical operations at each station are as follows:

- **Target Field** – Passengers board on both sides of the center platform.
- **Fridley** – Because the station platform is located on the west side of the mainlines, existing Northstar trains use the west track (Track 2) to load and unload passengers.
- **Coon Rapids – Riverdale, Anoka, Ramsey, Elk River** – These stations have platforms on the west and east sides of the main tracks that are connected by an overhead pedestrian bridge. Big Lake-bound trains only use the east track (Track 1) and Target Field-bound trains only use the west track (Track 2).
- **Big Lake** – The platform at Big Lake Station is located on a stub track west of the main tracks and all existing trains use the stub track.

3. Development of Proposed Case RTC Models

3.1. Proposed Case Traffic

This feasibility assessment examines the impacts of extending Northstar's passenger train service to serve St. Cloud. The Federal Railroad Administration (FRA) recommends that during the planning of a proposed passenger train service, a study should be conducted to measure the current and future capacity needs of the operation. FRA suggests that passenger and freight train operations be evaluated over a 20-year period to ensure that the services sharing track can coexist without degrading each other's operations. To accomplish this, 2020 freight volumes were projected to 2040 and schedules for extended Northstar service to St. Cloud were developed.

3.1.1. 2040 Freight Traffic

Freight traffic levels were estimated for 2040 using a growth rate of 2% per year compounded, as recommended by FRA in their *"Railroad Corridor Transportation Plans; a Guidance Manual"*. [1] The FRA

[1] https://railroads.dot.gov/elibrary/railroad-corridor-transportation-plans-guidance-manual

guidance manual does not specifically state whether the existing train count, tonnage, or number of rail cars should be increased by 2% per year compounded to determine 2040 traffic levels. BNSF requested that the number of rail cars be increased and that certain types of traffic should be treated differently (i.e., coal train traffic is expected to remain constant whereas grain train traffic fluctuates depending on U.S. trade agreements). For the Northstar Commuter Rail Extension Feasibility Assessment, each train type was designated to either grow or remain constant over the 20-year horizon period, and maximum train lengths were identified for each train type. Table 6 lists the growth assumptions for freight trains by train type.

Table 6: Freight Growth Assumptions by Train Type

Train Type	Maximum Train Length or Number of Cars in 2040	Notes
B-Bare Table Intermodal	75 cars	Length of Trains and Quantity of Trains Expected to Increase
C-Coal Loads		No Increase in Quantity or Length Expected
D-Light Engines		Quantity of Engines Expected to Increase
E-Empty Unit Coal	230 cars	Number of Trailing Cars can grow to over 10,000 feet
F-Foreign RR Detour	130 cars	Length of Trains and Quantity of Trains Expected to Increase
G-Grain Loads	111 cars	Length of Trains and Quantity of Trains Expected to Increase
H-High Priority Merchandise	107 cars	Length and Quantity of Trains Expected to Increase
L-Local Trains		No Increase in Quantity or Length Expected
M-Merchandise	94 cars	Length and Quantity of Trains Expected to Increase
Q-Guaranteed Intermodal	73 cars	Length and Quantity of Trains Expected to Increase
S-Stack Train	83 cars	Length and Quantity of Trains Expected to Increase
U-Unit Excluding Coal/Grain	161 cars (over 10,000 feet)	Length and Quantity of Trains Expected to Increase
V-Vehicle / Parts	145 cars (over 10,000 feet)	Length and Quantity of Trains Expected to Increase
X-Empty Grain	161 cars (over 10,000 feet)	Length and Quantity of Trains Expected to Increase
Z-UPS/Guaranteed Intermodal	74 cars	Length and Quantity of Trains Expected to Increase

The network's existing number of train cars changes as the freight trains pick up and set out cars. To provide a fair estimate of the number of cars in 2040, each train's highest car count was used in the train car inflation calculations.

During a discussion of traffic growth in the kickoff meeting, BNSF stated that their trains could grow to a maximum of 10,000 feet with a 0.8-0.9 HP/ton power-to-weight ratio for loaded trains; lighter consists (empty cars) could grow longer. Generally, the maximum length of a train is limited by the network's infrastructure. For trains to fit into the yards and sidings along their routes and not block critical interlockings or grade crossings, some trains are limited to lengths less than 10,000 feet. During follow-up discussions, BNSF requested that the models consider trains longer than 10,000 feet. This simulates the growing trend of railroads increasing the length of trains to reduce the number of freight trips operating in the network. BNSF noted that longer trains are typically comprised of lighter loads and empty cars.

To determine the number of trains and their lengths in 2040, the number of train cars was increased by 2% compounded per year until the trains reached their maximum length. After the freight trains reached the maximum length, additional trains were added to the network to facilitate the remaining cars. To maintain BNSF's stated power-to-weight ratio, additional locomotives were added to trains as needed.

Using the methodology described above, it was determined that the 2040 traffic would include 48 more freight trains per week than in 2020. Table 7 presents the network traffic by train type over a week of typical operations in 2040.

Table 7: Network Train Traffic in 2040

Train Type	Weekly Train Count in 2040
A-Amtrak (Empire Builder)	14
A-Commuter (Northstar)	Varies by Service Alternative
B-Bare Table Intermodal	8
C-Coal Loads	34
D-Light Engines	3
E-Empty Unit Coal	30
F-Foreign RR Detour	49
G-Grain Loads	26
H-Hi Priority Merchandise	48
L-Local	21
M-Merchandise	5
Q-Guaranteed Intermodal	40
S-Stack Train	47
U-Unit ex Coal/Grain	96
V-Vehicle / Parts	51
X-Empty Grain	17
Z-Trains	40

Table 8 lists the number of freight trains operating between each Origin and Destination pair in 2040.

Table 8: Freight Volumes by Origin and Destination Pair in 2040

Origin and Destination Pairs (Subdivision)	Trains per Week (2040)
Gregory - Becker (Staples)	40
Andover (Hinckley) - Northtown Yard (Staples)	2
Andover (Hinckley) - University (Staples)	94
Andover (Hinckley) - Lyndale Junction (Wayzata)	11
Gregory - Northtown Yard (Staples)	49
University - Northtown Yard (Staples)	27
University (Staples) – CPR Shoreham Yard (CPR Paynesville Sub)	23
Gregory - University (Staples)	224
Gregory (Staples) – Lyndale Junction (Wayzata)	10
Lyndale Junction (Wayzata) – University (Staples)	8

*Local and Passenger trains not included

3.1.2. 2040 Northstar Traffic

Schedules for four Northstar Service Alternatives were defined as part of the feasibility assessment. The schedules are presented in each of the Technical Memoranda on Operating Assumptions (Appendices B, C, D, and E).

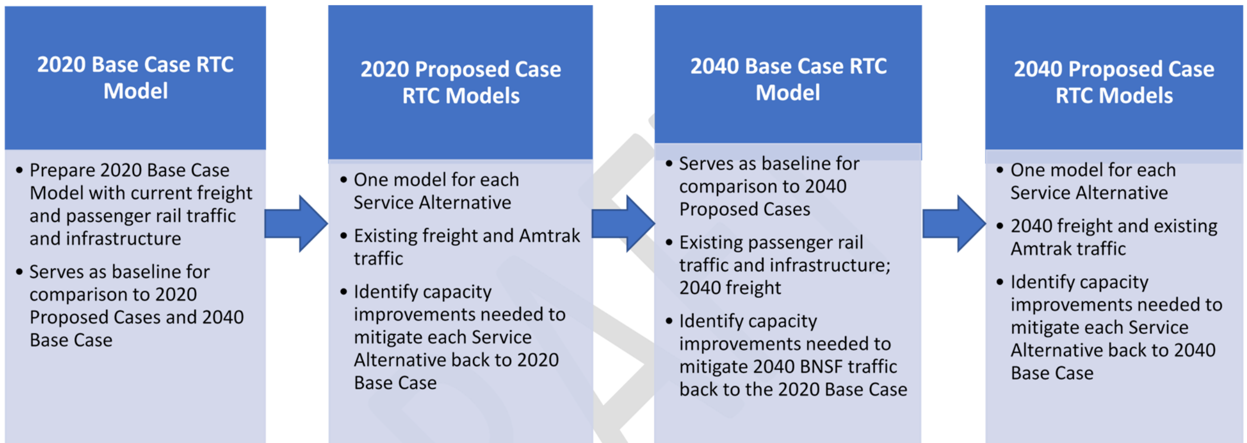
3.1.3. 2040 Amtrak Traffic

The 2040 Empire Builder schedule was assumed to be the same as in the 2020 Base Case.

4. RTC Methodology

A four-part analysis was used to evaluate the impacts of the proposed Northstar Service Alternatives on existing and future BNSF traffic. Using RTC, any significant impact caused by the service expansion was measured and mitigated. Through this process the infrastructure needed to implement the proposed Service Alternatives was identified. Figure 6 presents the methodology.

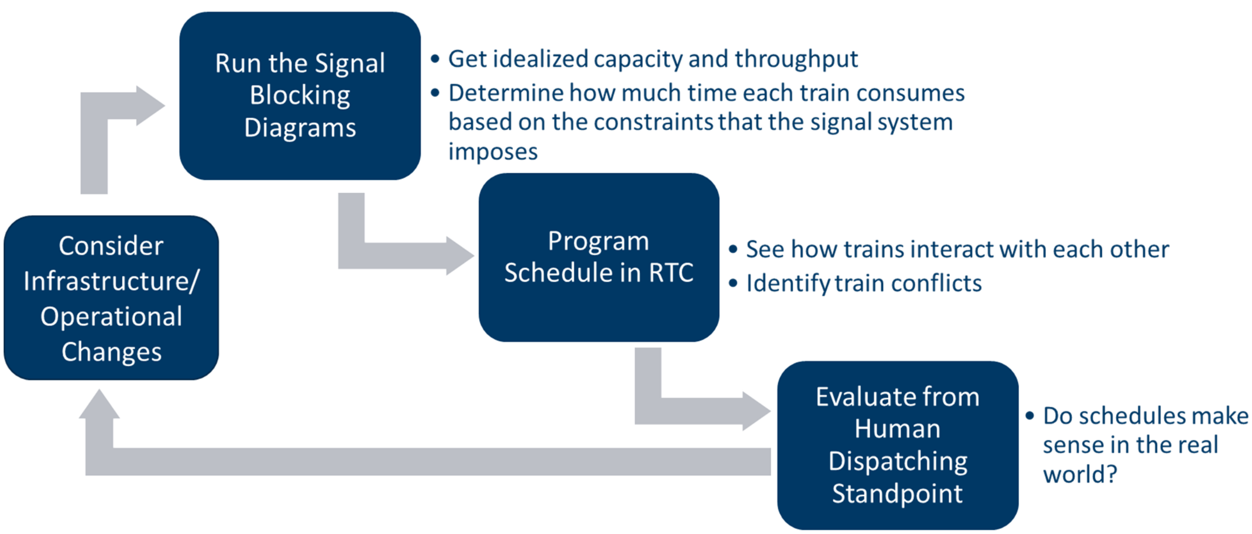
Figure 6: RTC Methodology Diagram



4.1. Signal Blocking Diagrams

Before fully developing the RTC models shown in Figure 6, the capacity of the network was analyzed using a software application that was refined for this Feasibility Assessment. A train's speed, length, and stopping distance, along with physical attributes of the area being traversed and the design of the signal system, were input into the application to produce Signal Blocking Diagrams (SBDs). The SBD charts a train's track occupancy throughout its trip. This information was used to determine the maximum number of trains that could traverse a segment of track in a given time period. The schedule of each Service Alternative was then simulated in RTC to confirm the SBD analysis. The results of the SBD were further vetted by BNSF operations experts. Figure 7 illustrates the process used for evaluating network capacity using SBDs.

Figure 7: Signal Blocking Diagram Analysis Process



SBDs for each of the proposed Service Alternatives are in Attachment 1.

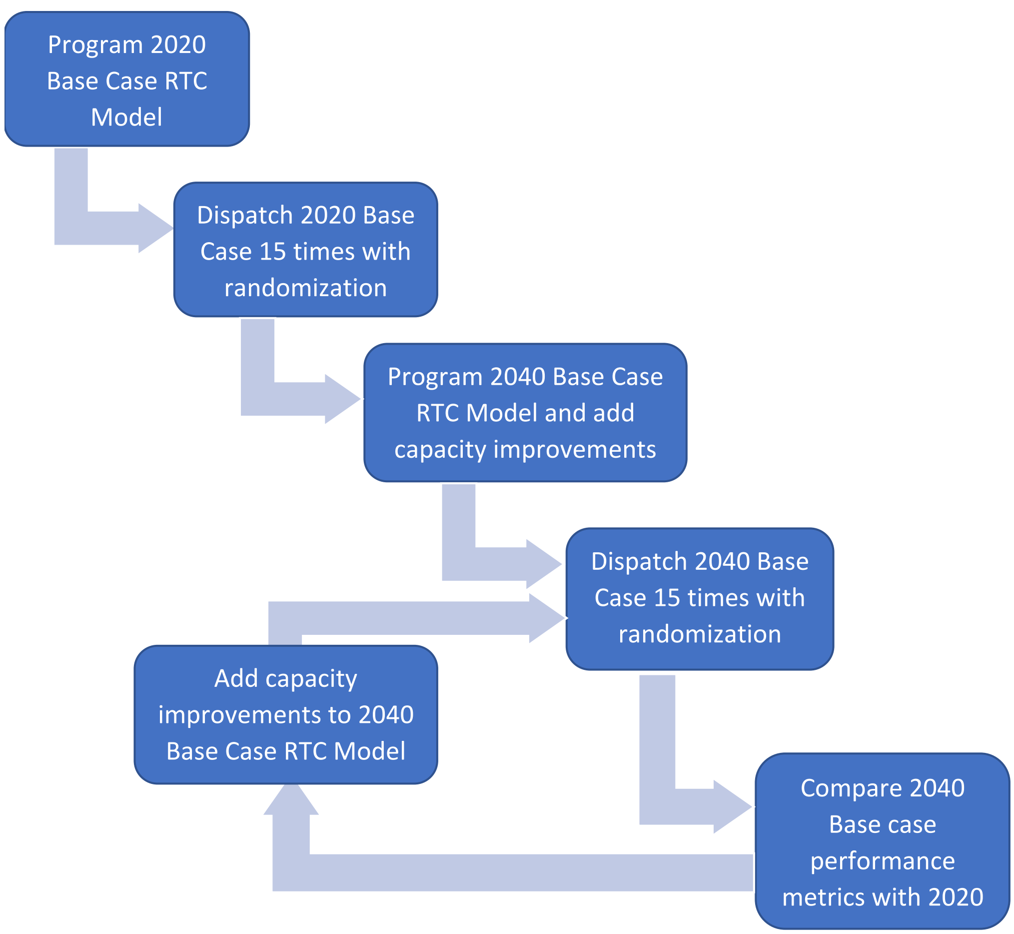
4.2. Evaluations and Metrics

RTC models were prepared for the following cases:

1. Base Case 2020
2. Base Case 2040
3. Proposed Case 2020
    a. Minimum Service Alternative
    b. Minimum Bi-Directional Service Alternative
    c. Northstar Express Service Alternative
    d. Bi-Directional Service Alternative
4. Proposed Case 2040
    a. Minimum Service Alternative
    b. Minimum Bi-Directional Service Alternative
    c. Northstar Express Service Alternative
    d. Bi-Directional Service Alternative

Figure 8 depicts the evaluation methodology used to compare two cases: the 2040 Base Case vs. the 2020 Base Case.

Figure 8: 2040 Base Case Evaluation Methodology



The process illustrated in Figure 8 was completed to compare all other cases. Table 9 shows the pairs of Proposed RTC cases and Base Cases that were compared.

Table 9: RTC Cases for Comparison

RTC Case	Compared to 2020 Base Case	Compared to 2040 Base Case
2020 Minimum Service Alternative	✔	
2020 Minimum Bi-Directional Service Alternative	✔	
2020 Northstar Express Service Alternative	✔	
2020 Bi-Directional Service Alternative	✔	
2040 Base Case	✔	
2040 Minimum Service Alternative		✔
2040 Minimum Bi-Directional Service Alternative		✔
2040 Northstar Express Service Alternative		✔
2040 Bi-Directional Service Alternative		✔

Cases were compared with one another using RTC software outputs. Details of how the models were dispatched, how the data was collected, and how the RTC performance metrics were used are shown in the sections below.

4.2.1. Dispatching

RTC allows users to adjust dispatch logic parameters to emulate the procedures that a railroad dispatcher would use in the real world. Options under RTC's 'Operating Objectives' menus were adjusted until the dispatch results were similar to what was observed in the field. Additional detail on RTC dispatch settings is included in Attachment 2.

All RTC models were dispatched 15 times, collecting 15 data points for evaluation. Results were evaluated using a statistical t-Test. A t-Test is commonly used in statistics to compare two data sets. The t-Test evaluates whether the variation between the data sets represents a significant or non-significant difference in performance. The t-Test provides an understanding of how changes to the model's network or traffic impact train performance metrics.

To better interpret the results of the RTC data, a two tailed t-Test was conducted to compare the Proposed Case and Base Case data. The t-Test process is as follows:

- To conduct the t-Test, each sample's mean (m) and standard deviation (σ) were found.

  m = average (m1, m2, m3….)

$$\sigma = \sqrt{\frac{(m1-m)^2+(m2-m)^2+(m3-m)^2+\cdots\ldots\ldots}{n}}$$ where n = sample size

- Next, the t-value for the data sets was calculated using the formula below (Stone & Ellis, 2016):

$$t = \frac{(m - m')}{\sqrt{\frac{s^2}{n} + \frac{s'^2}{n'}}}$$

  Where m, m' are the means of each data set, n and n' are sample's sizes, and s and s' are the standard deviations.

- A typical t-value was obtained using the standard t-table value for the degree of freedom (DF) = n-1 and based on the level of significance (α) which determined the accuracy of test. The t-value obtained from the data sets was then compared with the standard t-value obtained from the table. If the t-value were less than the t-table value, the two data sets were deemed equal. If the t-value from the data sets were greater than the t-table value, than one data set was deemed to be greater or less than the other.

4.2.2. Randomization

In RTC, trains are programmed to operate at scheduled times. In real-world operations, scheduled freight trains often vary from scheduled departure times, while other types of freight trains operate only when needed. To account for this variability, the time that trains are scheduled to enter the network is programmed with "randomization". Randomization defines a window of time that a train can enter the network, bounded by early and late parameters. Table 10 displays the randomization programmed into the network by train type.

Table 10: BNSF Staples Subdivision Train Traffic Randomization Settings

Train Type	Amount of Time Trains Can Enter Network Before Scheduled Time (hh:mm)	Amount of Time Trains Can Enter Network After Scheduled Time (hh:mm)
A-Amtrak (Empire Builder)	00:00	00:00
A-Commuter (NorthStar)	00:00	00:00
B-Bare Table Intermodal	03:00	03:00
C-Coal Loads	00:30	01:30
D-Light Engines	20:00	20:00
E-Empty Unit Coal	00:30	01:30
F-Foreign RR Detour	03:00	03:00
G-Grain Loads	00:30	01:30
H-Hi Priority Merchandise	00:30	01:30
L-Local	00:30	01:30
M-Merchandise	00:30	01:30
Q-Guaranteed Intermodal	00:00	00:30
S-Stack Train	00:00	00:30
U-Unit ex Coal/Grain	03:00	03:00
V-Vehicle / Parts	00:00	00:30
X-Empty Grain	00:30	01:30
Z-Trains	00:00	00:30

4.2.3. Performance Metrics

RTC outputs nine files detailing a model's set of dispatches. The Summary file is the primary source of results for train performance by type and group. Data contained in the summary files are used for comparing Proposed and Base Cases.

Two RTC performance metrics were used for comparing RTC cases: 1) Average True Delay Minutes per 100 Train Miles (TM), which measures the additional time a train takes to traverse its route over the train's ideal run time, and 2) Average Elapsed Time per train (minutes), which measures the average time it takes a group of trains to traverse the network.

To compare the 2040 Base Case with the 2020 Base Case, the True Delay Minutes per 100 TM metric was used. Because BNSF train counts and train lengths are different in the two cases, the Average Elapsed Time metric was not used. The Average Elapsed Time metric is not recommended for the following reasons:

1. Average Elapsed Time is calculated in RTC from the time the head of a train enters the network to the time the train's rear end exits the network, making trip time directly related to a train's length. This relationship means that, without increasing the speed limit, trains with increased length will always take longer to complete the same route as a shorter train.
2. Lengthening a train changes its power-to-weight ratio, impacting the train's acceleration and deceleration. This impacts a train's elapsed time independent of other changes to the network.

To compare the 2020 and 2040 Proposed Cases with the 2020 and 2040 Base Cases, respectively, the Average Elapsed Time metric is used.

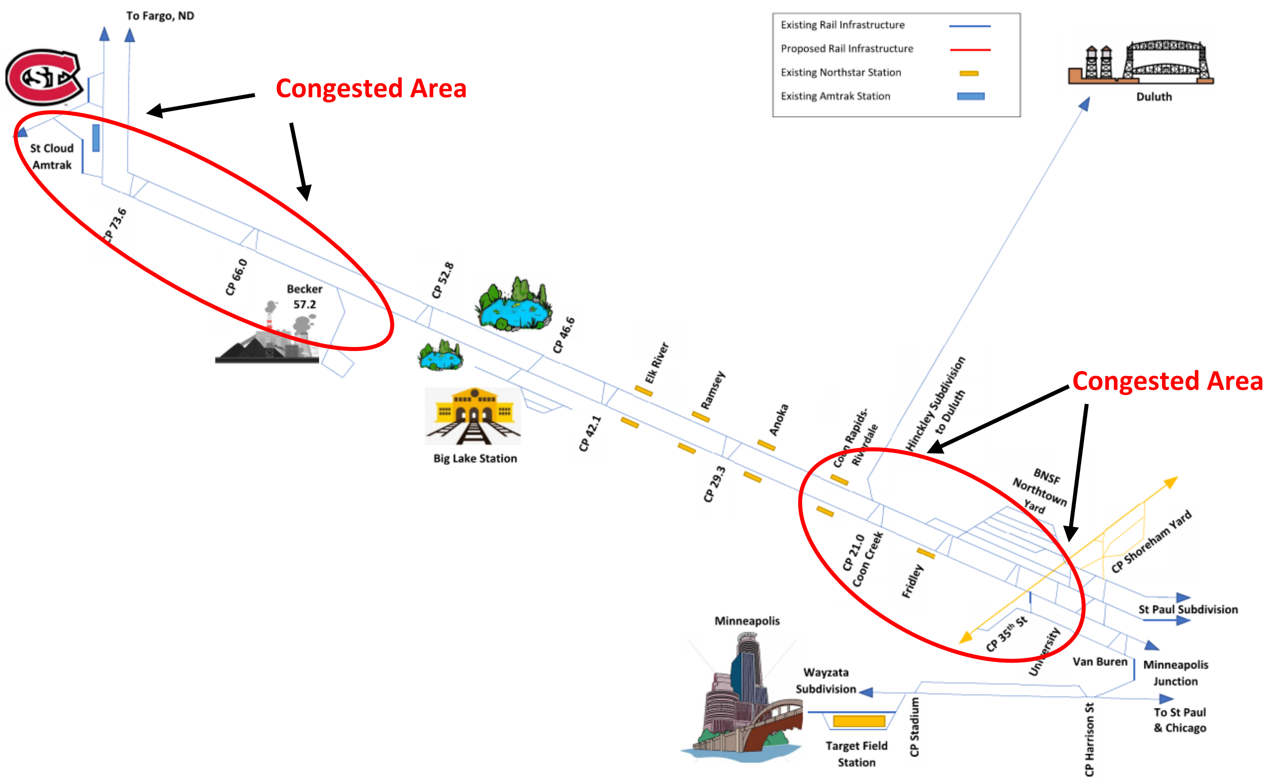
5. Evaluation of Network Capacity

Operation of the Base Case 2020 model, discussed in Section 2, was observed in RTC and "hot spots" of congestion were identified. Similarly, operations were observed for each of the Service Alternatives and 2040 freight traffic. The sections below highlight observations of existing network constraints and the constraints due to increased freight traffic and extended Northstar service.

5.1. 2020 Base Case Network Capacity

Figure 9 presents a graphic of the 2020 network between Minneapolis and St. Cloud with important features and areas of congestion.

Figure 9: 2020 Base Case Network Capacity



Along Northstar's route, trains operate on a single main track between CP Stadium and CP Interstate. Between CP Interstate and St. Cloud, trains operate on a two-track mainline. Within the 2020 Base Case, major points of constraint include:

- Northtown Yard – trains stop to change crews on the main tracks or enter and leave the yard at either end (CP Interstate on the west end and CP University on the east end). Some trains cross several main tracks to enter or leave the yard.
- Becker – loaded and empty unit coal trains arrive at and leave the Sherco power plant. Train crews must stop and operate track switches by hand.
- Minneapolis Junction to CP University – trains of several railroads arrive and depart via several routes in different directions at slow speeds with conflicting routes causing congestion.
- CP 21 at Coon Creek – trains moving via the Hinckley Subdivision (to and from Superior and Duluth) enter or leave the Staples Subdivision where trains to and from Northtown Yard are also changing main tracks.

The Base Case constrained locations are discussed further below.

5.1.1. Northtown Yard

Constraints at Northtown Yard are discussed in Section 2.3.2.

5.1.2. Becker

Operations near Becker (MP 57.2) are complex due to the location of the coal-fired power plant in the area. Trains entering and leaving the power plant at Becker can only operate on Track 2 (west track) between Becker and the next closest control point, CP MP 66 (9 miles west). In addition, two local trains per day stop on Track 1 (east track) at Becker to set off and pick up cars. Because there is no control point or crossovers between Tracks 1 and 2 at Becker, there is limited operating flexibility to pass stopped trains on Tracks 1 or 2.

5.1.3. Minneapolis Junction to CP University

Trains to and from the BNSF Wayzata, Midway, St. Paul, and Staples Subdivisions as well as Union Pacific, Canadian Pacific and short line freight trains, Amtrak intercity trains, and Northstar commuter trains all converge in this segment. Many freight trains are operating at 10 miles per hour moving into or out of yards and/or connecting tracks at junctions. CP University is also the east end of BNSF's busy Northtown Yard. BNSF's Union Yard is a short distance east of Minneapolis Junction. Union Yard is served by the railroad's high-priority intermodal trains (Z-trains) which carry parcels, mail and other time-sensitive commodities. Light engine movements (locomotives without trains) also move through this segment. Northstar commuter trains to and from Target Field Station on the Wayzata Subdivision join the Midway Subdivision at CP Van Buren.

5.1.4. CP 21/Coon Creek

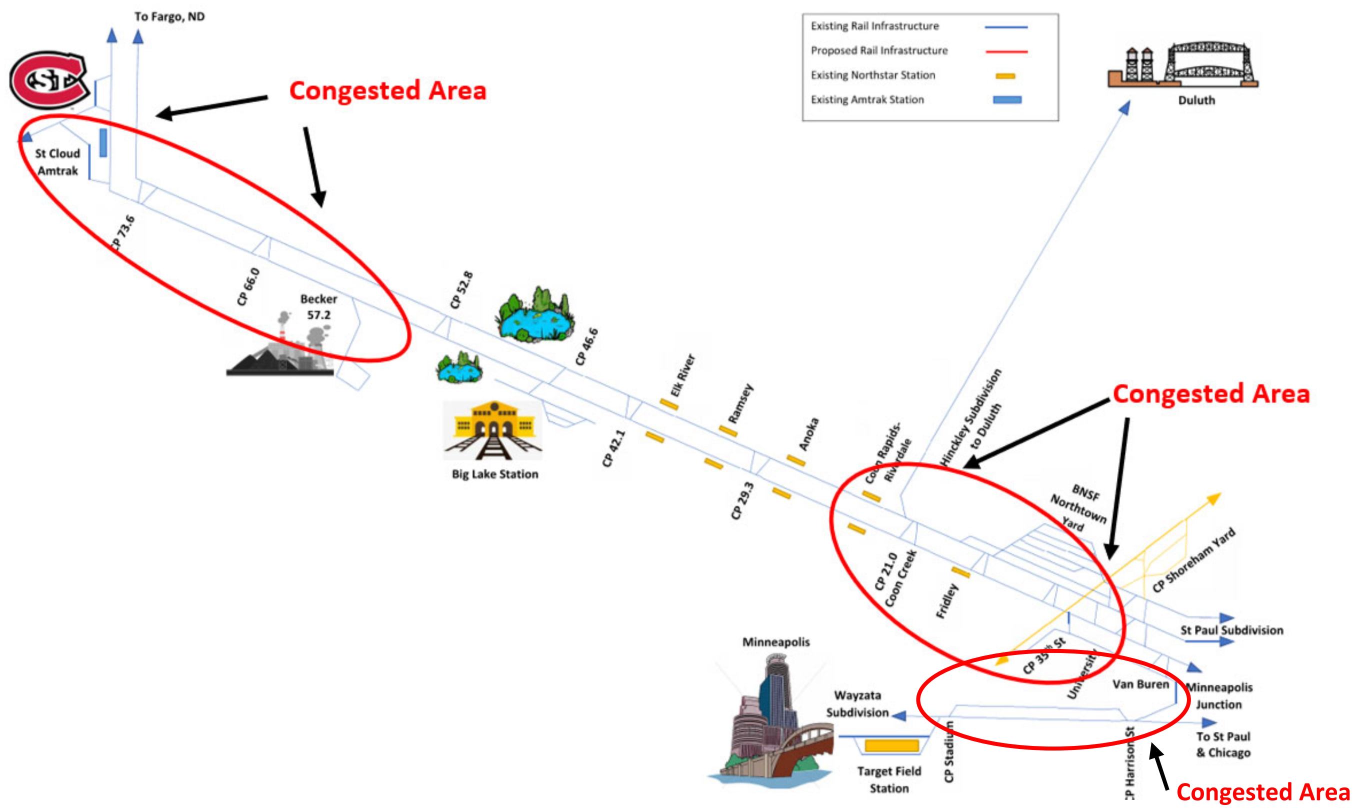
CP 21/Coon Creek connects the single-track Hinckley Subdivision to the double-track Staples Subdivision. This junction links the Twin Cities to the Twin Ports area of Superior, WI and Duluth, MN and links the Twin Cities to St. Cloud and points west. Freight trains often change tracks at CP 21 to facilitate parallel movements into and out of Northtown Yard (approximately 5 miles to the east) and to reduce conflicts near Fridley and CP Interstate. Capacity at the junction is most limited during the morning peak period. During the morning peak, Northstar operates on Main Track 2 at 30-minute intervals, causing westbound freight trains to hold at MP 16.3 while eastbound freight trains and the eastbound Amtrak Empire Builder operate on Main Track 1.

5.2. 2040 Base Case Network Capacity

The 2040 Base Case was modeled with a horizon year level of traffic for freight trains as presented in Table 7. Northstar and Amtrak service levels were assumed to remain unchanged from the 2020 Base Case.

In addition to the congested areas identified in the 2020 Base Case, it was found that, in 2040, the track between CP Van Buren and CP Harrison St. became increasingly congested. This area is depicted in Figure 10.

Figure 10: 2040 Base Case Network Capacity



The single west wye track between CP Van Buren and CP Harrison Street is Northstar's route through Minneapolis Junction. Minneapolis Junction connects BNSF's Wayzata and Midway Subdivisions. Freight trains operating between the Wayzata Sub and Northtown Yard conflict with Northstar trains between Big Lake and Target Field Station in this segment. In 2040, when more freight trains would operate through the network, conflicts would occur more frequently than in 2020 conditions.

5.3. Proposed Case Network Capacity

5.3.1. Description of Service Alternatives

Four Service Alternatives were identified for extending Northstar service to St. Cloud. High-level definitions of the Service Alternatives are as follows:

- **Minimum Service Alternative**: One existing weekday AM peak train to Minneapolis will be extended to begin its trip in St. Cloud and one existing PM peak train will be extended to operate from Minneapolis to St. Cloud.
- **Minimum Bi-Directional Service Alternative**: In the weekday AM peak, one existing train to Minneapolis will be extended to begin its trip in St. Cloud and existing train will be extended to operate from Minneapolis to St. Cloud. In the weekday PM peak, one existing train to Minneapolis will be extended to begin its trip in St. Cloud and one existing train will be extended to operate from Minneapolis to St. Cloud.
- **Express Service Alternative**: One weekday Express train in each direction between Minneapolis and St. Cloud will be added during the AM and PM peak periods.

- **Bi-Directional Service Alternative**: Two existing weekday AM peak trains to Minneapolis will be extended to begin their trips in St. Cloud and one new AM peak train will operate from Minneapolis to St. Cloud. In the PM peak, one existing train to Minneapolis will be extended to begin its trip in St. Cloud and one new train will operate from St. Cloud to Minneapolis. From Minneapolis, two existing trains will be extended to St. Cloud and two new trains will be operated to St. Cloud. One new train will operate from Big Lake to Minneapolis.

On weekdays, all trains in each of the Service Alternatives, except for the Northstar Express Service Alternative, are proposed to stop at all stations. Northstar Express trains will operate non-stop between St Cloud and Minneapolis. On weekends and holidays, each of the four Service Alternatives will add one morning and one afternoon non-stop express train service in each direction between St. Cloud and Minneapolis. The level of weekend/holiday service is the same for all four Service Alternatives. The weekend express trains in all four Service Alternatives are in addition to the existing Northstar local service between Big Lake and Minneapolis.

BNSF requested that Northstar crews from the existing crew base location at Northtown Yard, which go on and off duty at Big Lake, be used to operate any Northstar service extension. Additionally, the crew layover facility will remain in Minneapolis. Continuing to use the Northtown crew base, with crews reporting at Big Lake, will require trains to deadhead 27 miles west to St. Cloud before inbound service begins. For each train operating to or from St Cloud, an additional 54 miles would be traveled.

Detailed information on the Service Alternatives is provided in the Technical Memoranda on Operating Assumptions (Appendices B, C, D, and E).

5.3.2. 2020 and 2040 Proposed Cases

Each of the proposed Service Alternatives was modeled with existing freight and with 2040 freight volumes. Generally, it was observed that congestion under a 2020 Proposed Case became more congested under the associated 2040 Proposed Case (i.e. congested locations for the 2020 Minimum Service Alternative became more congested under the 2040 Minimum Service Alternative). The following sections discuss the observed congestion in the 2020 and 2040 network for each of the Service Alternatives.

5.3.2.1. 2020 and 2040 Minimum Service Alternative

When the Minimum Service Alternative was added to the 2020 Base Case, additional congestion was observed between Big Lake and St. Cloud as a result of the four additional Northstar trains proposed to operate in that segment of track. At St. Cloud, freight train traffic was interrupted by Northstar trains as they access the proposed station by both crossing over from Track 1 to Track 2 and slow down to enter or leave the station track. Congestion also increased at Big Lake. The existing Big Lake Station was designed to function as the terminus of the service, so it is only accessible from the east. The proposed service would require trains to access the station from the west. If the existing track configuration were utilized under the 2020 Minimum Service Alternative, eastbound trains needing to stop at Big Lake Station would have to pull past the Big Lake stub track entrance, change ends, and then make a reverse movement into the stub track. The additional train movements and stopping on the mainline reduced the network's capacity.

In 2040, the Minimum Service Alternative with 2040 freight traffic created additional congestion between St. Cloud and Big Lake, near Northtown Yard, and between CP Van Buren and CP Stadium.

5.3.2.2. 2020 and 2040 Minimum Bi-Directional Service Alternative

When the Minimum Bi-Directional Service Alternative was added to the 2020 Base Case, additional congestion was observed between Big Lake and St. Cloud as a result of the six additional Northstar trains proposed to operate in that segment of track. Similar to the Minimum Service Alternative, Minimum Bi-Directional Service Alternative trains would interfere with freight operations at St. Cloud due to crossover moves and would use up mainline capacity with reverse moves to access Big Lake Station.

In 2040, the Minimum Bi-Directional Service Alternative with 2040 freight traffic created additional congestion between St. Cloud and Big Lake, near Northtown Yard, and between CP Van Buren and CP Stadium.

5.3.2.3. 2020 and 2040 Northstar Express Service Alternative

When the Northstar Express Service Alternative was added to the 2020 Base Case, additional congestion was observed between St. Cloud and Minneapolis as a result of the eight additional Northstar trains proposed to operate between St. Cloud and Big Lake and four additional trains between Big Lake and Minneapolis. Similar to the Minimum Service Alternative, Northstar Express Service Alternative trains would interfere with freight operations at St. Cloud due to crossover moves and would use mainline capacity with reverse moves to access Big Lake Maintenance Facility (BLMF). In addition, the Northstar Express Service Alternative would require time slots to traverse the congested area between CP Coon Creek and CP Interstate, increasing the likelihood of freight trains having to wait to accommodate the proposed trains.

In 2040, the Northstar Express Service Alternative with 2040 freight traffic created additional congestion between St. Cloud and Big Lake and between CP Coon Creek and CP Stadium.

5.3.2.4. 2020 and 2040 Bi-Directional Service Alternative

When the Bi-Directional Service Alternative was added to the 2020 Base Case, additional congestion was observed along the entire route between St. Cloud and Minneapolis as a result of the 16 additional Northstar trains proposed to operate between St. Cloud and Big Lake and six additional trains between Big Lake and Minneapolis. Additionally, the Bi-Directional Service Alternative proposes passenger train meets west of Big Lake, which would require both main tracks to be reserved for passenger operations. This Service Alternative also extends Northstar's hours of operation, causing more interruption to the freight train operations in the network.

In 2040, the Bi-Directional Service Alternative with 2040 freight traffic created additional congestion between St. Cloud and Big Lake and between CP Coon Creek and CP Stadium.

6. RTC Modeling Results

The following sections present the results of the evaluation of proposed Northstar Service Alternatives in 2020 and 2040 using RTC.

6.1. 2020 Results

6.1.1. 2020 Minimum Service Alternative

To mitigate the impact of the 2020 Minimum Service Alternative on the 2020 Base Case, the following capacity improvements are needed:

- Construct station track for Northstar Service at St. Cloud
- Upgrade crossovers east of St. Cloud Station to #24 crossovers
- Construct new CTC control point with #24 universal crossover west of St. Cloud Station
- Extend station track at Big Lake to the west and construct new CTC control point with #24 universal crossover at MP 47.1

In addition, the passenger fare collection system and information system would be upgraded. Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 11 shows the capacity improvements needed for the Minimum Service Alternative in 2020 in red.

Figure 11: 2020 Minimum Service Alternative Capacity Improvements

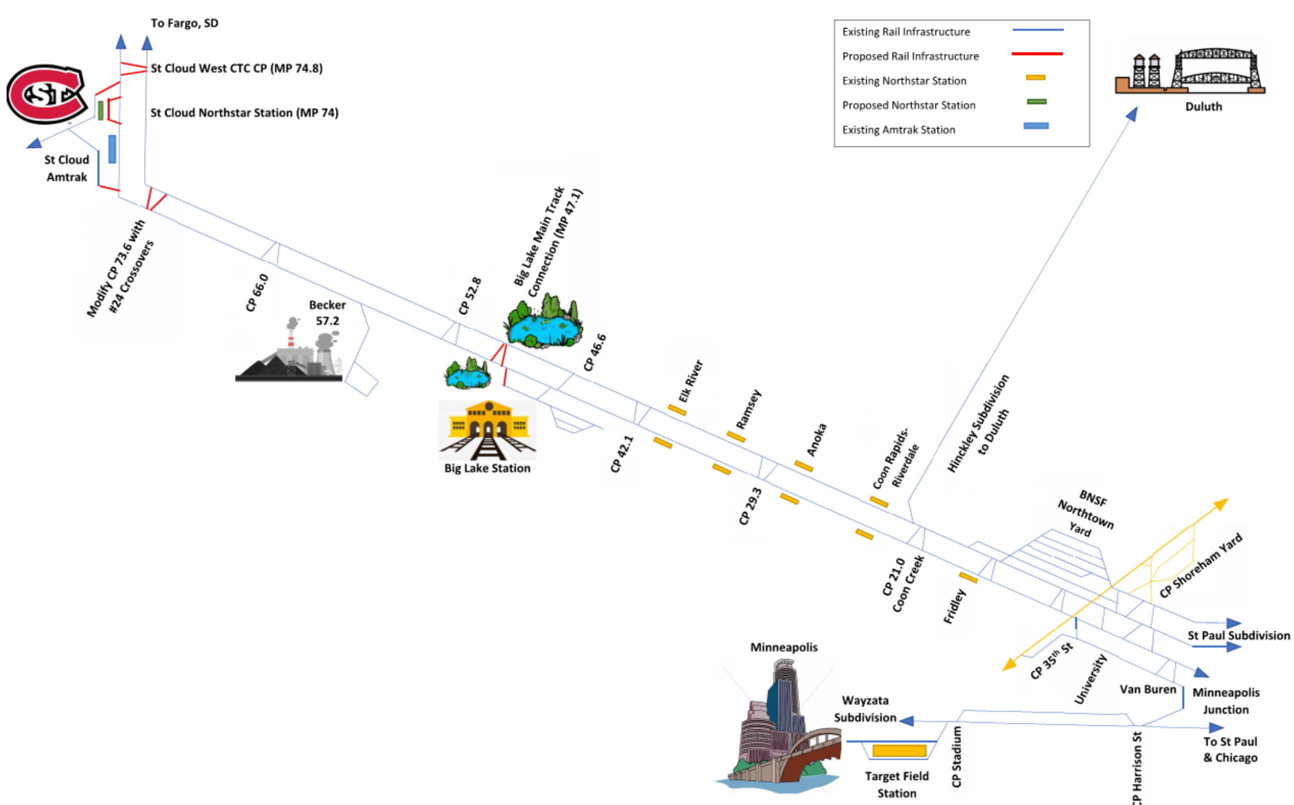


Table 11 presents the results of the RTC analysis and a comparison between the 2020 Base Case and the 2020 Minimum Service Alternative with the capacity improvements shown in Figure 11.

Table 11: 2020 Minimum Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2020 Base Case	BNSF	89.1
2020 Minimum Service	BNSF	88.6

With the proposed capacity improvements in place, the average elapsed time for a BNSF train to traverse the network under the 2020 Minimum Service Alternative would be less than 2020 Base Case levels. The 2020 Minimum Service Alternative would not impact 2020 BNSF operations.

6.1.2. 2020 Minimum Bi-Directional Service Alternative

To mitigate the impact of the 2020 Minimum Bi-Directional Service Alternative on the 2020 Base Case, the following capacity improvements are needed:

- All improvements for the Minimum Service Alternative
- Procurement of one additional Northstar trainset
- Construction of additional capacity at Big Lake Maintenance Facility for storage and maintenance of new trainset
- Construction of center platform at Big Lake Station

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 12 shows the capacity improvements needed for the Minimum Bi-Directional Service Alternative in 2020 in red.

Figure 12: 2020 Minimum Bi-Directional Service Alternative Capacity Improvements

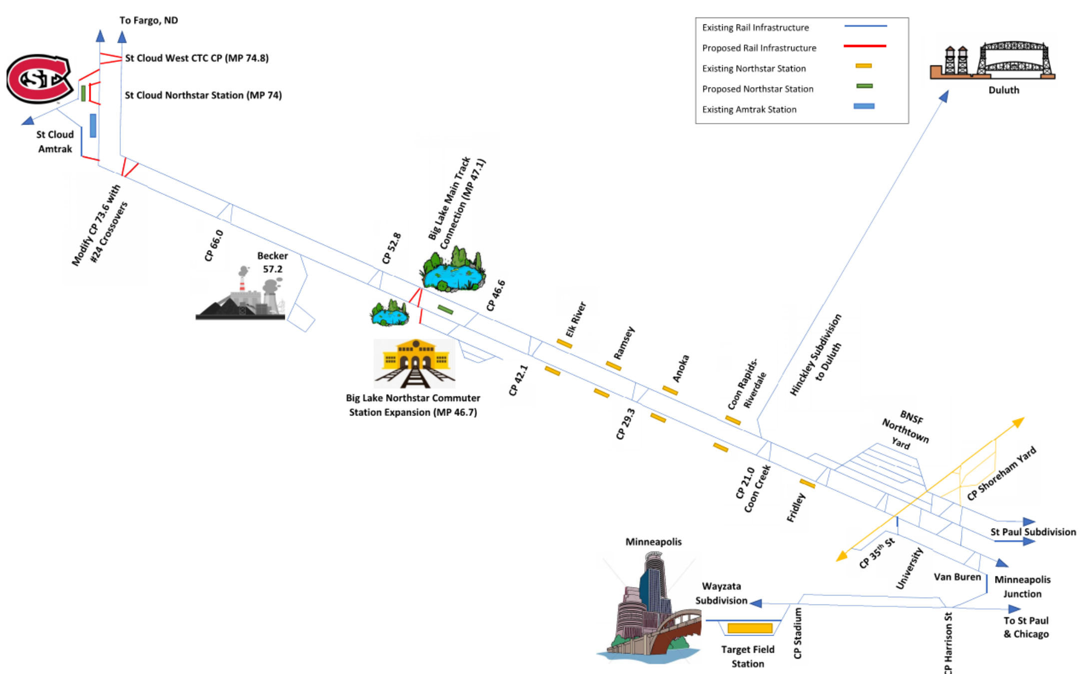


Table 12 presents the results of the RTC analysis and a comparison between the 2020 Base Case and the 2020 Minimum Bi-Directional Service Alternative with the capacity improvements shown in Figure 12.

Table 12: 2020 Minimum Bi-Directional Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2020 Base Case	BNSF	89.1
2020 Minimum Bi-Directional Service	BNSF	88.6

With the proposed capacity improvements in place, the average elapsed time for a BNSF train to traverse the network under the 2020 Minimum Bi-Directional Service Alternative would be less than 2020 Base Case levels. The 2020 Minimum Bi-Directional Service Alternative would not impact 2020 BNSF operations.

6.1.3. 2020 Northstar Express Service Alternative

To mitigate the impact of the 2020 Northstar Express Service Alternative on the 2020 Base Case, the following capacity improvements are needed:

- All improvements for the Minimum Service Alternative
- Procurement of one additional Northstar trainset
- Construction of additional capacity at Big Lake Maintenance Facility for storage and maintenance of new trainset
- Construction of a third main track with additional #24 crossovers and CTC control points between CP Coon Creek and CP Interstate

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 13 shows the capacity improvements needed for the Northstar Express Service Alternative in 2020 in red.

Figure 13: 2020 Northstar Express Service Alternative Capacity Improvement

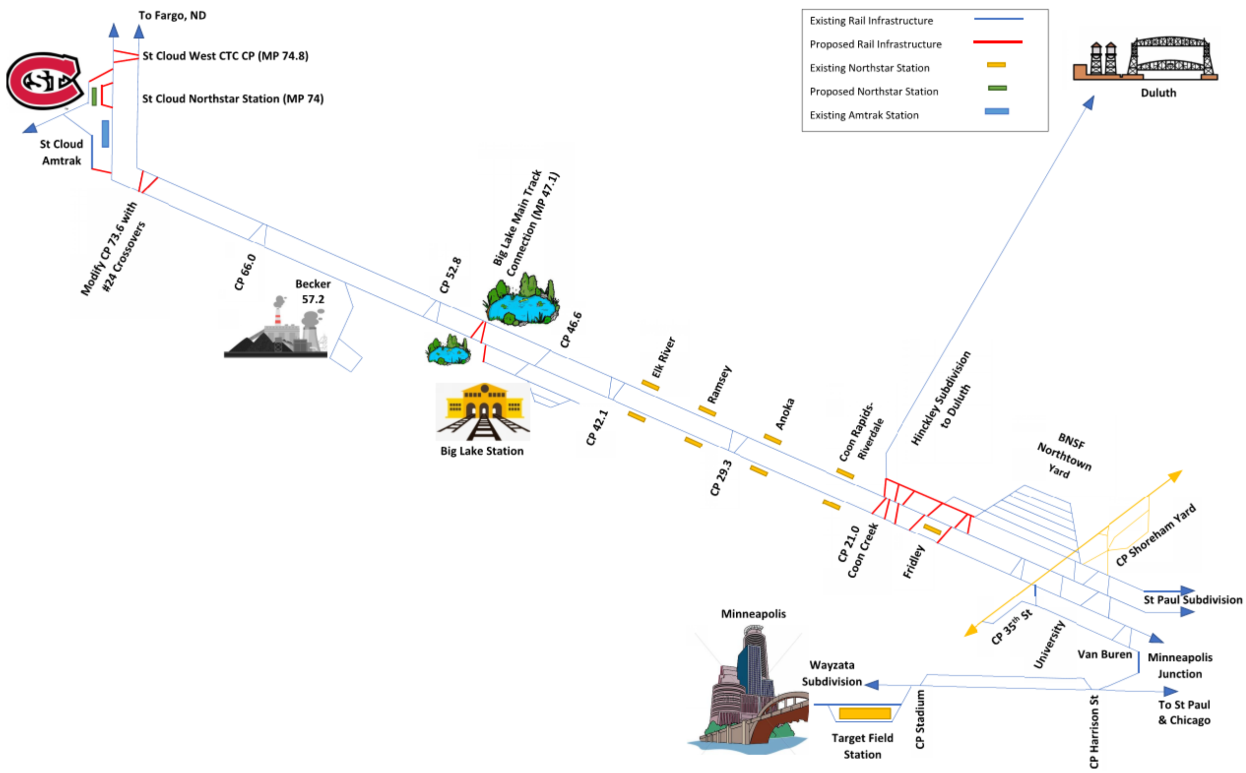


Table 13 presents the results of the RTC analysis and a comparison between the 2020 Base Case and the 2020 Northstar Express Service Alternative with the capacity improvements shown in Figure 13.

Table 13: 2020 Northstar Express Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2020 Base Case	BNSF	89.1
2020 Northstar Express Service	BNSF	88.3

With the proposed capacity improvements in place, the average elapsed time for a BNSF train to traverse the network under the 2020 Northstar Express Service Alternative would be less than 2020 Base Case levels. The 2020 Northstar Express Service Alternative would not impact 2020 BNSF operations.

6.1.4. 2020 Bi-Directional Service Alternative

To mitigate the impact of the 2020 Bi-Directional Service Alternative on the 2020 Base Case, the following capacity improvements are needed:

- All improvements for the Minimum Service Alternative
- Procurement of one additional Northstar trainset
- Upgrade crossovers at MP 66 to #24 crossovers

- Construct new CTC control point at Becker (MP 57.2) with #24 universal crossover
- Construction of additional capacity at Big Lake Maintenance Facility for storage and maintenance of new trainset
- Construction of center platform at Big Lake Station
- Construction of a third main track with additional #24 crossovers and CTC control points between CP 21 at Coon Creek and CP Interstate

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 14 shows the capacity improvements needed for the Bi-Directional Service Alternative in 2020 in red.

Figure 14: 2020 Bi-Directional Service Alternative Capacity Improvements

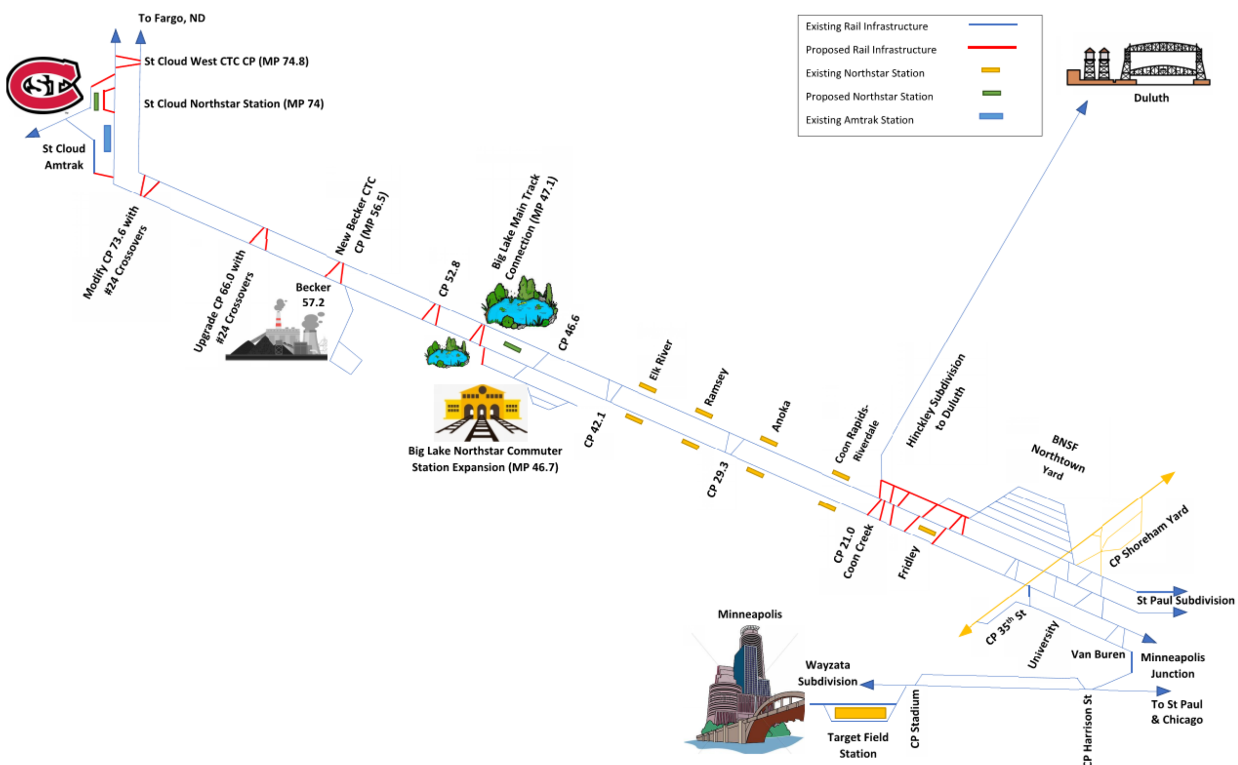


Table 14 presents the results of the RTC analysis and a comparison between the 2020 Base Case and the 2020 Bi-Directional Service Alternative with the capacity improvements shown in Figure 14.

Table 14: 2020 Bi-Directional Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2020 Base Case	BNSF	89.1
2020 Bi-Directional Service	BNSF	88.1

With the proposed capacity improvements in place, the average elapsed time for a BNSF train to traverse the network under the 2020 Bi-Directional Service Alternative would be less than 2020 Base Case levels. The 2020 Bi-Directional Service Alternative would not impact 2020 BNSF operations.

6.2. 2040 Results

6.2.1. 2040 Base Case

To mitigate the impact of the 2040 Base Case (2040 freight traffic) on the 2020 Base Case, the following capacity improvements are needed:

- Construction of a third main track with additional #24 crossovers and CTC control points between CP Coon Creek and CP Interstate
- Construction of a second main track between CP Van Buren and CP Harrison and upgrading the existing auxiliary track and adding crossovers to create a second main track between CP Harrison St. and CP Stadium

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 15 shows the capacity improvements needed to mitigate the 2040 freight traffic in red.

Figure 15: 2040 Base Case Capacity Improvements

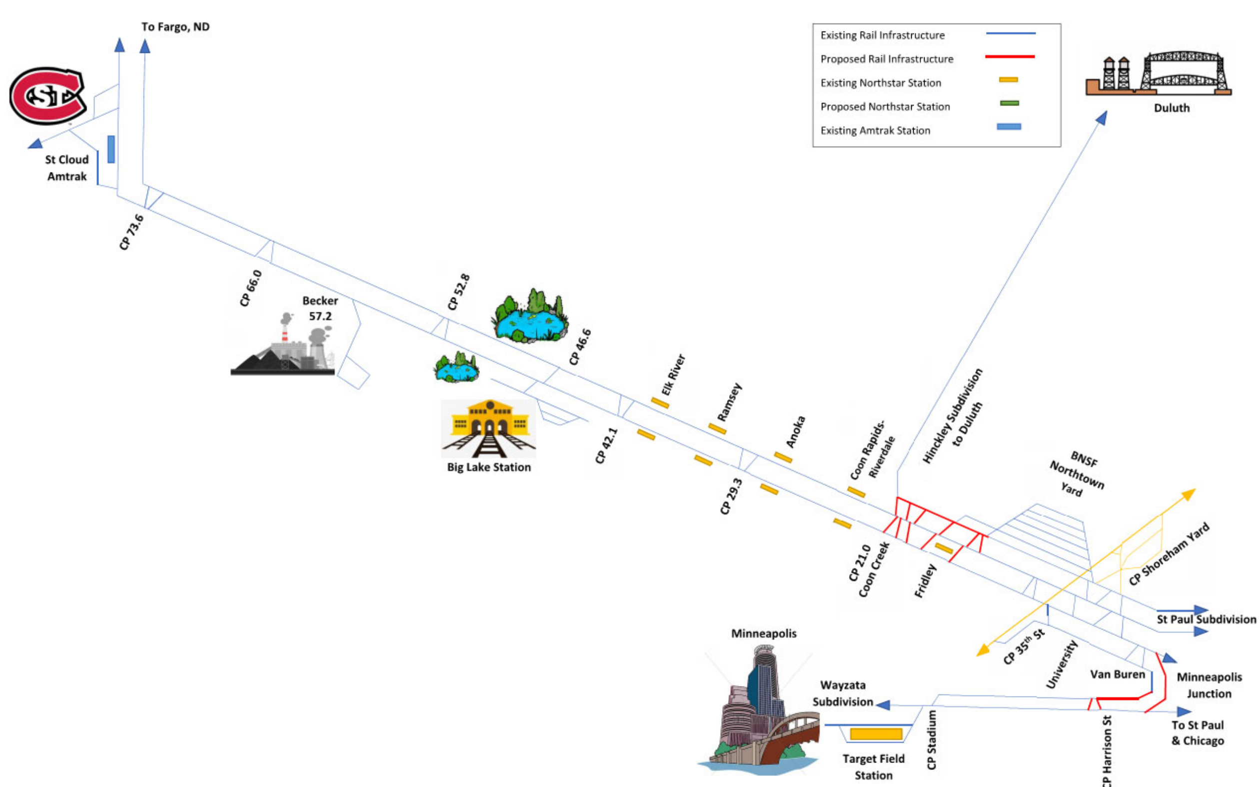


Table 15 presents the results of the RTC analysis and a comparison between the 2020 Base Case and the 2040 Base Case with the capacity improvements shown in Figure 15.

Table 15: 2040 Base Case RTC Results

Service Year and Northstar Service Alternative	Category	True Delay Minutes per 100 TM (Minutes)
2020 Base Case	BNSF	10.4
2040 Base Case	BNSF	10.9

With the proposed capacity improvements in place, the average true delay minutes per 100 train miles per train for the 2040 Base Case would be slightly greater than 2020 Base Case levels. A statistical t-test evaluating the 15 dispatches found that the difference in true delay was not significant. The addition of the 2040 Base Case freight traffic would not significantly impact 2020 BNSF operations.

6.2.2. 2040 Minimum Service Alternative

To mitigate the impact of the 2040 Minimum Service Alternative on the 2040 Base Case, the following capacity improvements are needed:

- All improvements for the 2020 Minimum Service Alternative
- Construct new CTC control point at Becker (MP 57.2) with #24 universal crossover
- Construction of a third main track with additional #24 crossovers and CTC control points between CP Coon Creek and CP Interstate
- Construction of a second main track between CP Van Buren and CP Harrison and upgrade of the existing auxiliary track to main track with additional crossovers between CP Harrison and CP Stadium

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 16 shows the capacity improvements needed for the Minimum Service Alternative in 2040 in red.

Figure 16: 2040 Minimum Service Alternative Capacity Improvements

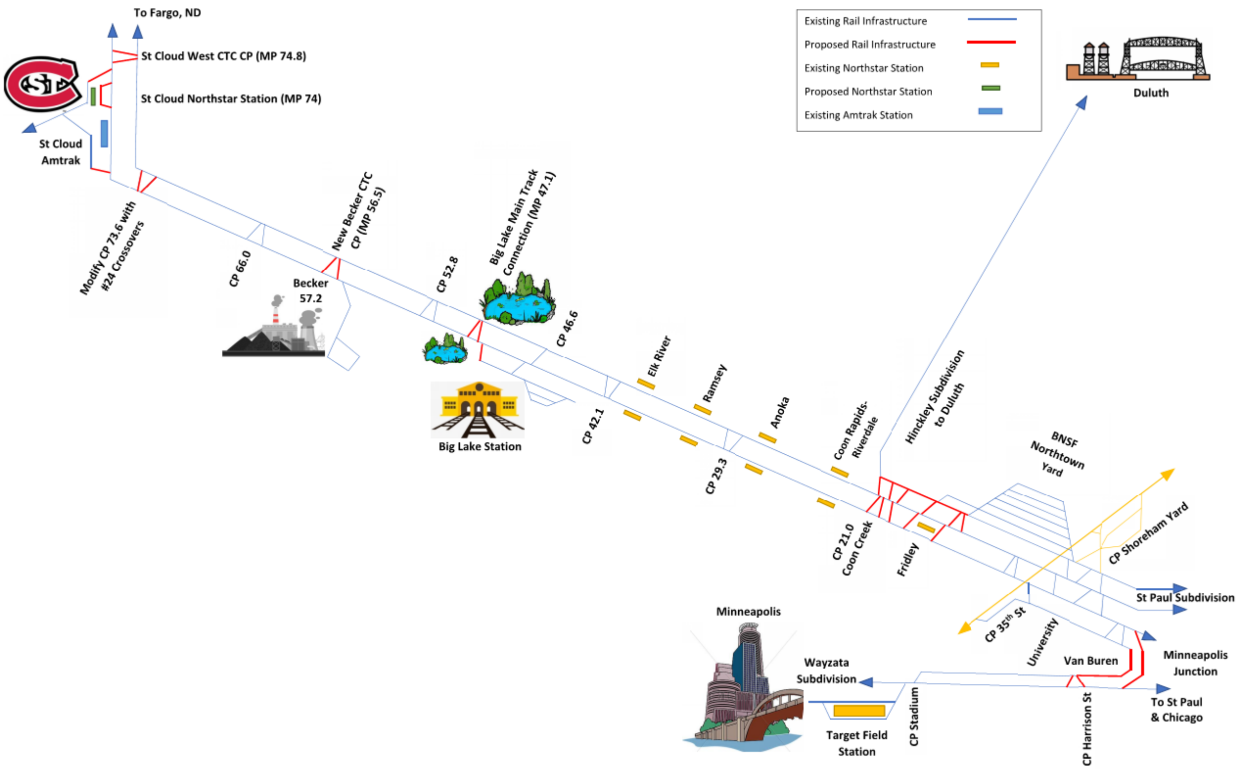


Table 16 presents the results of the RTC analysis and a comparison between the 2040 Base Case and the 2040 Minimum Service Alternative with the capacity improvements shown in Figure 16.

Table 16: 2040 Minimum Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2040 Base Case	BNSF	90.2
2040 Minimum Service	BNSF	90.6

With the proposed capacity improvements in place, the average elapsed time for a BNSF train to traverse the network under the 2040 Minimum Service Alternative, would be slightly greater than 2040 Base Case levels. A statistical t-test evaluating the 15 dispatches found that the difference in average elapsed time between the 2040 Minimum Service Alternative and the 2040 Base Case was not significant. Therefore, the 2040 Minimum Service Alternative would not significantly impact 2040 BNSF operations.

6.2.3. 2040 Minimum Bi-Directional Service Alternative

To mitigate the impact of the 2040 Minimum Bi-Directional Service Alternative on the 2040 Base Case, the following capacity improvements are needed:

- All improvements for the 2020 Minimum Bi-Directional Service Alternative

- Upgrade crossovers at MP 66 to #24 crossovers
- Construct new CTC control point at Becker (MP 57.2) with #24 universal crossover
- Construction of a third main track with additional #24 crossovers and control points between CP Coon Creek and CP Interstate
- Construction of a second main track between CP Van Buren and CP Harrison and upgrade of the existing auxiliary track to main track with additional crossovers between CP Harrison and CP Stadium

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 17 shows the capacity improvements needed for the Minimum Bi-Directional Service Alternative in 2040 in red.

Figure 17: 2040 Minimum Bi-Directional Service Alternative Capacity Improvements

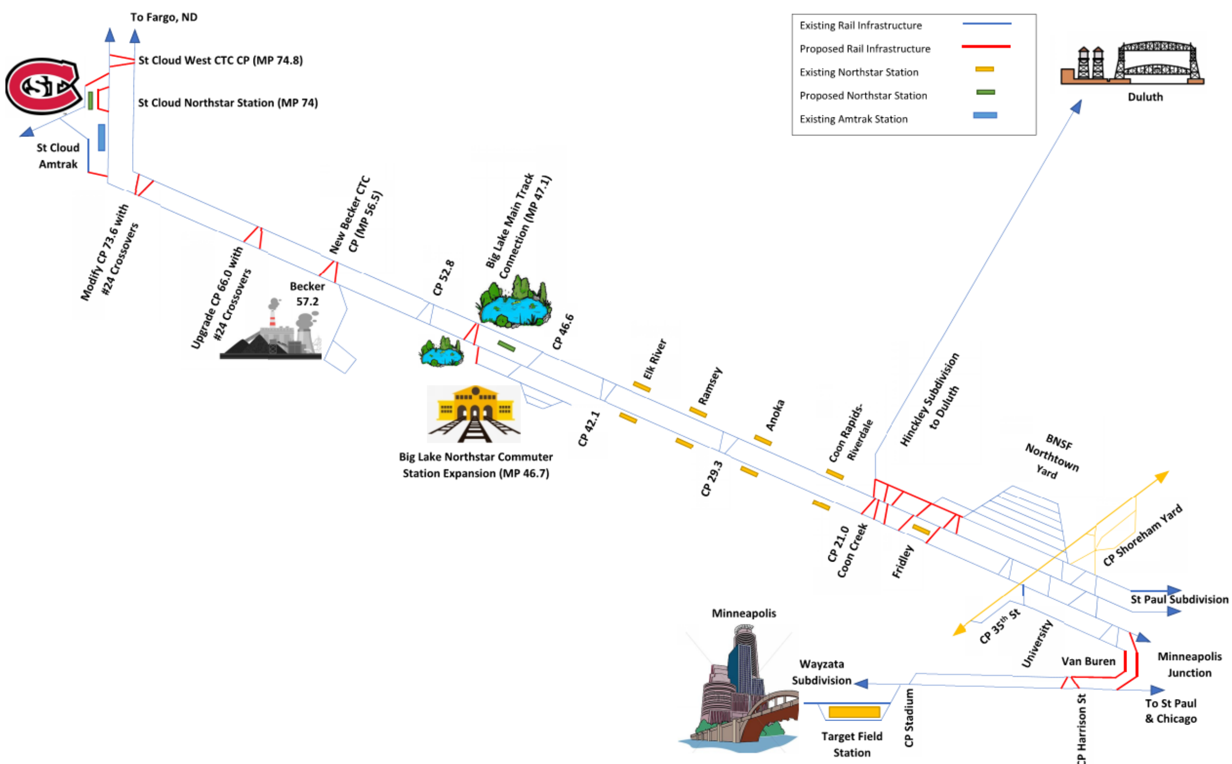


Table 17 presents the results of the RTC analysis and a comparison between the 2040 Base Case and the 2040 Minimum Bi-Directional Service Alternative with the capacity improvements shown in Figure 17.

Table 17: 2040 Minimum Bi-Directional Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2040 Base Case	BNSF	90.2
2040 Minimum Bi-Directional Service	BNSF	90.3

With the proposed capacity improvements in place, the average elapsed time for a BNSF train to traverse the network under the 2040 Minimum Bi-Directional Service Alternative would be slightly greater than 2040 Base Case levels. A statistical t-test evaluating the 15 dispatches found that the difference in average elapsed time between the 2040 Minimum Bi-Directional Service Alternative and the 2040 Base Case was not significant. Therefore, the 2040 Minimum Bi-Directional Service Alternative would not significantly impact 2040 BNSF operations.

6.2.4. 2040 Northstar Express Service Alternative

To mitigate the impact of the 2040 Northstar Express Service Alternative on the 2040 Base Case, the following capacity improvements are needed:

- All improvements for the 2020 Northstar Express Service Alternative
- Upgrade crossovers at MP 66 to #24
- Construct new CTC control point at Becker (MP 57.2) with #24 universal crossover
- Construction of a third main track with additional #24 crossovers between CP Interstate and CP Van Buren
- Construction of a second main track between CP Van Buren and CP Harrison and upgrade of the existing auxiliary track to main track with additional crossovers between CP Harrison and CP Stadium

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 18 shows the capacity improvements needed for the Northstar Express Service Alternative in 2040 in red.

Figure 18: 2040 Northstar Express Service Alternative Capacity Improvements

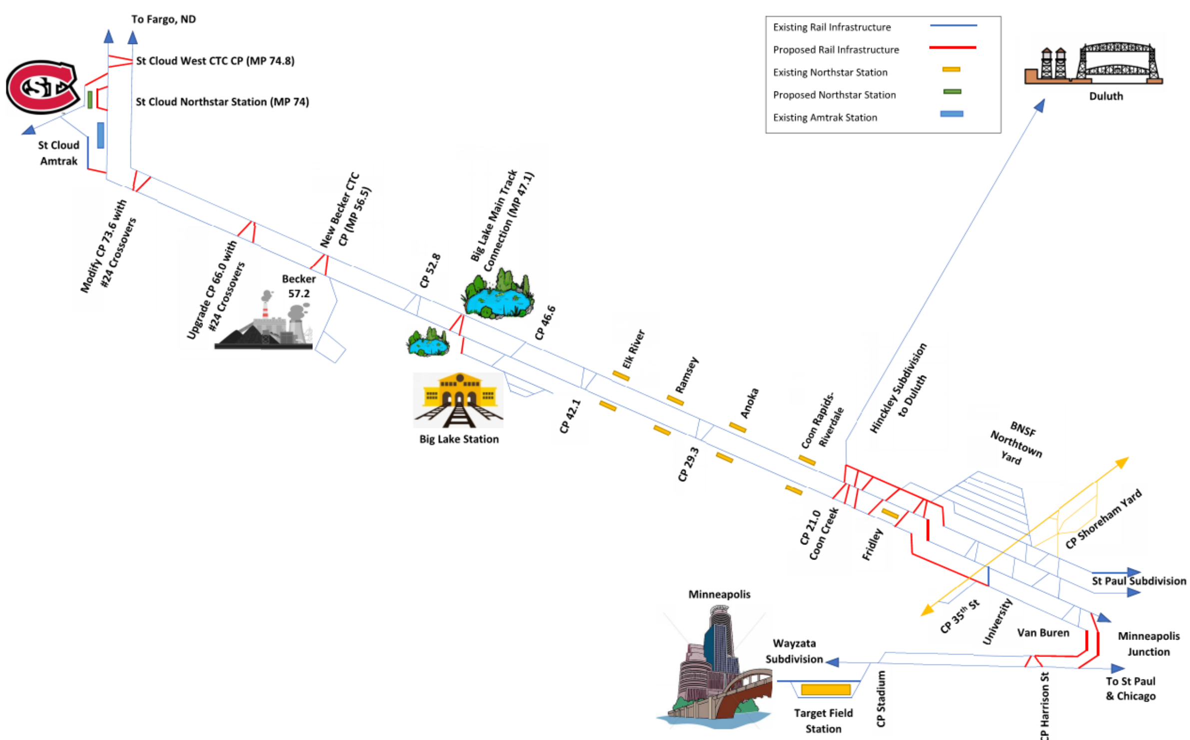


Table 18 presents the results of the RTC analysis and a comparison between the 2040 Base Case and the 2040 Northstar Express Service Alternative with the capacity improvements shown in Figure 18.

Table 18: 2040 Northstar Express Service Alternative RTC Results

Service Year and Northstar Service Alternative	Category	Average Elapsed Time per Train (Minutes)
2040 Base Case	BNSF	90.2
2040 Northstar Express Service	BNSF	90.5

With the proposed capacity improvements in place, the average elapsed time for a BNSF trains to traverse the network under the 2040 Northstar Express Service Alternative would be slightly greater than 2040 Base Case levels. A statistical t-test evaluating the 15 dispatches found that the difference in average elapsed time between the 2040 Northstar Express Service Alternative and the 2040 Base Case was not significant. Therefore, the 2040 Northstar Express Service Alternative would not significantly impact BNSF operations.

6.2.5. 2040 Bi-Directional Service Alternative

To mitigate the impact of the 2040 Bi-Directional Service Alternative on the 2040 Base Case, the following capacity improvements are needed:

- All improvements for the 2040 Bi-Directional Service Alternative
- Construction of a five-mile-long third main track between Big Lake Station and MP 52.8
- Construction of a third main track with additional #24 crossovers between CP Interstate and CP Van Buren
- Construction of a second main track between CP Van Buren and CP Harrison and upgrade of the existing auxiliary track to main track with additional crossovers between CP Harrison and CP Stadium

Concept engineering plans for the capacity improvements are provided in **Appendix G**.

Figure 19 shows the capacity improvements needed for the Bi-Directional Service Alternative in 2040 in red.

Figure 19: 2040 Bi-Directional Service Alternative Capacity Improvement

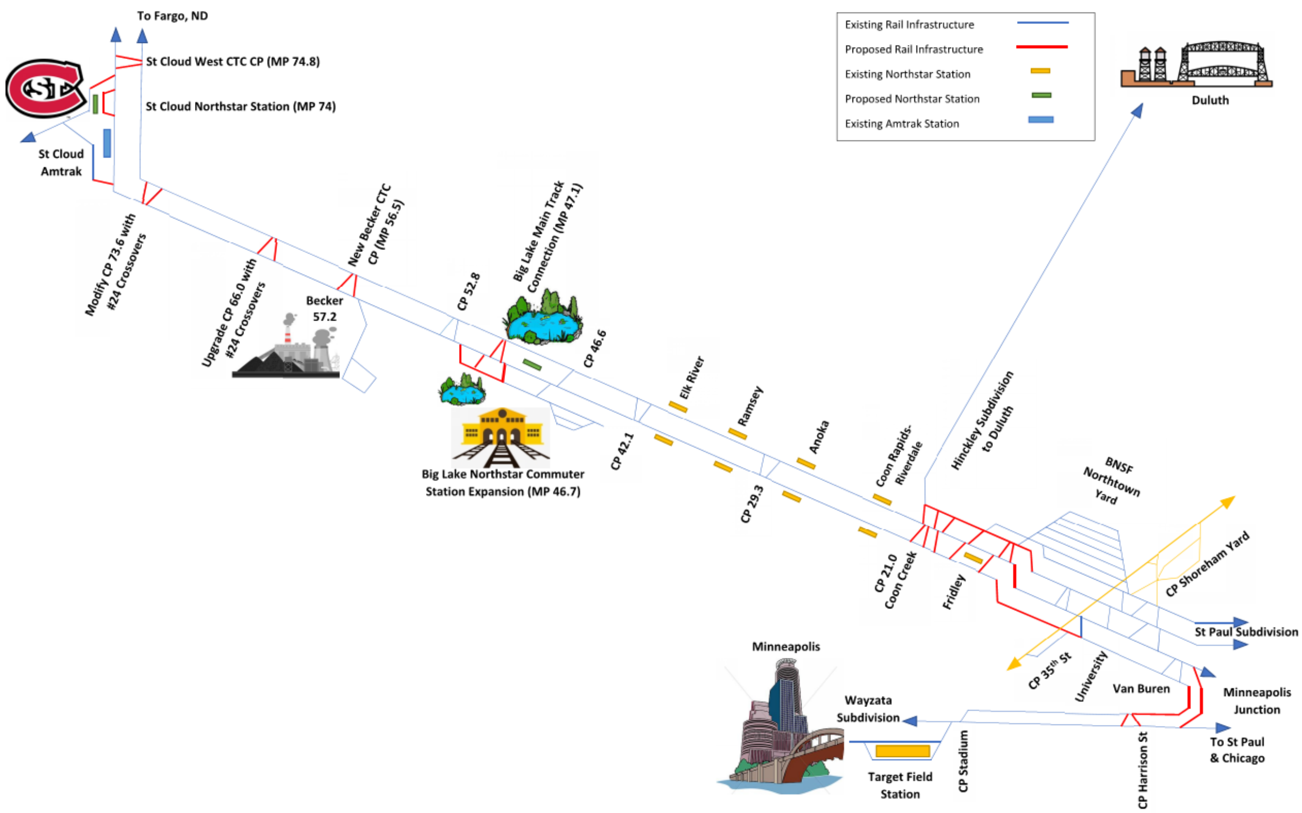


Table 19 presents the results of the RTC analysis and a comparison between the 2040 Base Case and the 2040 Bi-Direct onal Service Alternative with the capac ty mprovements shown in Figure 19.

Table 19: 2040 Bi-Directional Service Alternative RTC Re ult

Service Year and North tar Service Alternative	Category	Average Elap ed Time per Train (Minute)
2040 Base Case	BNSF	90.2
2040 B -Directional Service	BNSF	90.2

With the proposed capacity mprovements in place, the average elapsed t me of a BNSF train to traverse the network under the 2040 Bi-Direct onal Service Alternative would be equal to 2040 Base Case levels. The 2040 Bi-Directional Service Alternat ve would not significantly mpact 2040 BNSF operat ons.

7. Summary of Re ult

The RTC modeling results discussed in Section 6 showed that with the addit on of the capacity improvements, each of the proposed Service Alternat ves could operate without unduly impacting BNSF’s performance in 2020 and 2040. Stringlines for the 2020 Base Case, 2020 Proposed Cases, 2040 Base Case, and 2040 Proposed Cases are available on request to the MnDOT Supervisor of Freight and

Rail Planning.[2] Table 20 summarizes the RTC modeling results for the 2020 Base Case, 2020 Proposed Cases, 2040 Base Case, and 2040 Proposed Cases.

Table 20: Summary of RTC Modeling Re ult

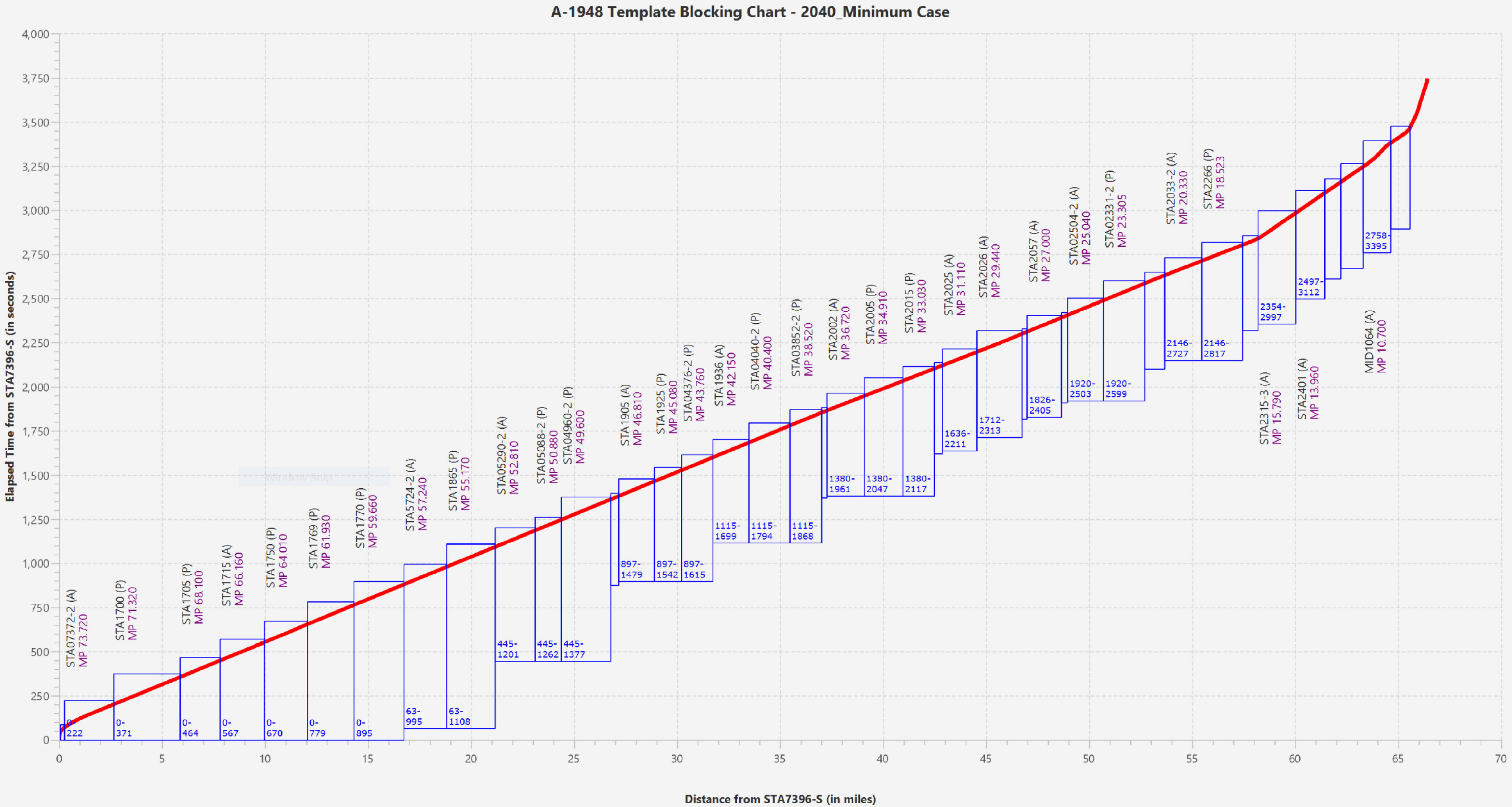
Service Year and North tar Service Alternative	Category	True Delay Minute per 100TM	Elap ed Time per Train (Minute)	Change in Performance from 2020 (Elap ed Time per Train in Minute)	Change in Performance from 2040 (Elap ed Time per Train in Minute)
2020 Base Case	BNSF	10.4	89.1	-	
2020 Min mum Service	BNSF	-	88.6	-0.5	
2020 Min mum B -Directional Service	BNSF	-	88.6	-0.5	
2020 Northstar Express Service	BNSF	-	88.3	-0.8	
2020 B -Directional Service	BNSF	-	88.1	-1.0	
2040 Base Case	BNSF	10.9	90.2	0.9	
2040 Min mum Service	BNSF	-	90.6		0.4
2040 Min mum B -Directional Service	BNSF	-	90.3		0.1
2040 Northstar Express Service	BNSF	-	90.5		0.3
2040 B -Directional Service	BNSF	-	90.2		0.0

[2] https://www.dot.state.mn.us/ofrw/contacts.html

Attachment 1

Signal Blocking Diagrams

Blocking Time Chart



Attributes	Offsets	Graphics	Signal Parameters
☑ Show Blocks	○ Show time and distance from origin	Time the Block is Assigned	Typical Clear Ahead Count (# of absolute signals requested in advance of train): 2
☑ Show Signal IDs	◉ Show time and distance from first node selected	Signal Node ID (A=Absolute, P=Permissive)	Typical Signal Request Ahead of Train (in seconds): 480
☑ Show Field MPs		Field MP of Signal Node	Signal Release Time (in seconds): 15

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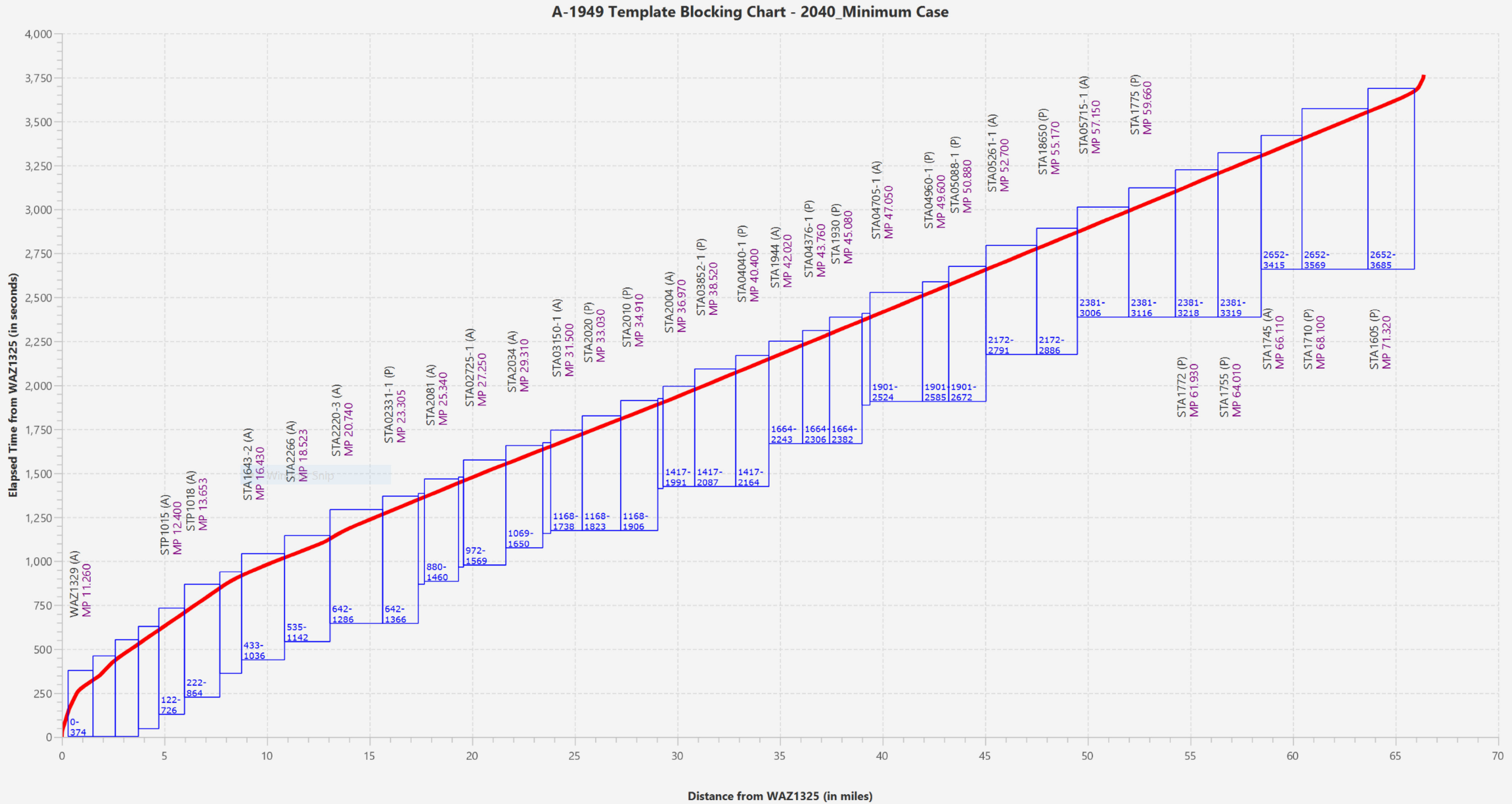
Blocking Time Chart



Attributes	Offsets	Graphics	Signal Parameters	
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☑ Show Signal IDs	◉ Show time and distance from first node selected	Signal Node ID (A=Absolute, P=Permissive)	Typical Signal Request Ahead of Train (in seconds):	480
☑ Show Field MPs		Field MP of Signal Node	Signal Release Time (in seconds):	15

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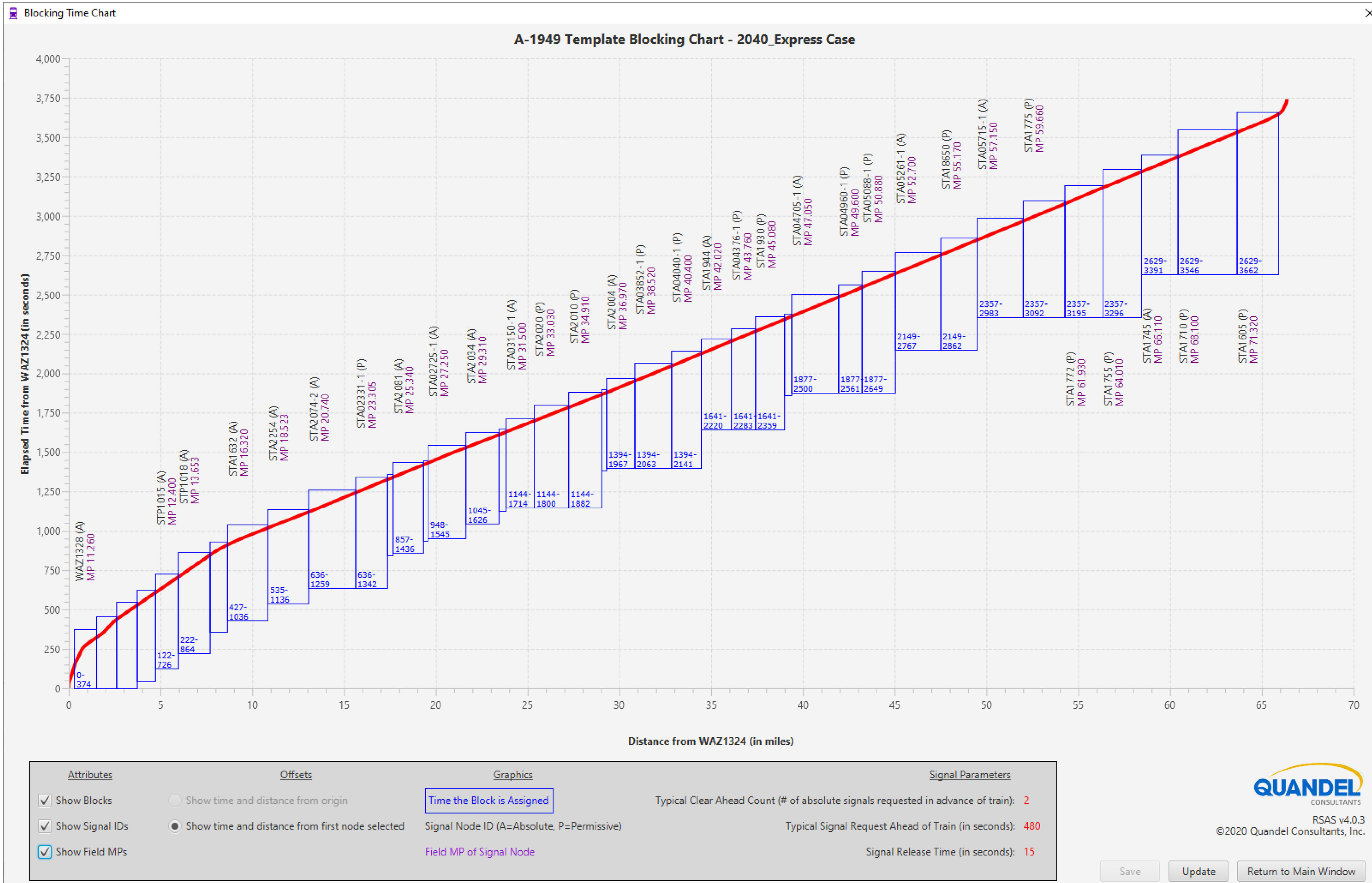

Blocking Time Chart
A-1949 Template Blocking Chart - 2040_Express Case
Elapsed Time from WAZ1324 (in seconds)
Distance from WAZ1324 (in miles)
WAZ1328 (A)
MP 11.260
STP1015 (A)
MP 12.400
STP1018 (A)
MP 13.653
STA1632 (A)
MP 16.320
STA2254 (A)
MP 18.523
STA2074-2 (A)
MP 20.740
STA02331-1 (P)
MP 23.305
STA2081 (A)
MP 25.340
STA02725-1 (A)
MP 27.250
STA2034 (A)
MP 29.310
STA03150-1 (A)
MP 31.500
STA2020 (P)
MP 33.030
STA2010 (P)
MP 34.910
STA2004 (A)
MP 36.970
STA03852-1 (P)
MP 38.520
STA04040-1 (P)
MP 40.400
STA1944 (A)
MP 42.020
STA04376-1 (P)
MP 43.760
STA1930 (P)
MP 45.080
STA04705-1 (A)
MP 47.050
STA04960-1 (P)
MP 49.600
STA05088-1 (P)
MP 50.880
STA05261-1 (A)
MP 52.700
STA18650 (P)
MP 55.170
STA05715-1 (A)
MP 57.150
STA1775 (P)
MP 59.660
STA1772 (P)
MP 61.930
STA1755 (P)
MP 64.010
STA1745 (A)
MP 66.110
STA1710 (P)
MP 68.100
STA1605 (P)
MP 71.320
Attributes
Show Blocks
Show Signal IDs
Show Field MPs
Offsets
Show time and distance from origin
Show time and distance from first node selected
Graphics
Time the Block is Assigned
Signal Node ID (A=Absolute, P=Permissive)
Field MP of Signal Node
Signal Parameters
Typical Clear Ahead Count (# of absolute signals requested in advance of train): 2
Typical Signal Request Ahead of Train (in seconds): 480
Signal Release Time (in seconds): 15
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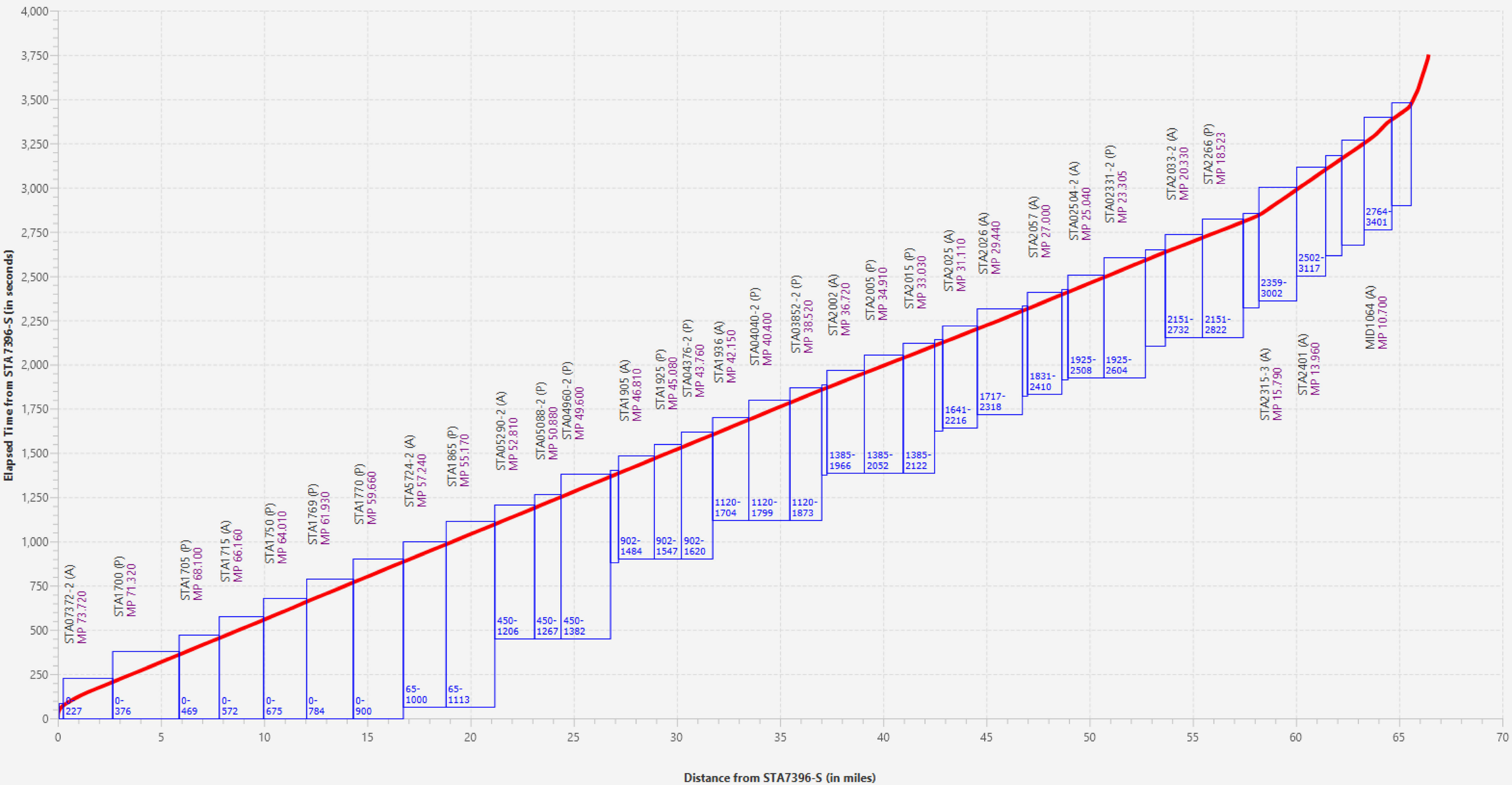
Blocking Time Chart

A-1948 Template Blocking Chart - 2040_MinBiDirectional Case



Attributes	Offsets	Graphics	Signal Parameters	
☑ Show Blocks	○ Show time and distance from origin	Time the Block is Assigned	Typical Clear Ahead Count (# of absolute signals requested in advance of train):	2
☑ Show Signal IDs	● Show time and distance from first node selected	Signal Node ID (A=Absolute, P=Permissive)	Typical Signal Request Ahead of Train (in seconds):	480
☑ Show Field MPs		Field MP of Signal Node	Signal Release Time (in seconds):	15

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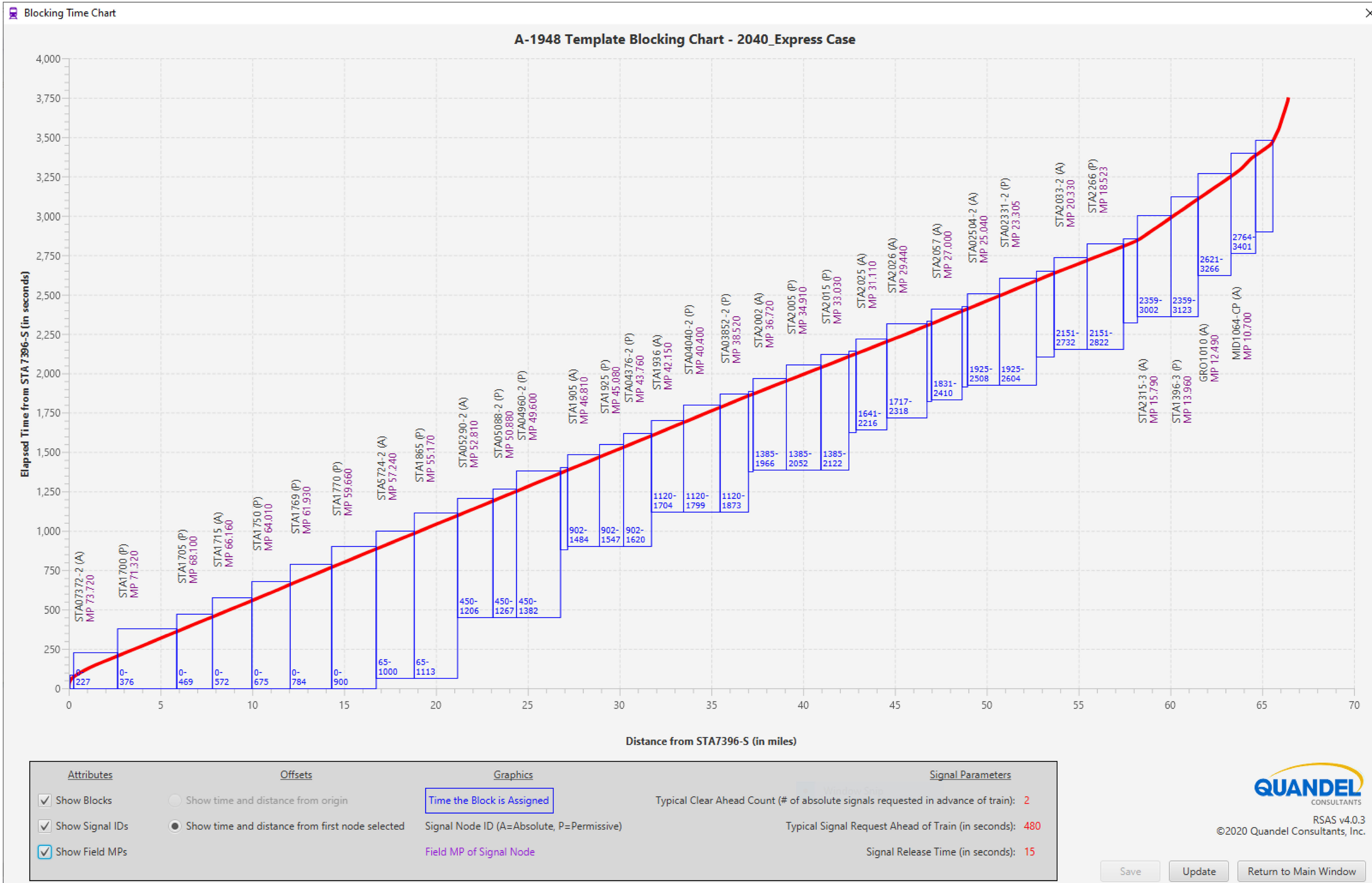

Blocking Time Chart
A-1948 Template Blocking Chart - 2040_Express Case
Elapsed Time from STA7396-S (in seconds)
Distance from STA7396-S (in miles)
STA07372-2 (A) MP 73.720
STA1700 (P) MP 71.320
STA1705 (P) MP 68.100
STA1715 (A) MP 66.160
STA1750 (P) MP 64.010
STA1769 (P) MP 61.930
STA1770 (P) MP 59.660
STA5724-2 (A) MP 57.240
STA1865 (P) MP 55.170
STA05290-2 (A) MP 52.810
STA05088-2 (P) MP 50.880
STA04960-2 (P) MP 49.600
STA1905 (A) MP 46.810
STA1925 (P) MP 45.080
STA04376-2 (P) MP 43.760
STA1936 (A) MP 42.150
STA04040-2 (P) MP 40.400
STA03852-2 (P) MP 38.520
STA2002 (A) MP 36.720
STA2005 (P) MP 34.910
STA2015 (P) MP 33.030
STA2025 (A) MP 31.110
STA2026 (A) MP 29.440
STA2057 (A) MP 27.000
STA02504-2 (A) MP 25.040
STA02331-2 (P) MP 23.305
STA2033-2 (A) MP 20.330
STA2266 (P) MP 18.523
STA2315-3 (A) MP 15.790
STA1396-3 (P) MP 13.960
GRO1010 (A) MP 12.490
MID1064-CP (A) MP 10.700
0-227
0-376
0-469
0-572
0-675
0-784
0-900
65-1000
65-1113
450-1206
450-1267
450-1382
902-1484
902-1547
902-1620
1120-1704
1120-1799
1120-1873
1385-1966
1385-2052
1385-2122
1641-2216
1717-2318
1831-2410
1925-2508
1925-2604
2151-2732
2151-2822
2359-3002
2359-3123
2621-3266
2764-3401
Attributes
Show Blocks
Show Signal IDs
Show Field MPs
Offsets
Show time and distance from origin
Show time and distance from first node selected
Graphics
Time the Block is Assigned
Signal Node ID (A=Absolute, P=Permissive)
Field MP of Signal Node
Signal Parameters
Typical Clear Ahead Count (# of absolute signals requested in advance of train): 2
Typical Signal Request Ahead of Train (in seconds): 480
Signal Release Time (in seconds): 15
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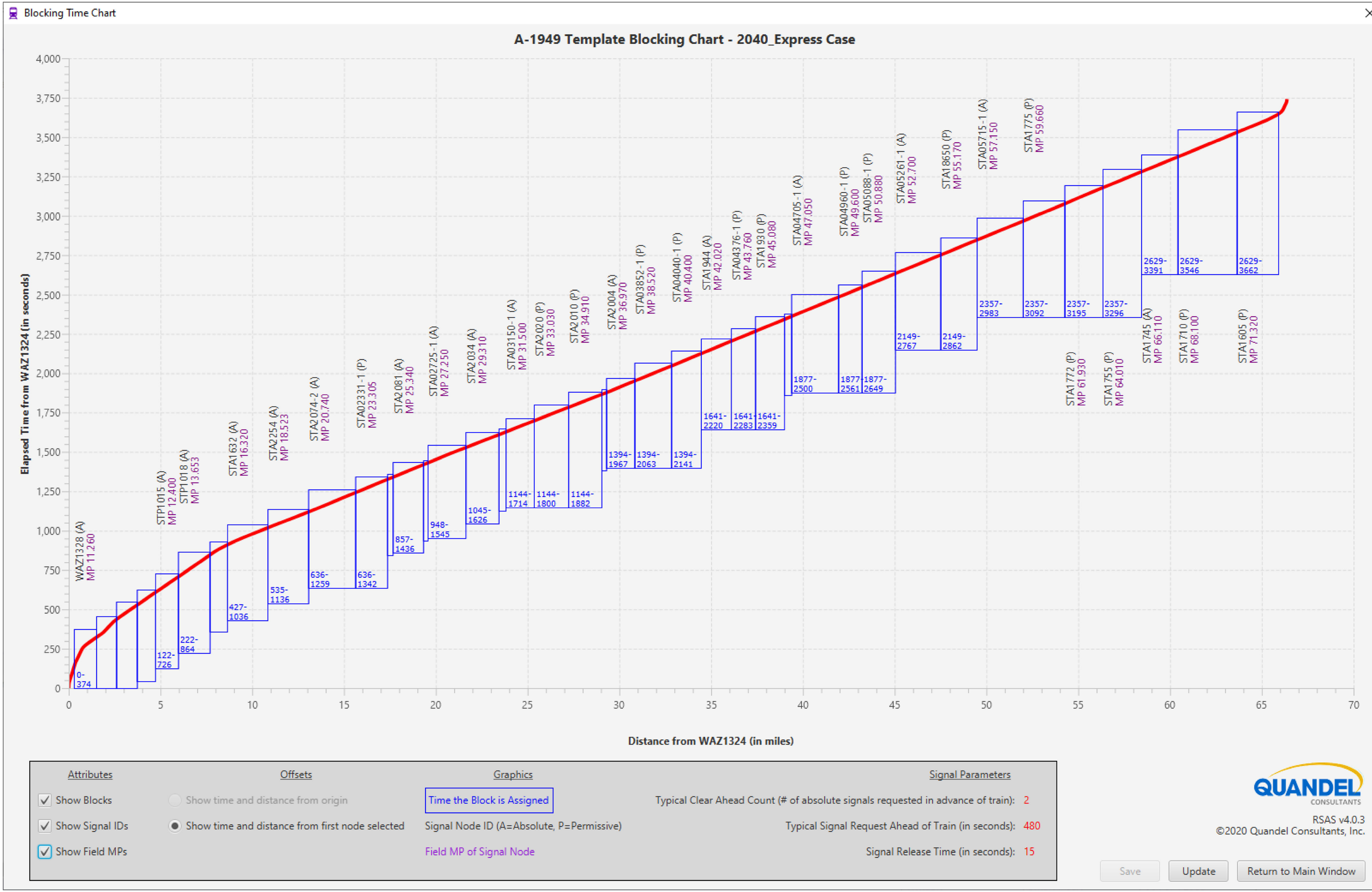
Blocking Time Chart
A-1949 Template Blocking Chart - 2040_Express Case
Elapsed Time from WAZ1324 (in seconds)
Distance from WAZ1324 (in miles)
WAZ1328 (A) MP 11.260
STP1015 (A) MP 12.400
STP1018 (A) MP 13.653
STA1632 (A) MP 16.320
STA2254 (A) MP 18.523
STA2074-2 (A) MP 20.740
STA02331-1 (P) MP 23.305
STA2081 (A) MP 25.340
STA02725-1 (A) MP 27.250
STA2034 (A) MP 29.310
STA03150-1 (A) MP 31.500
STA2020 (P) MP 33.030
STA2010 (P) MP 34.910
STA2004 (A) MP 36.970
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STA05261-1 (A) MP 52.700
STA18650 (P) MP 55.170
STA05715-1 (A) MP 57.150
STA1775 (P) MP 59.660
STA1772 (P) MP 61.930
STA1755 (P) MP 64.010
STA1745 (A) MP 66.110
STA1710 (P) MP 68.100
STA1605 (P) MP 71.320
0-374
122-726
222-864
427-1036
535-1136
636-1259
636-1342
857-1436
948-1545
1045-1626
1144-1714
1144-1800
1144-1882
1394-1967
1394-2063
1394-2141
1641-2220
1641-2283
1641-2359
1877-2500
1877-2561
1877-2649
2149-2767
2149-2862
2357-2983
2357-3092
2357-3195
2357-3296
2629-3391
2629-3546
2629-3662
Attributes
Show Blocks
Show Signal IDs
Show Field MPs
Offsets
Show time and distance from origin
Show time and distance from first node selected
Graphics
Time the Block is Assigned
Signal Node ID (A=Absolute, P=Permissive)
Field MP of Signal Node
Signal Parameters
Typical Clear Ahead Count (# of absolute signals requested in advance of train): 2
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Signal Release Time (in seconds): 15
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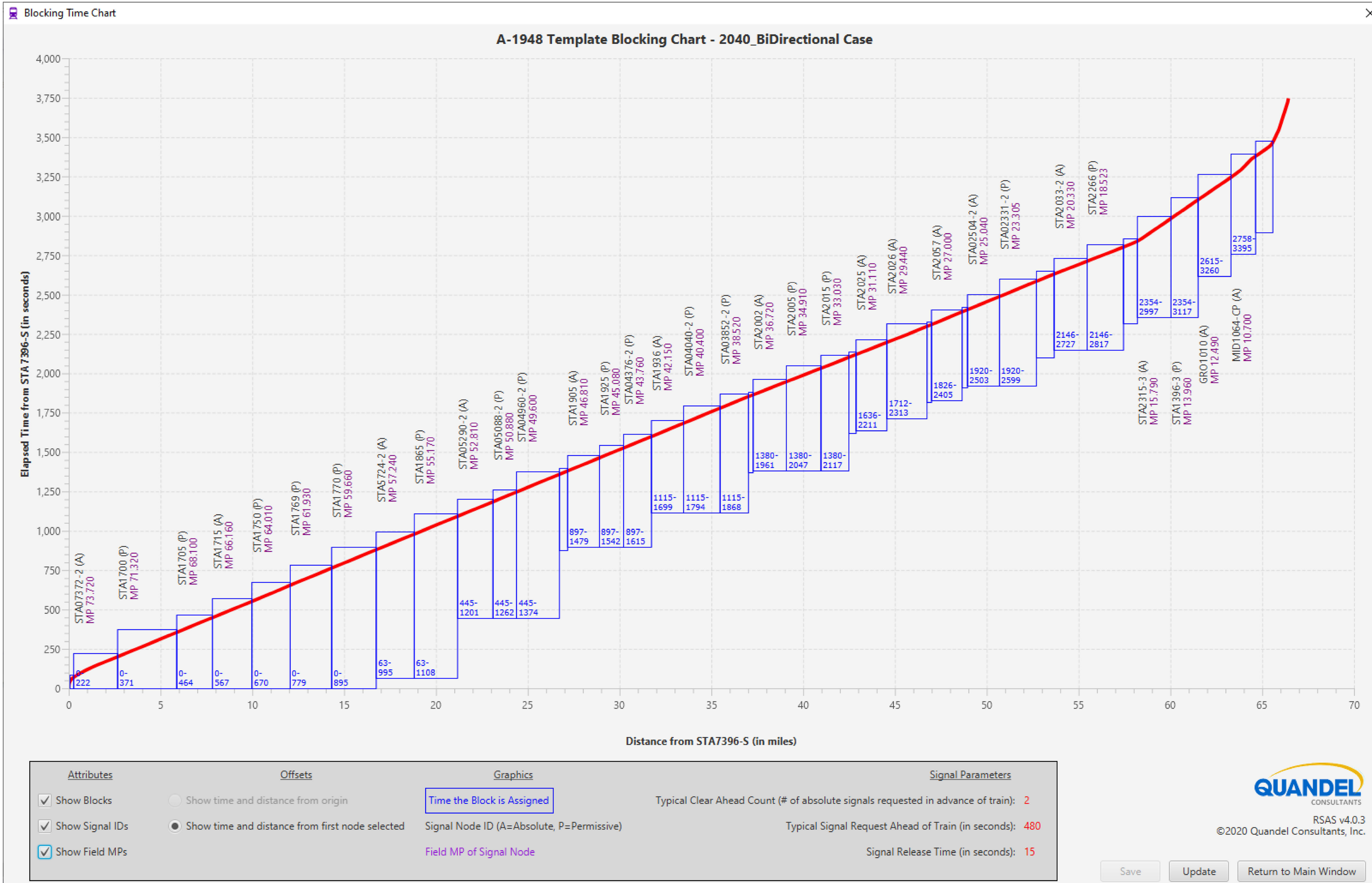

Blocking Time Chart
A-1948 Template Blocking Chart - 2040_BiDirectional Case
Elapsed Time from STA7396-S (in seconds)
Distance from STA7396-S (in miles)
STA07372-2 (A) MP 73.720
STA1700 (P) MP 71.320
STA1705 (P) MP 68.100
STA1715 (A) MP 66.160
STA1750 (P) MP 64.010
STA1769 (P) MP 61.930
STA1770 (P) MP 59.660
STA5724-2 (A) MP 57.240
STA1865 (P) MP 55.170
STA05290-2 (A) MP 52.810
STA05088-2 (P) MP 50.880
STA04960-2 (P) MP 49.600
STA1905 (A) MP 46.810
STA1925 (P) MP 45.080
STA04376-2 (P) MP 43.760
STA1936 (A) MP 42.150
STA04040-2 (P) MP 40.400
STA03852-2 (P) MP 38.520
STA2002 (A) MP 36.720
STA2005 (P) MP 34.910
STA2015 (P) MP 33.030
STA2025 (A) MP 31.110
STA2026 (A) MP 29.440
STA2057 (A) MP 27.000
STA02504-2 (A) MP 25.040
STA02331-2 (P) MP 23.305
STA2033-2 (A) MP 20.330
STA2266 (P) MP 18.523
STA2315-3 (A) MP 15.790
STA1396-3 (P) MP 13.960
GRO1010 (A) MP 12.490
MID1064-CP (A) MP 10.700
Attributes
Show Blocks
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Signal Release Time (in seconds): 15
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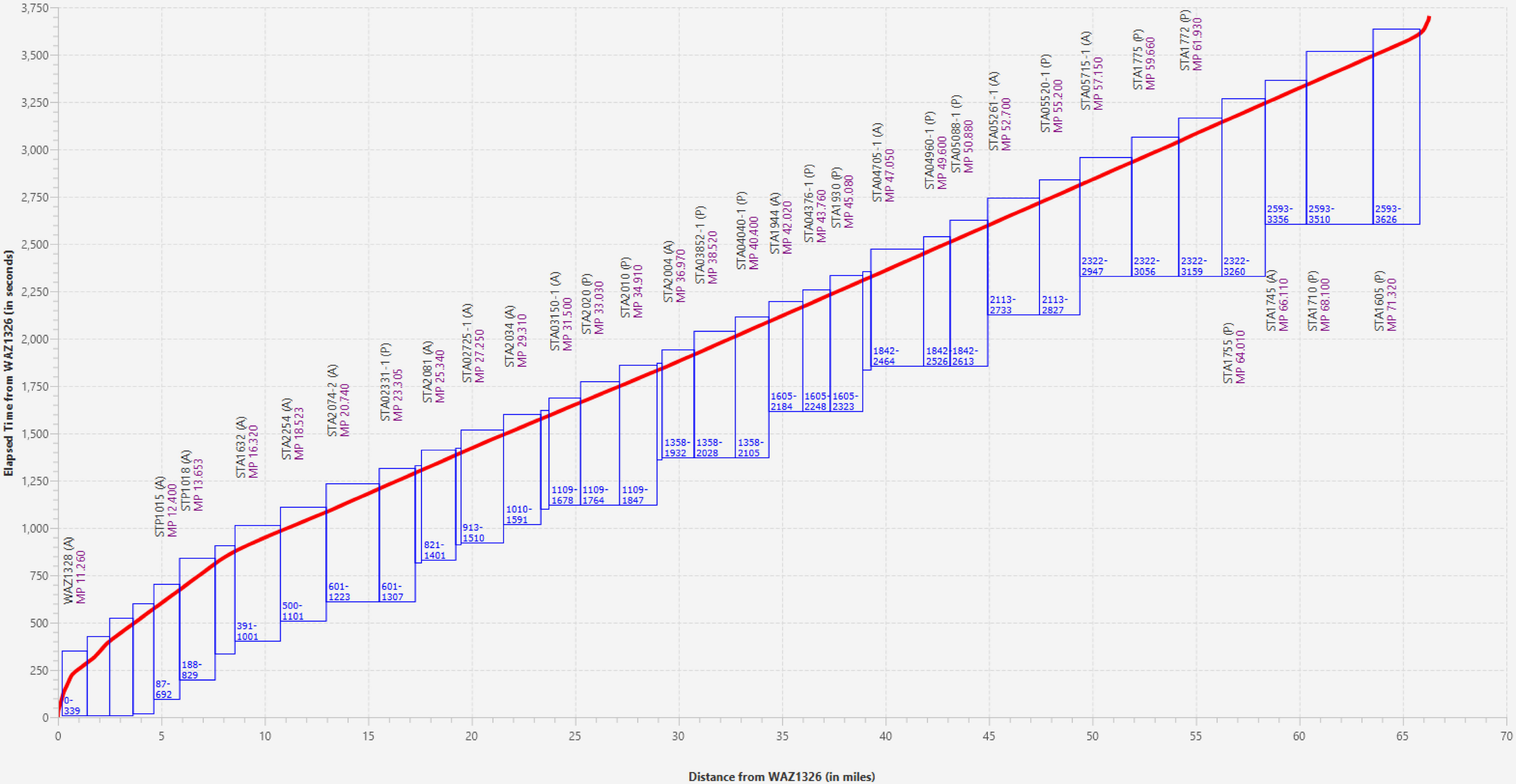
Blocking Time Chart

A-1949 Template Blocking Chart - 2040_BiDirectional Case



Attributes	Offsets	Graphics	Signal Parameters
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☑ Show Field MPs		Field MP of Signal Node	Signal Release Time (in seconds): 15

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Attachment 2

RTC Dispatching Details

DEPARTMENT OF TRANSPORTATION

Technical Documentation on RTC Dispatch Parameters

RTC allows users to adjust dispatch logic parameters to emulate the procedures that a railroad dispatcher would use in the real world. Options under RTC's 'Operating Objectives' menus were adjusted until the dispatch results were similar to what was observed in the field.

As part of the assessment using RTC, the following dispatch objectives were evaluated:

1. Avoid Lateness
2. Minimize Energy Consumption
3. Minimize Crew Expirations
4. Train Rank Dominance
5. Adherence to Train-Type Conflict Delay Caps
6. Maximize Average System Train Speed
7. Maintain Train Order
8. Pacing Preference

Train type operating objectives were also evaluated. These objectives included Dispatch Rank, Dispatch Priority Range, and Target Conflict Delay Cap.

The railroad is double tracked throughout most of the modeling limits and an assortment of trains of varying importance operate on them. Within the model limits, BNSF generally operates trains righthanded and prioritizes passenger traffic and Z-Train traffic. The Z-Train category consists of guaranteed intermodal and mail trains. Although these rules are generally followed, it is important that RTC does not unnecessarily hinder network performance to obey them. Through an iterative process the objectives were adjusted to best replicate operations over the modeling limits.

Dispatch objectives were adjusted to replicate network performance. Maintain Train Order was set as most important; ensuring that trains will not stop on the mainline to allow a trailing, yet more important, train to pass them. Adherence to Train-Type Conflict Delay Caps, Pacing Preference, and Train Rank Dominance were all set at the second most important level; ensuring that train ranking and priority are still factors in dispatching. Avoid Lateness and Maximize Average System Train Speed were set to third most important followed by Minimizing Energy Consumption and Minimizing Crew Expirations.

Train type operating objectives were simplified to maximize the network's output. All freight trains were set with equal train priorities to keep trains operating as they do in the real world. Although train Rank and Priority are the same for all freight trains, the Target Conflict Delay Caps were varied based on each train category's importance. Table 1 summarizes the Target Conflict Delay Caps.

Table 1: Target Conflict Delay Cap Settings

Train Category	Target Conflict Delay Cap (HH:MM)
Bare Table Intermodal, High Priority Merchandise, Intermodal, Guaranteed Intermodal, Stack Train, Vehicle Parts, UPS	1:00
Light Engines, Foreign RR Detour, Local, Merchandise, Empty Grain	2:00
Coal Loads, Grain Loads, Unit Train Excluding Grain or Coal	4:00

The Target Conflict Delay Caps tell the dispatch logic which trains to keep moving and which trains can be stopped to resolve a meet-pass conflict.

Passenger trains were set with the highest priorities and have a Target Conflict Delay Cap of 5 minutes. This ensures trains would not stop along their route. Within the passenger category, Northstar trains were given priority above Amtrak trains because disruptions to Northstar trains can cause network-wide delays.