

# Conceptual Planning Analysis for San Francisco RAB Feasibility Study

## Task 2: Conceptual Planning Analysis June 19, 2017

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**optimizing railways** SMA Rail Consulting + IT, Corp.

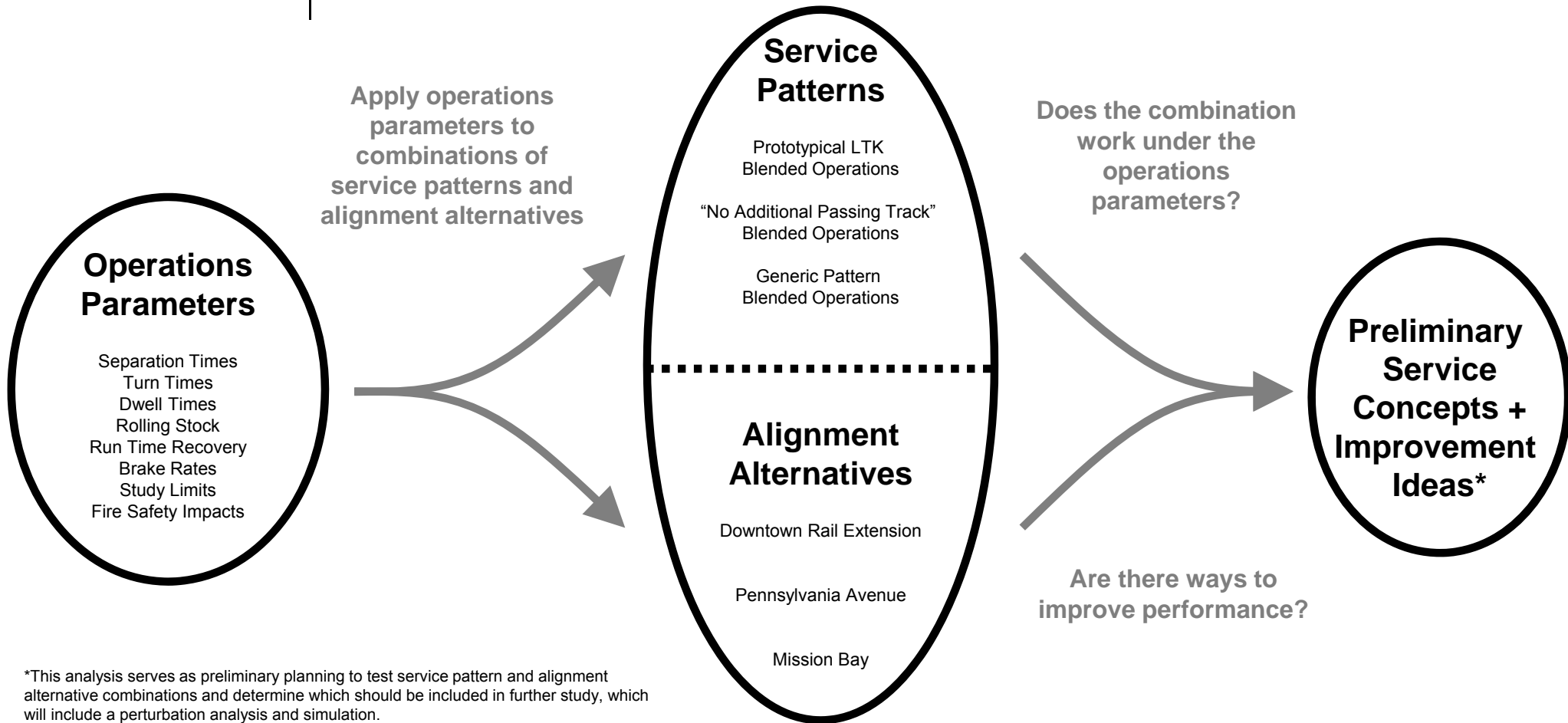
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# Methodology\*



\*This analysis serves as preliminary planning to test service pattern and alignment alternative combinations and determine which should be included in further study, which will include a perturbation analysis and simulation.

# Summary of Theoretical Findings

This effort builds on previous efforts and intends to further analyze the infrastructure alignments under consideration for connecting the Peninsula Corridor to the TTC.

## **Approach:**

Static operation concepts were developed, applying planning parameters for signaling-enforced train separation times, station dwell times, terminal turn times, and run time recovery margins, in order to build a better understanding of the available capacity and viable service plans under normal conditions (i.e. absent of major disruptions).

Accommodation for minor every day disruptions should already be reflected in the analysis given that the planning parameters have some tolerance build in. However, dynamic simulation tools can be applied to develop a detailed understanding of operational reliability under perturbed conditions.

# Summary of Theoretical Findings (continued)

## Key Findings:

1. Workable operation concepts can be developed for every combination of service plan and infrastructure alternative (including the LTK blended operation schedule), allowing operation of 10 trains per peak hour and direction in and out of the TTC, therefore potentially reducing the need to terminate trains at 4<sup>th</sup>/King (or Townsend) under normal operating conditions and without consideration of special events.
2. Under normal conditions, only two tracks are required in the tunnel leading up to the TTC to operate the analyzed service plans. More detailed analysis is recommended to identify the most effective approach to provide infrastructure redundancy (e.g. the proposed third tunnel track) to help mitigate the potential effects of major service disruptions.

## Summary of Theoretical Findings (continued)

3. The 10-slot *Generic Pattern* developed for this study requires only five (5) platform edges at the TTC, compared to six (6) edges required for the 10-slot LTK and NAPT patterns. In theory, this *Generic Pattern* could support a 12-slot pattern with all trains going to the TTC, and no trains terminating at 4<sup>th</sup>/King (or Townsend).
4. Only two platform tracks are required for the 4<sup>th</sup>/Townsend underground station (or Mission Bay) in order to operate the regular peak hour patterns analyzed. Adding special event services or parking a protect unit at the station before the TTC would require additional tracks at a 4<sup>th</sup>/Townsend station. A 4<sup>th</sup>/Townsend station capable of handling all service (e.g. in case of a major disruption to TTC) would require six station platform tracks (and six platform faces).
5. Runtime differences between alignments (TTC-DTX vs. Mission Bay) are minimal.

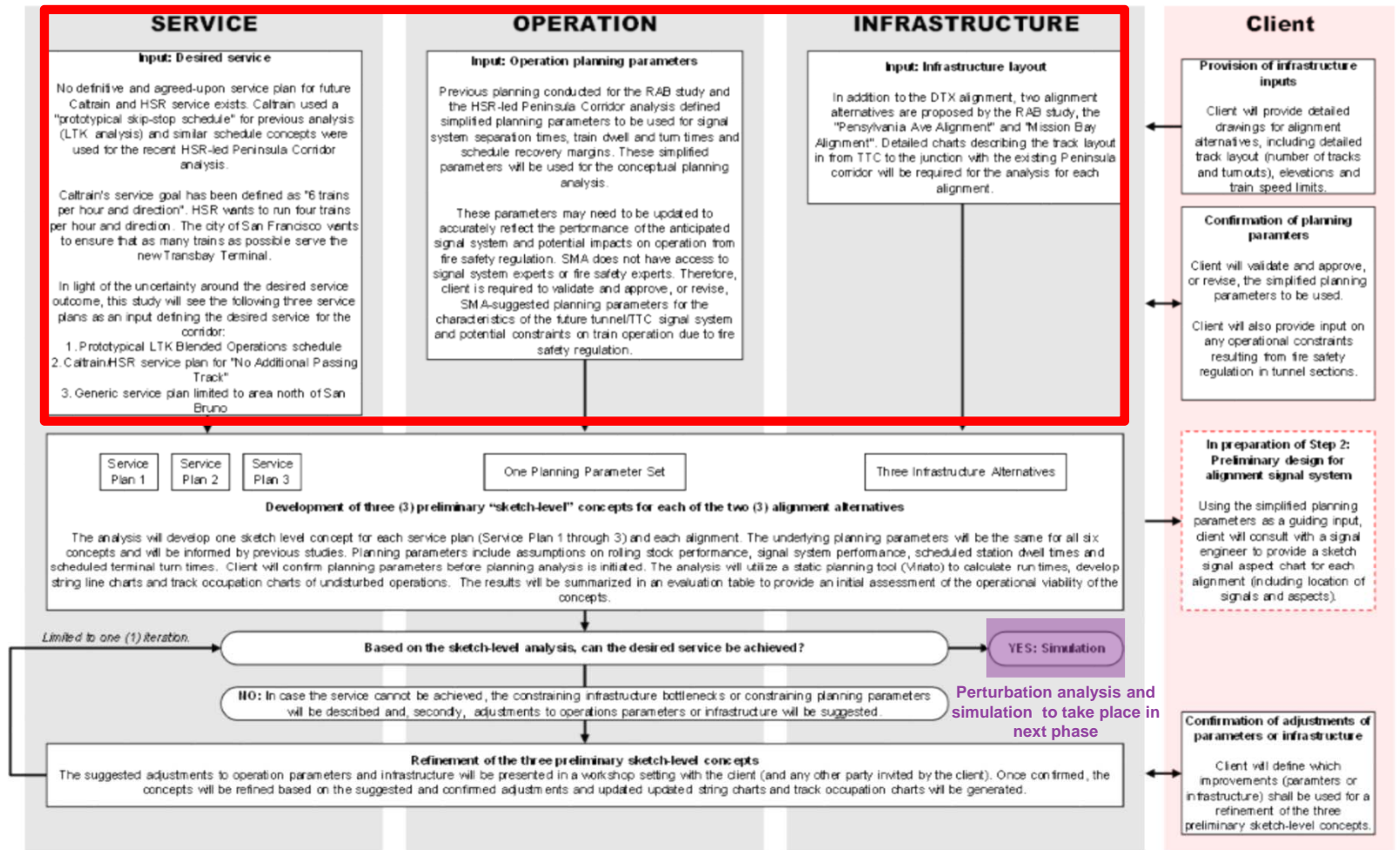
## Summary of Theoretical Findings (continued)

6. All concepts allowed separating HSR and Caltrain services at the TTC, resulting in dedicated platform edges for both services.
7. The most constraining bottleneck was identified to be the control point before the TTC (CP TTC) due to the crossing conflicts between trains at this location as well as the platform space of the TTC terminal itself.
8. Access to the proposed storage and maintenance yard locations (Site 1 and Site 2) seems possible if non-revenue trains going out of service use the revenue slot they would have used if they stayed in service. This should be a sound assumption, given that no splitting or joining of trains is anticipated. While entering and exiting those yard locations was analyzed, movement within the yard locations was not analyzed nor was any analysis performed on the storage or layover maintenance functions currently being performed at 4<sup>th</sup> /King and their relocation to any of these southern yard locations.

# Task 1: Base Assumptions



# Base Assumptions



# Operations Parameters\*

Parameter	Assumption	Old Assumption (2015 Analysis)
Signal system train separation times <sup>1</sup>	3.0 minutes following train on corridor and in stations 2.0 minutes merging/diverging at junctions 3.0 minutes separation at junctions for opposing train movements	2.0 minutes following train on corridor and in stations 2.0 minutes merging/diverging at junctions 2.0 minutes separation at junctions for opposing train movements
Minimum scheduled terminal turn time	HSR: 20 minutes Caltrain: 20 minutes	HSR: 45 minutes Caltrain: 20 minutes
Scheduled station dwell times at intermediate station stops	Caltrain: 1 minute (Based on LTK station dwell analysis, using average 90 <sup>th</sup> percentile value, rounded to next minute) <sup>2</sup> HSR: 2 minutes	Caltrain: 1 minute HSR: 2 minutes
Rolling stock	HSR: Generic High Speed Trainset (capable of high-level boarding only) Caltrain: 8-car EMU based on RFP specs (capable of high- and low-level boarding)	HSR: Siemens Velaro (ICE 3 406 x 2 sets) Caltrain: Double-Decker EMU (Stadler KISS RABe511 x 4 sets)
Run time recovery	10% equally distributed run time recovery	10% equally distributed run time recovery
Brake Rate (CBOSS)	1.33 mphps (HSR), 1.37 mphps (Caltrain)	1.33 mphps (HSR), 1.37 mphps (Caltrain)
Study Limits	22 <sup>nd</sup> Street Station - TTC (Generic Service Pattern) Extended further south if needed for railyard analysis  Millbrae – TTC (LTK and NAPT Service Patterns)	South San Francisco - TTC
Fire Safety Impacts in Tunnels	One train per vent zone per track (also see 1.1 Fire Life Safety Impacts in Tunnels)	One train per vent zone per track

<sup>1</sup> Signal system parameters are still under discussion by corridor operators. The above assumption reflects the values that were used during 2016's CHSRA-led Blended Operations Planning

<sup>2</sup> Source: Caltrain Comments on the HSR Proposed Methodology for Perturbation Analysis, November 2016 (PROJECTS\2055.1-PB, SF Peninsula Blended Schedule\A3 Exchanged Memos\20161101 Caltrain, Response to HSR Blended Ops Planning.pdf)

\*Additional detail on operations parameters can be found in the SMA "Planning Parameters and Assumptions" document, which was created in conjunction with this analysis.

**This conceptual planning analysis does not assume perfect, delay-free operations. Rather, it takes into account the potential for operational perturbations with overly conservative parameters, namely the following:**

### Turn Times :

A value of 20 minutes was used for turns. It is assumed that this value includes turn recovery.

### Runtime Recovery:

10% runtime recovery was included in all service patterns. This accounts for delays en route (e.g. a longer-than-average dwell time at a station).

# Service Patterns

Caltrain’s service goal has been defined as “six trains per hour and direction” while HSR has a goal of four trains per hour and direction. In light of the uncertainty around the desired service outcome, this study uses the following three peak-hour service plans as inputs defining the range of desired service for the corridor:

- Service Plan 1: Prototypical LTK Blended Operations schedule<sup>1</sup>
- Service Plan 2: Caltrain/HSR service plan for “No Additional Passing Track”<sup>2</sup>
- Service Plan 3: Generic service plan limited to area north of South San Francisco<sup>3</sup>

All patterns accommodate turns at the terminal station (TTC or 4<sup>th</sup>/Townsend) and address conflicting moves at the entry/exit into the terminal station.

<sup>1</sup> Source: March 2012 Caltrain/California HSR Blended Operations Analysis

<sup>2</sup> Source: 2016 Peninsula Corridor Integrated Schedule Study

<sup>3</sup> Developed during this analysis

# Prototypical LTK Blended Operations (LTK)\*

 HSR  
 Caltrain

SOUTHBOUND	21	427	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (TTC)	●	⊖	●	●	⊖	●	⊖	●	●	⊖
3RD STREET / TOWNSEND / 4th AND KING		●	●		●		●	●		●
22nd STREET		●	●		●		●	●		●
BAYSHORE					●					
SOUTH SAN FRANCISCO								●		
SAN BRUNO					●					●
MILLBRAE (arr.)	:01	:05	:14	:16	:25	:31	:35	:44	:46	:56

NORTHBOUND	422	12	424	14	426	416	16	418	18	420
MILLBRAE (dep.)	:08	:14	:17	:24	:27	:40	:44	:46	:54	:58
SAN BRUNO					●					●
SOUTH SAN FRANCISCO			●					●		
BAYSHORE					●					
22nd STREET										●
3RD STREET / TOWNSEND / 4th AND KING	●		●		●	●		●		●
TRANSBAY TRANSIT CENTER (TTC)	⊖	●	●	●	⊖	⊖	●	●	●	⊖

\*The undisturbed train schedule developed by LTK was used in this analysis; the disturbed scenario was not used. Instead, potential operational perturbations are taken into account through overly conservative planning parameters applied to the service patterns, namely 20-minute turn times at terminal stations and 10% evenly-distributed runtime recovery throughout trains' runs.

# “No Additional Passing Track” Blended Operations (NAPT)

 HSR  
 Caltrain

SOUTHBOUND	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (TTC)	●	⊖	●	●	⊖	●	⊖	●	●	⊖
3RD STREET / TOWNSEND / 4th AND KING		●	●		●		●	●		●
22nd STREET		●	●		●		●	●		●
BAYSHORE					●					
SOUTH SAN FRANCISCO								●		
SAN BRUNO					●					●
MILLBRAE (arr.)	:02	:05	:19	:15	:23	:32	:37	:50	:44	:55

NORTHBOUND	418	420	1001	422	1103	424	426	1003	416	1101
MILLBRAE (dep.)	:07	:10	:14	:25	:29	:37	:39	:44	:53	:59
SAN BRUNO		●					●			
SOUTH SAN FRANCISCO				●					●	
BAYSHORE							●			
22nd STREET		●								
3RD STREET / TOWNSEND / 4th AND KING	●	●		●		●	●		●	
TRANSBAY TRANSIT CENTER (TTC)	●	⊖	●	⊖	●	●	⊖	●	⊖	●

## Generic Pattern Blended Operations (GEN)\*

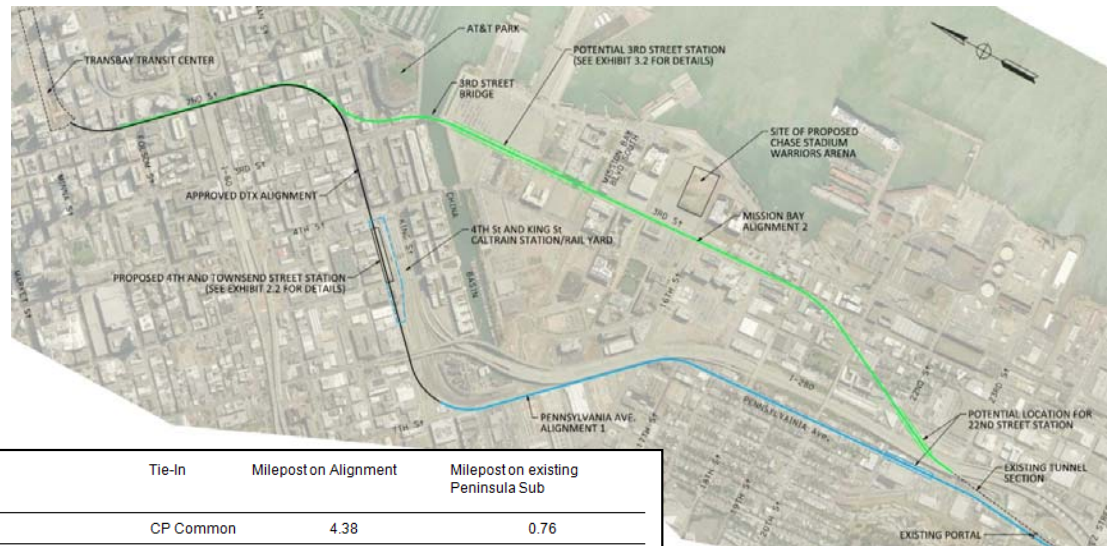
A generic slot pattern with six-minute headways (10 slots per hour per direction) was developed in addition to the LTK and NAPT patterns. The goal was to see how a frequent, repetitive pattern that efficiently meets operational requirements (i.e. TTC turns as close to the 20-minute minimum and separation times at CP TTC as close to the 3-minute minimum as feasible) performs against the preexisting patterns. Speeds and stopping patterns are constant among all trains within the generic pattern to ensure operational constraints at the TTC and CP TTC are not violated. Because slots are identical, any train can use any slot.

A five-minute generic pattern (12 slots per hour per direction) was developed in addition to the six-minute pattern.

\*The existing tunnel portal near 22<sup>nd</sup> Street Station was used as the southern study limit to include constraints at the TTC and CP TTC in the pattern while limiting HSR and Caltrain runtime impacts due inflexible speeds within the pattern. 22<sup>nd</sup> Street would serve as the transition between the generic slot pattern to the north and a different pattern (e.g. NAPT or LTK) to the south. The transition can be moved further south (e.g. South San Francisco Station) if potential tie-in locations for relocated railyards are included in the analysis.

# Alignment Alternatives & Tie-Ins to Existing PCJPB Peninsula Sub<sup>1 2</sup>

- Downtown Rail Extension (DTX)
- Pennsylvania Avenue (PEN)
- Mission Bay (MBY)



Alignment	Tie-In	Milepost on Alignment	Milepost on existing Peninsula Sub
DTX	CP Common	4.38	0.76
Pennsylvania Avenue	CP Army	5.88	2.26
Mission Bay	"CP TBD"	5.23	1.91

<sup>1</sup> Source: San Francisco Railyard Alternatives and I-280 Boulevard Feasibility Study: Alignment Conceptual Designs, dated September 16, 2016 (CH2M Hill)

<sup>2</sup> Source: Track Chart San Francisco – Gilroy, dated September 4, 2012 (PCJPB)

# Speed & Elevation Profiles

The DTX alignment speed profile was taken from the Track Plan and Profile Key Map of the Parsons planset<sup>1</sup>, which gives curve limits and coinciding speeds for the DTX only. The PEN and MBY speed profiles were calculated using curve radii found in the CH2M Hill planset<sup>2</sup> and the Caltrain radii-speed formula (curve speed limits are not provided in the CH2M Hill planset):

$$V_{max} = \sqrt{\frac{E_a + 3}{0.0007 \times D}}$$

where:

$E_a$  = superelevation = 3"

$D$  = degree of curvature:

$$D = \frac{36000}{2\pi R} = \frac{5729.6}{R}$$

Elevation values were taken from each alignment's grade profile in the CH2M Hill planset.

<sup>1</sup>Source: Transbay Transit Center Program Caltrain Downtown Extension: Preliminary Engineering Plans, dated February 3, 2012 (Parsons)

<sup>2</sup> Source: San Francisco Railyard Alternatives and I-280 Boulevard Feasibility Study: Alignment Conceptual Designs, dated September 16, 2016 (CH2M Hill)



# DTX Critical Points (Viriato Inputs)

DTX Track Layout (Node Name)	Milepost	Number of Tracks (from previous node)
TRANSBAY TRANSIT CENTER	2.47	-
CP Transbay Transit Center	2.98	3
CP Townsend North	3.64	3
4TH & TOWNSEND	3.84	3 ( 2 platform tracks, outside)
CP Townsend South	4.06	3
DTX Tie-in	4.38	2
CP Common (Peninsula Sub)	0.76	

Note: CP Common currently at MP 0.53, but DTX tie-in located at MP 0.76.

DTX Speed Limits (mph)	Milepost Range	Source / Comment
20	2.47 – 2.72	Assumption
22	2.72 – 2.93	Parsons 2012, page 5 (Key Map)
35	2.93 – 3.71	Parsons 2012, page 5 (Key Map)
40	3.71 – 4.11	Parsons 2012, page 5 (Key Map)
30	4.11 – 4.38	Assumption, based on radius >650ft stated in Parsons, page 19

DTX Elevation (ft)	Milepost	Source / Comment
-30	2.47	CH2M RAB Drawings Package
-30	2.94	CH2M RAB Drawings Package
-45	3.53	CH2M RAB Drawings Package
-35	3.76	CH2M RAB Drawings Package
-35	3.95	CH2M RAB Drawings Package
13.15	4.38	CH2M RAB Drawings Package

# PEN Critical Points (Viriato Inputs)

Pennsylvania Ave Track Layout (Node Name)	Milepost <sup>3</sup>	Number of Tracks (from previous node)
TRANSBAY TRANSIT CENTER	2.47	-
CP Transbay Transit Center	2.98	3
CP Townsend North	3.64	3
4TH & TOWNSEND	3.84	3 ( 2 platform tracks, outside) Potentially up to 3 additional stub-end platform tracks
CP Townsend South	4.06	3
22ND STREET	5.39	2
PEN Tie-in	5.88	2
CP Army (Peninsula Sub)	2.26	

<sup>3</sup> DTX MPs used for entire alignment with TTC at MP 2.47 (130+60). Conversion: [CH2MMP] = [DTX MP] – 2.81

Pennsylvania Ave Speed Limits (mph)	Milepost Range	Source / Comment
20	2.47 – 2.72	Assumption
22	2.72 – 2.93	Parsons 2012, page 5 (Key Map)
35	2.93 – 3.71	Parsons 2012, page 5 (Key Map)
40	3.71 – 4.11	Parsons 2012, page 5 (Key Map)
30	4.11 – 4.41	Assumption, based on 650ft Radius stated in Parsons, page 19
40	4.41 – 4.90	Assumed same as Peninsula Sub
75	4.90 – 5.88	Assumed same as Peninsula Sub

Pennsylvania Ave Elevation (ft)	Milepost	Source / Comment
-30	2.47	CH2M RAB Drawings Package
-30	2.94	CH2M RAB Drawings Package
-45	3.53	CH2M RAB Drawings Package
-35	3.76	CH2M RAB Drawings Package
-35	3.95	CH2M RAB Drawings Package
-80	4.38	CH2M RAB Drawings Package
-2	5.35	CH2M RAB Drawings Package
-2	5.47	CH2M RAB Drawings Package
32.84	5.88	CH2M RAB Drawings Package

# MBY Critical Points (Viriato Inputs)

Mission Bay Track Layout (Node Name)	Milepost <sup>4</sup>	Input Document Stationing	Number of Tracks (from previous node)
TRANSBAY TRANSIT CENTER	2.47	-18+00	-
CP Transbay Transit Center	2.98	9+00	3
3RD STREET	3.86	55+00	3 (2 outside platform tracks)
CP 3rd Street	3.97	61+00	3
22ND STREET	5.11	121+00	2
MBY Tie-in	5.23	128+00	2
CP TBD (Peninsula Sub)	1.91		

<sup>4</sup> DTX MPs used for entire alignment with TTC at MP 2.47 (130+60). Conversion: [CH2M MP] = [DTX MP] - 2.81

Mission Bay Speed Limits (mph)	Milepost Range	Source / Comment
20	2.47 – 2.72	Assumption
22	2.72 – 2.93	Parsons 2012, page 5 (Key Map)
30	2.93 – 3.62	CH2M 2016, Radius <750ft, assumed 30 MPH
35	3.62 – 3.71	CH2M 2016, Radius <870ft, assumed 35 MPH
40	3.71 – 3.78	CH2M 2016, Radius <1207ft, assumed 35 MPH
45	3.78 – 5.23	CH2M 2016, Radius <1207ft, assumed 35 MPH

Mission Bay Elevation (ft)	Milepost	Source / Comment
-30	2.47	CH2M RAB Drawings Package
-30	2.94	CH2M RAB Drawings Package
-115	3.61	CH2M RAB Drawings Package
-115	4.15	CH2M RAB Drawings Package
12	5.01	CH2M RAB Drawings Package
27.65	5.23	CH2M RAB Drawings Package

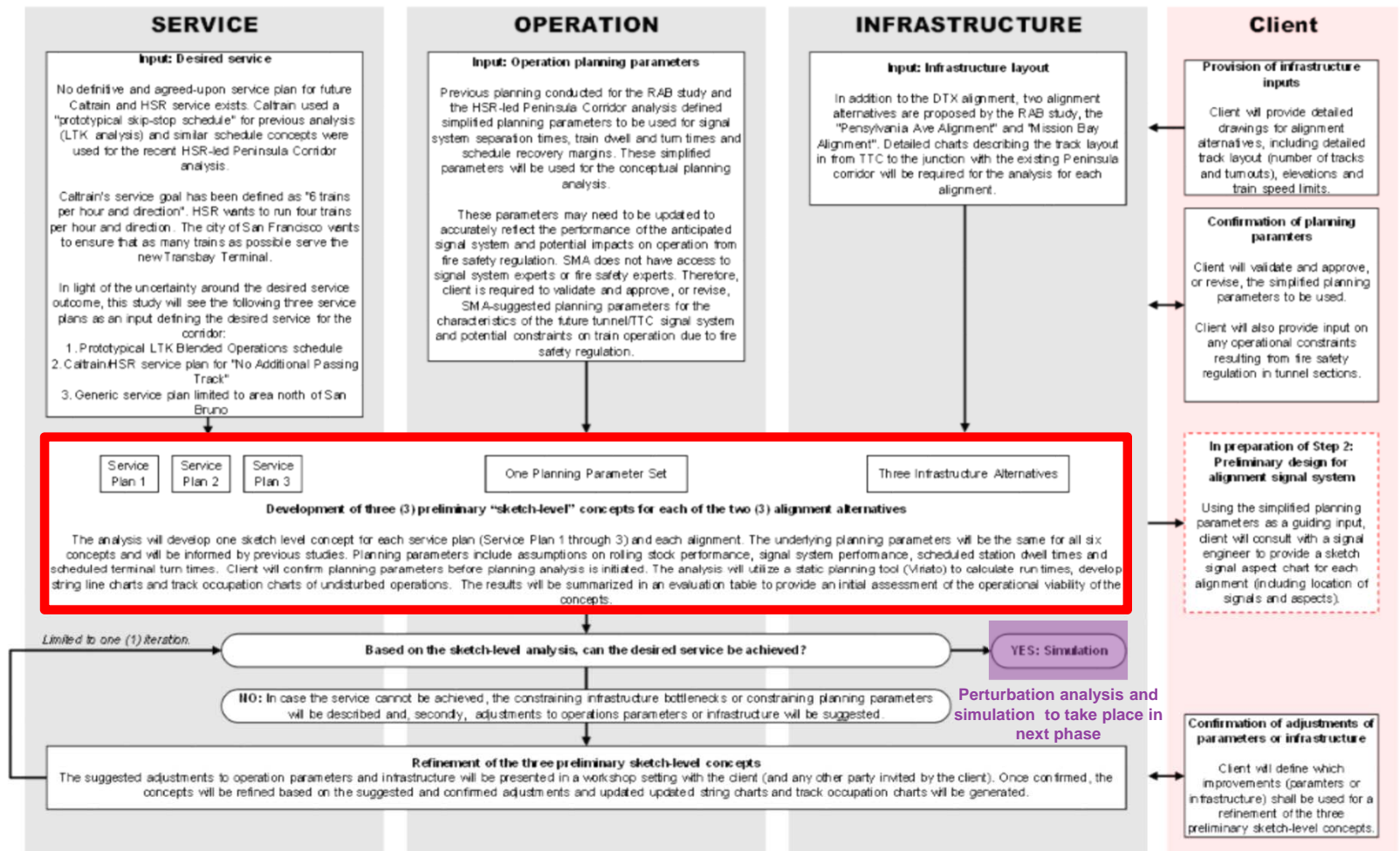
# Runtime Differences Between Alignments

The table below shows the runtimes, in minutes, between the TTC and Millbrae on each of the three alignment alternatives for every unique stopping pattern defined in the service plans used for the analysis, as defined in the scope of work (LTK and No-Additional-Passing-Tracks, or NAPT).

Train	DTX	Pennsylvania Ave	Mission Bay
417 (SB)	15.2	15.4	14.9
419 (SB)	17.1	17.3	16.7
423 (SB)	16.3	16.5	15.9
425 (SB)	16.3	16.5	15.9
1000 (SB)	13.5	13.7	13.3
1100 (SB)	14.0	14.2	13.8
416 (NB)	15.1	15.3	15.0
420 (NB)	15.9	16.1	15.5
424 (NB)	14.1	14.3	14.0
426 (NB)	16.0	16.2	15.9
1001 (NB)	13.5	13.7	13.3
1101 (NB)	14.1	14.3	13.9

## Task 2: Conceptual Planning Analysis

# Conceptual Planning Analysis



# Preliminary Concepts

Concept (Service Pattern- Alignment-Version)	Description		Slots**		
	Number of TTC Approach Tracks Used	HSR Stop at 4th/Townsend?	Total	To TTC	To 4th/ Townsend
NAPT-DTX-A	2	-	10	10	-
NAPT-DTX-B*	2	-	10	10	-
NAPT-DTX-C	2	Yes	10	10	-
NAPT-PEN-A	2	-	10	10	-
NAPT-PEN-B*	2	-	10	10	-
NAPT-MBY-A	2	-	10	10	-
NAPT-MBY-B*	2	-	10	10	-
LTK-DTX-A	2	-	10	10	-
LTK-DTX-B	3	-	10	10	-
LTK-DTX-C	2	Yes	10	10	-
LTK-DTX-D	2	-	11	10	1
LTK-PEN-A	2	-	10	10	-
LTK-PEN-B	3	-	10	10	-
LTK-MBY-A	2	-	10	10	-
LTK-MBY-B	3	-	10	10	-
GEN-DTX-A	2	-	10	10	-
GEN-DTX-C	2	-	12	10	2
GEN-DTX-D	2	-	12	12	-
GEN-DTX-E	2	Yes	12	12	-
GEN-DTX-F	2	Yes	10	10	-
GEN-PEN-A	2	-	10	10	-
GEN-MBY-A	2	-	10	10	-

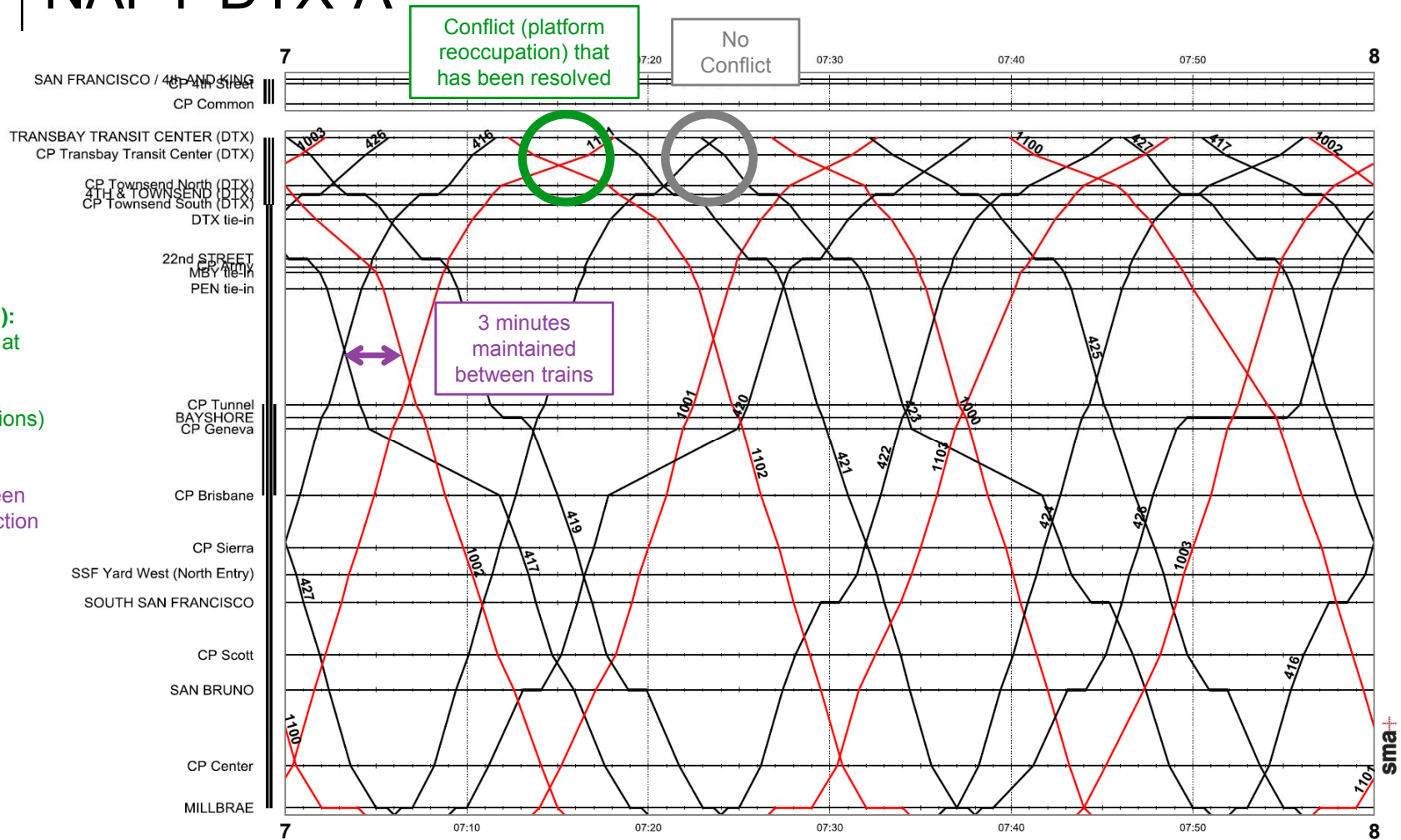
\*Concept uses reverse track operations for some trains from TTC to tie-in with the existing Caltrain corridor to reduce crossing conflicts at CP TTC and reduce supplemental runtimes.

\*\*Infrastructure requirements to accommodate terminating slots at 4<sup>th</sup>/Townsend detailed on slide 35.

# Example Stringline NAPT-DTX-A

**Separation Times (CP TTC):**  
3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
3.0-minute separation between trains traveling in same direction on same track





# Example Tabular Timetable NAPT-DTX-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at 22<sup>nd</sup> Street. The 22<sup>nd</sup> Street arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (DTX)	6:39	6:46	6:50	6:56	7:00	7:12	7:18	7:22	7:26	7:32
4TH & TOWNSEND (DTX)		6:50	6:57		7:04		7:22	7:27		7:38
22nd STREET		6:54	7:01		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:19					7:51
<b>MILLBRAE</b>	<b>7:02</b>	7:05	7:19		7:23	<b>7:32</b>	7:37	7:50		7:55

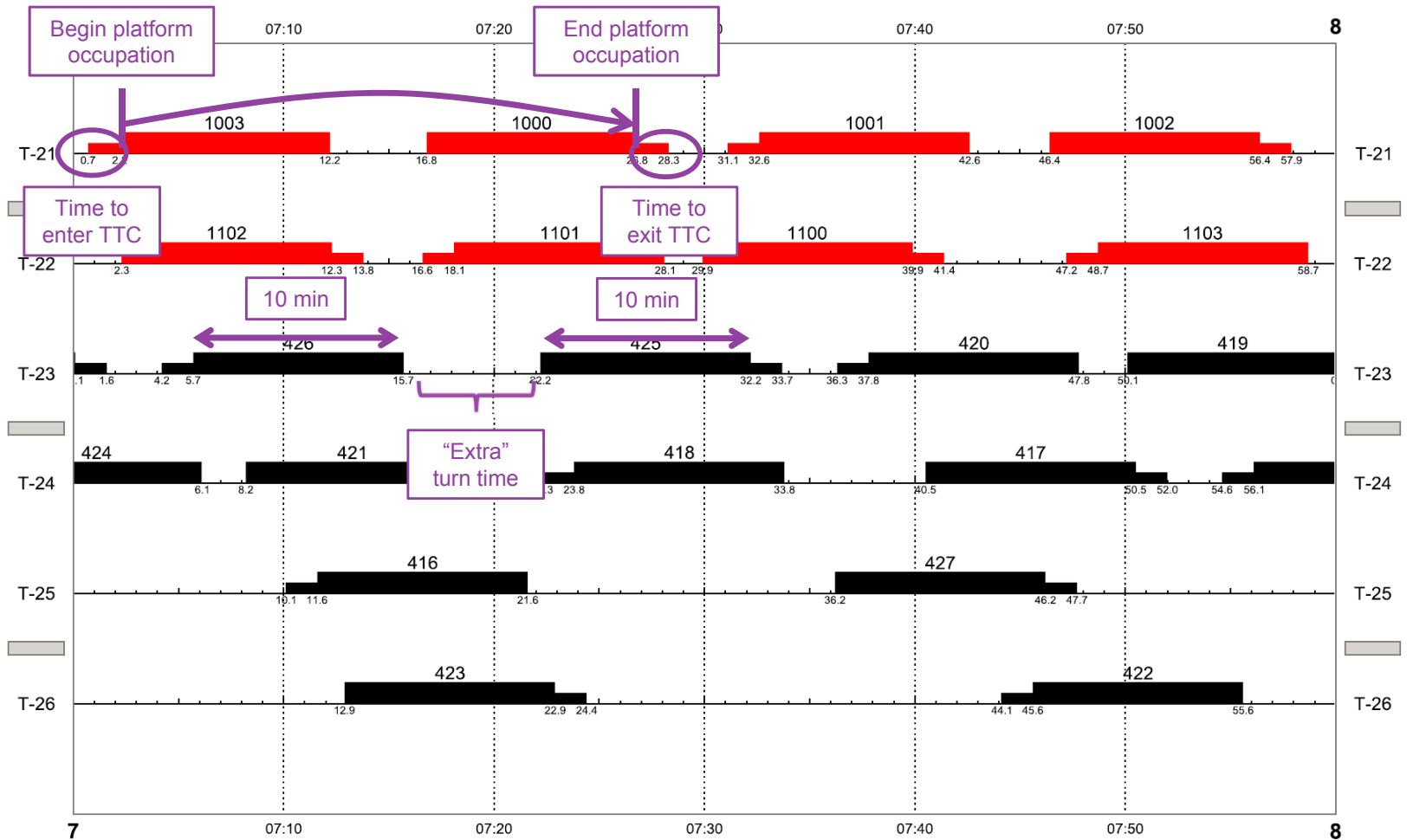
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
<b>MILLBRAE</b>	7:07		7:10	7:25	<b>7:29</b>	7:37		7:39	7:53	<b>7:59</b>
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22nd STREET			7:29							
4TH & TOWNSEND (DTX)	7:20		7:33	7:40		7:50		8:01	8:08	
TRANSBAY TRANSIT CENTER (DTX)	7:23	<b>7:32</b>	7:37	7:45	<b>7:48</b>	7:56	<b>8:02</b>	8:05	8:11	<b>8:18</b>

# Example TTC Platform Occupation NAPT-DTX-A

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap. The blank space between bands forming a train turn pair is additional turn time over the 20-minute minimum.

Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# GEN-DTX-A

A generic slot pattern with six-minute headways (10 slots per hour per direction) was developed in addition to the LTK and NAPT patterns and applied to the northern extent of the corridor, from the existing tunnel portal near the 22<sup>nd</sup> Street Station to the TTC.

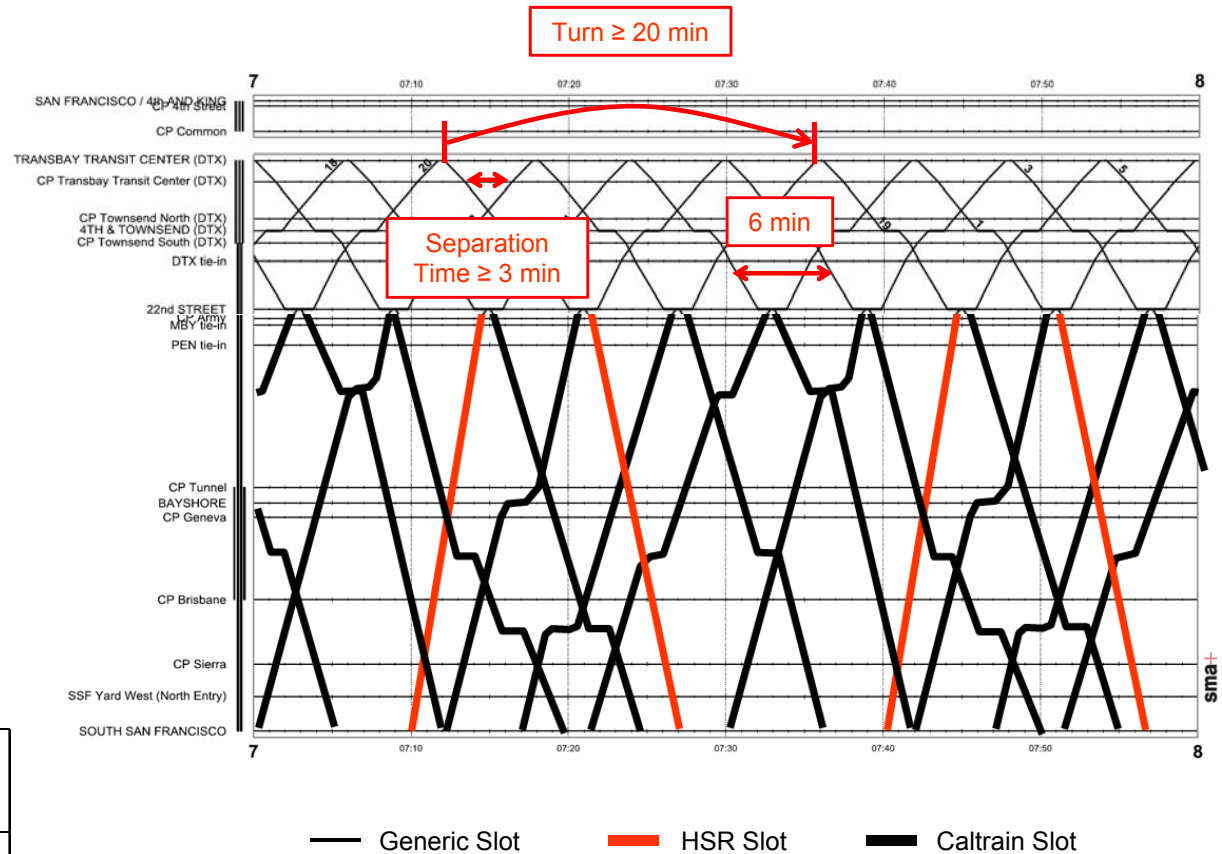
The goal was to see how a frequent, repetitive pattern that efficiently meets operational requirements (i.e. TTC turns as close to the 20-minute minimum and separation times at CP TTC as close to the 3-minute minimum as feasible) performs against the preexisting patterns.

Speeds and stopping patterns are constant among all trains within the generic pattern to ensure operational constraints at the TTC and CP TTC are not violated. Because slots are identical in the generic pattern, any train can use any slot.

22<sup>nd</sup> Street is the transition between the generic pattern to the north and a different pattern (e.g. LTK or NAPT) to the south. The limited range of the generic pattern allows for other service goals (e.g. faster HSR travel times and different stopping patterns) to be applied for a greater portion of the corridor.

Applying the generic pattern from the TTC to 22<sup>nd</sup> Street Station results in slower travel times than those in the NAPT and LTK patterns for some trains. The maximum potential additional travel time added under the generic pattern, by service type and direction is:

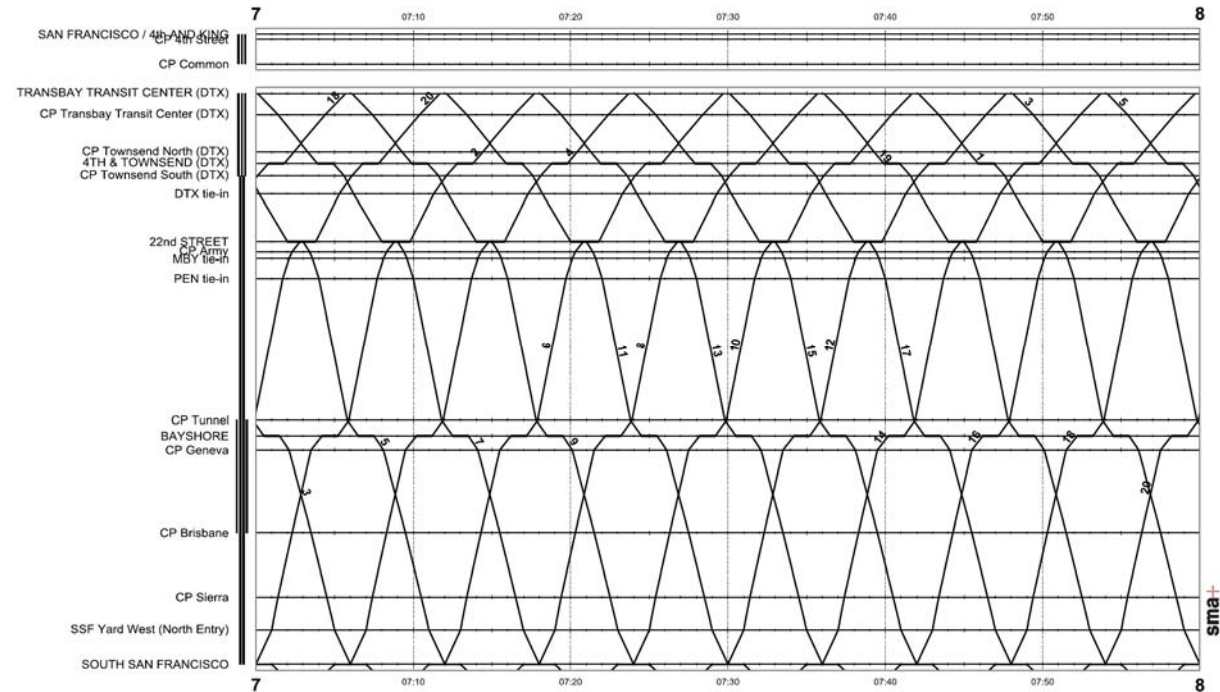
	22 <sup>nd</sup> Street to TTC			
	Fastest Travel Time (min)			
	HSR		Caltrain	
	NB	SB	NB	SB
NAPT/LTK	5.6	5.6	6.8	7.3
Generic	7.2	7.3	7.2	7.3
<b>Max Penalty</b>	<b>1.6</b>	<b>1.7</b>	<b>0.4</b>	<b>0</b>



# GEN-DTX-A

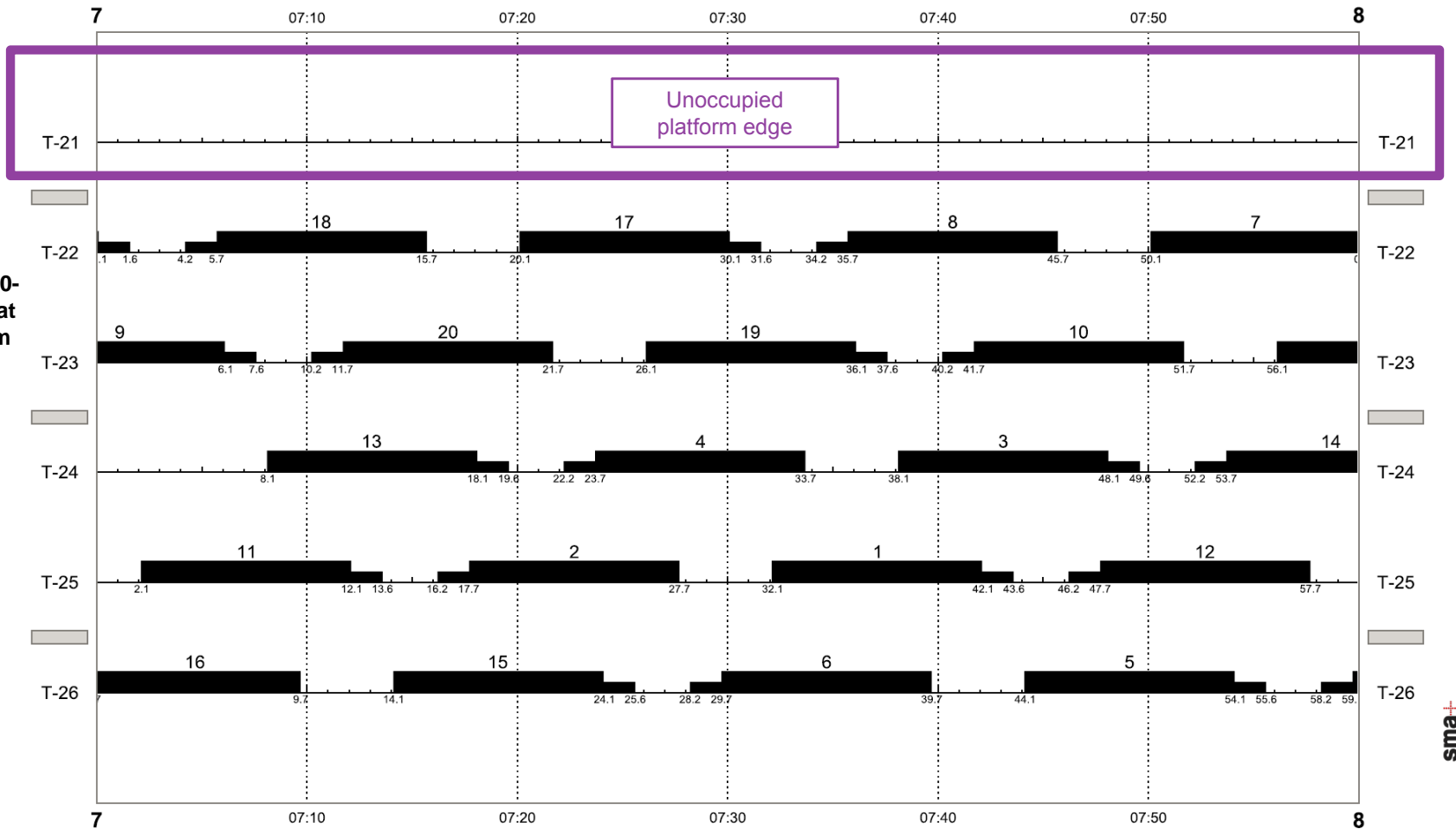
A generic slot pattern with six-minute headways (10 slots per hour per direction) was developed in addition to the LTK and NAPT patterns and applied to the northern extent of the corridor, from the existing tunnel portal near the 22<sup>nd</sup> Street Station to the TTC.

The generic pattern can be applied further south on the corridor (e.g. to South San Francisco) if potential tie-in locations for relocated railyards are included in the analysis.



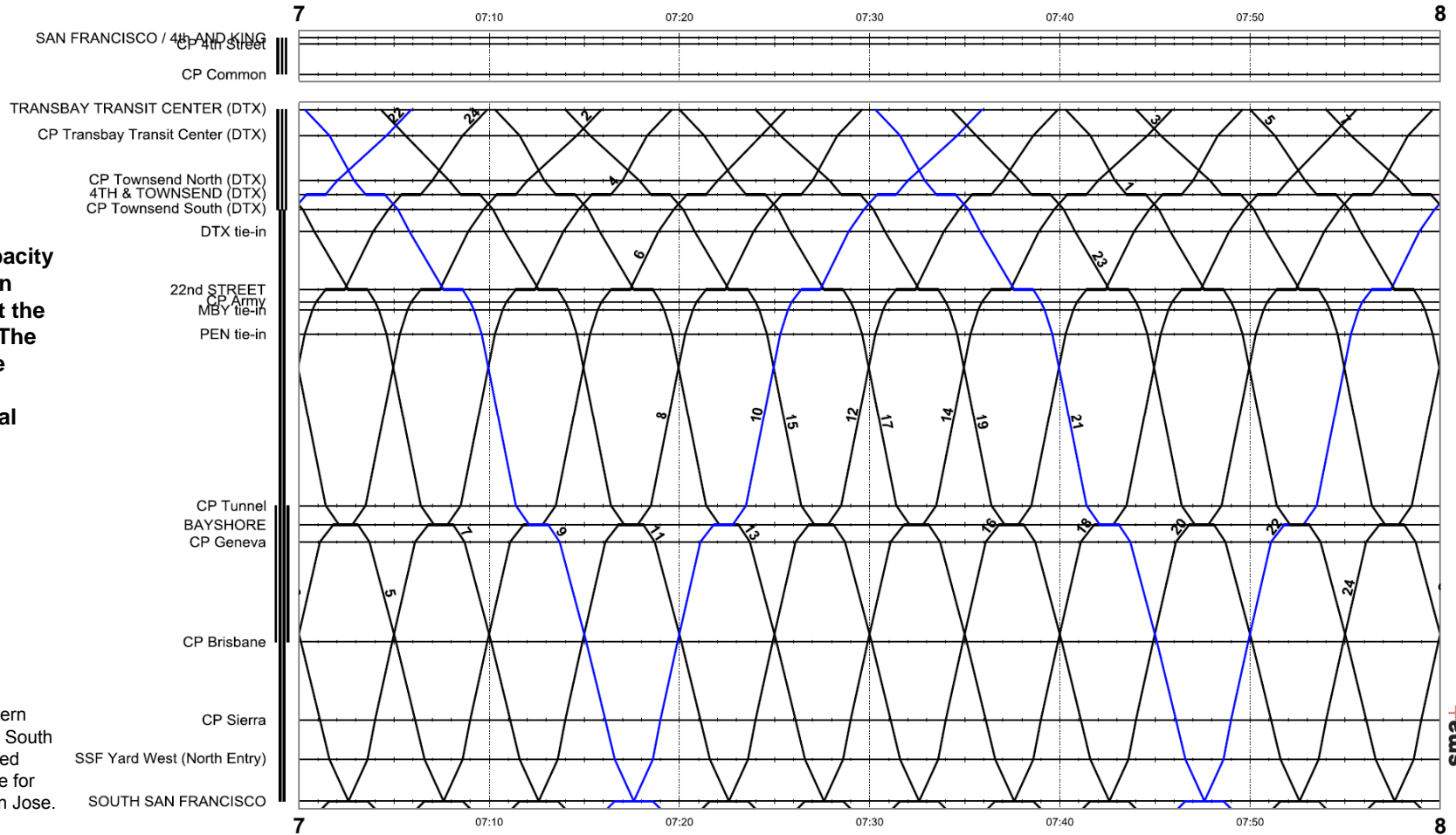
# GEN-Generic Service Pattern GEN-DTX-A

The main benefit of the 10-slot generic pattern is that it only requires 5 platform edges at the TTC.



# Generic Service Pattern GEN-DTX-D

— 11<sup>th</sup>/12<sup>th</sup> Slots

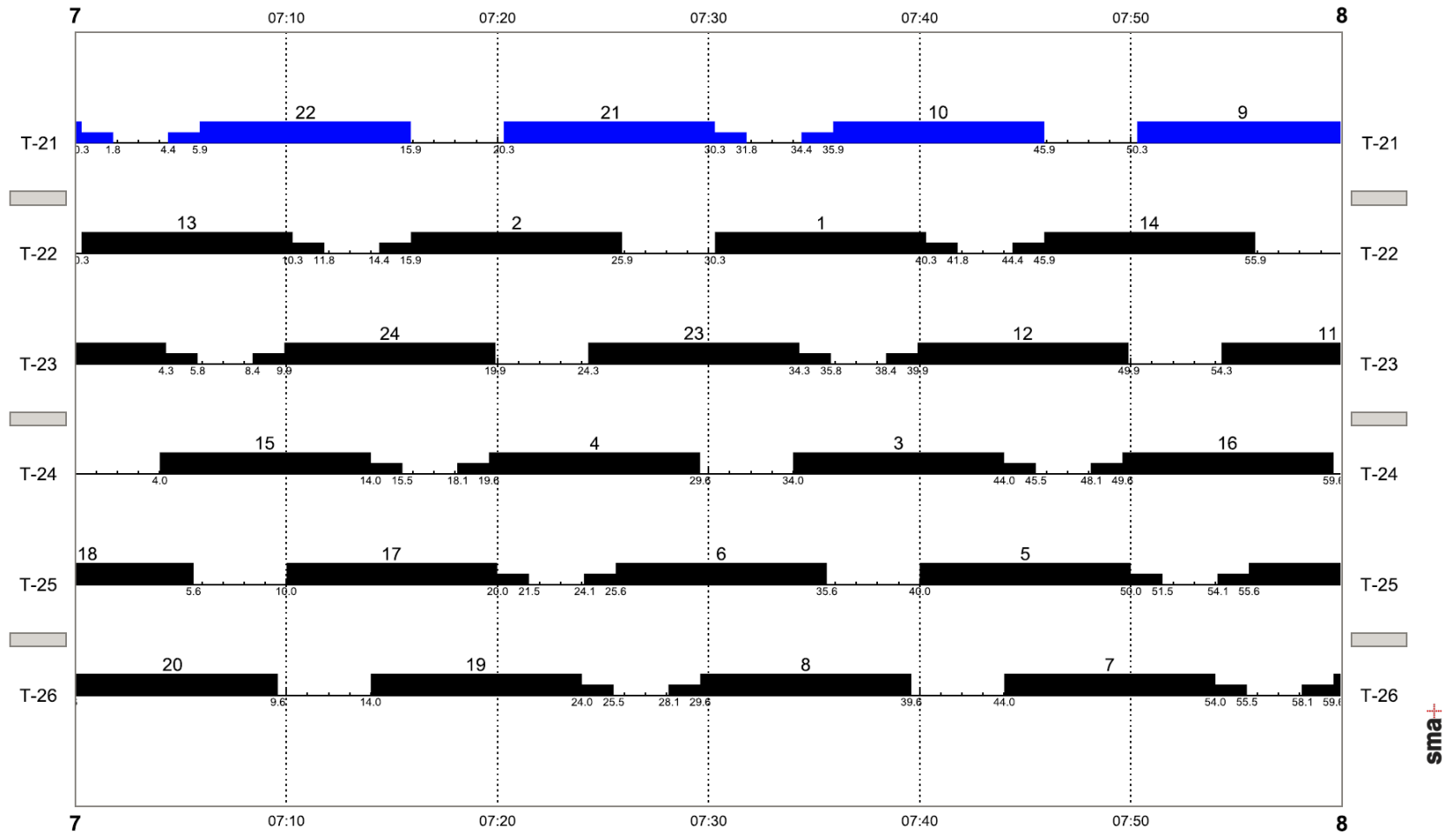


Because of the excess capacity at the TTC, a 12-slot pattern with all slots terminating at the TTC was also developed. The 11<sup>th</sup> and 12<sup>th</sup> slots could be used for regular service, deadhead moves, or special event service.

Disclaimer: the 12-slot generic pattern was solely applied from the TTC to South San Francisco; it was not determined whether a 12-slot service is feasible for the remainder of the corridor to San Jose.

# Generic Service Pattern GEN-DTX-D

The 11<sup>th</sup> and 12<sup>th</sup> slots (blue) have their own platform edge at the TTC.



# Generic Service Pattern GEN-DTX-C

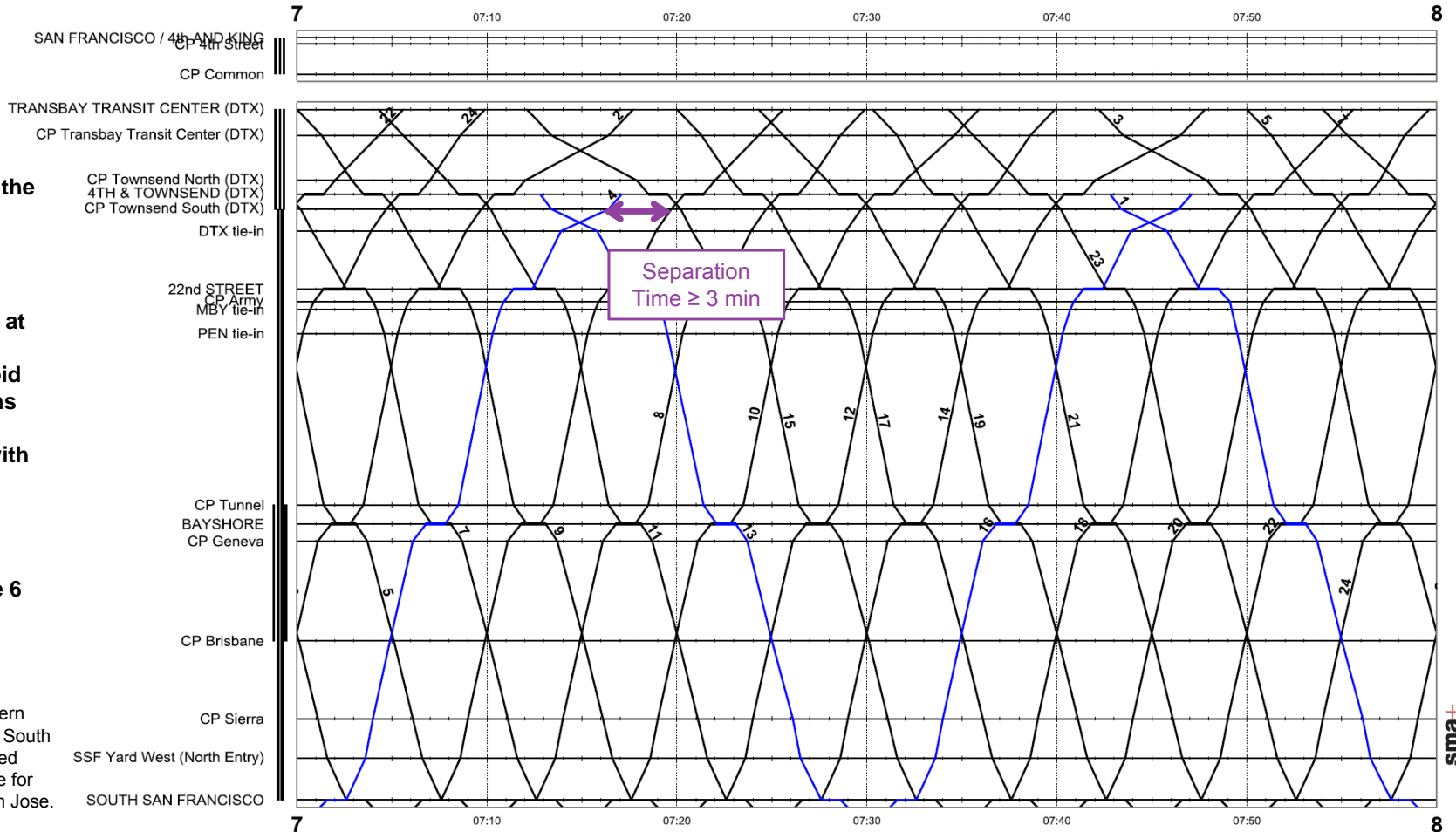
— 11<sup>th</sup>/12<sup>th</sup> Slots

A 12-slot pattern with 2 of the slots terminating at 4<sup>th</sup>/Townsend was also developed.

3-minute separation times at CP Townsend South were maintained in order to avoid conflicts between the trains starting/terminating at 4<sup>th</sup>/Townsend and those with service to/from the TTC.

Because only 10 slots terminate at the TTC, this concept only uses 5 of the 6 TTC platform edges.

Disclaimer: the 12-slot generic pattern was solely applied from the TTC to South San Francisco; it was not determined whether a 12-slot service is feasible for the remainder of the corridor to San Jose.

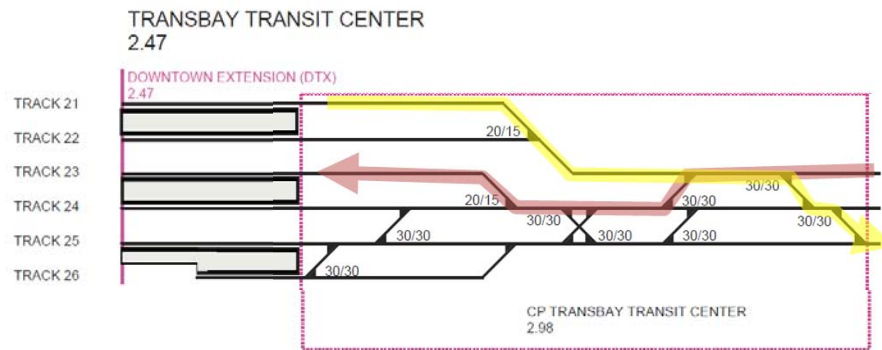




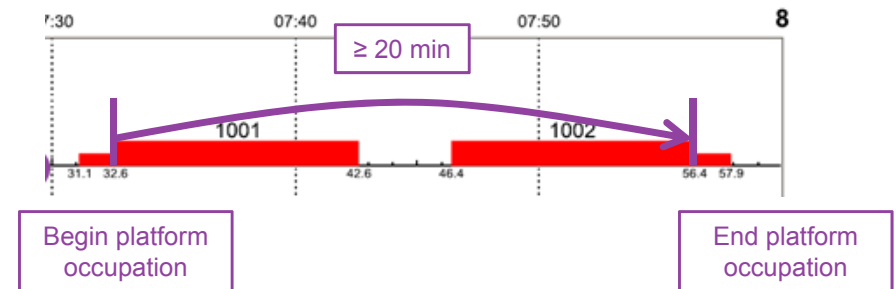
# Key Findings of Conceptual Planning

- The two largest constraints while creating the concepts were:
  - Avoiding conflicts at CP TTC (i.e. crossing conflicts and platform reoccupation times)
  - Ensuring minimum 20-minute turns at TTC

**Crossing Conflict:**



**Turn Time:**



## Key Findings of Conceptual Planning (cont.)

- This analysis indicates that all concepts work under operational constraints.
- All LTK and NAPT concepts can support dedicated HSR and Caltrain platform edges at the TTC, if desired.
  - This may also be the case with the Generic concepts, but first slots must be assigned to either HSR or Caltrain.
- The concepts with a third approach track result in minimal time savings (i.e. approximately four to five minutes total per hour for each concept) when compared against the two approach track concepts.
  - More detailed analysis is recommended to identify the most effective approach to provide infrastructure redundancy to help mitigate the effects of major service disruptions.
- The 10-slot Generic pattern requires five platform edges at the TTC, compared to six platform edges required by the 10-slot LTK and NAPT patterns.
  - This allows for a 12-slot Generic pattern with all trains terminating at the TTC.
  - More detailed simulation is necessary to determine the benefits of a free TTC platform edge during a service disruption.

# Key Findings of Conceptual Planning (cont.)

Concept	Description		Slots**			TTC Platform Tracks Used			Reduction in Supplemental Runtime Per Hour (min)	
	Number of TTC Approach Tracks Used	HSR Stop at 4th/Townsend?	Total	To TTC	To 4th/Townsend	Total	HSR	Caltrain	Using 3rd Approach Track for Some Trains	With Reverse Track Operations for Some Trains
NAPT-DTX-A	2	-	10	10	-	6	2	4	-	-
NAPT-DTX-B*	2	-	10	10	-	6	2	4	-	-5.0
NAPT-DTX-C	2	Yes	10	10	-	6	2	4	-	-
NAPT-PEN-A	2	-	10	10	-	6	2	4	-	-
NAPT-PEN-B*	2	-	10	10	-	6	2	4	-	-4.8
NAPT-MBY-A	2	-	10	10	-	6	2	4	-	-
NAPT-MBY-B*	2	-	10	10	-	6	2	4	-	-5.3
LTK-DTX-A	2	-	10	10	-	6	3	3	-	-
LTK-DTX-B	3	-	10	10	-	6	3	3	-4.4	-
LTK-DTX-C	2	Yes	10	10	-	6	3	3	-	-
LTK-DTX-D	2	-	11	10	1	6	3	3	-	-
LTK-PEN-A	2	-	10	10	-	6	3	3	-	-
LTK-PEN-B	3	-	10	10	-	6	3	3	-4.1	-
LTK-MBY-A	2	-	10	10	-	6	3	3	-	-
LTK-MBY-B	3	-	10	10	-	6	3	3	-4.8	-
GEN-DTX-A	2	-	10	10	-	5	-	-	-	-
GEN-DTX-C	2	-	12	10	2	5	-	-	-	-
GEN-DTX-D	2	-	12	12	-	6	-	-	-	-
GEN-DTX-E	2	Yes	12	12	-	6	-	-	-	-
GEN-DTX-F	2	Yes	10	10	-	5	-	-	-	-
GEN-PEN-A	2	-	10	10	-	5	-	-	-	-
GEN-MBY-A	2	-	10	10	-	5	-	-	-	-

\*Concept uses reverse track operations for some trains from TTC to tie-in with the existing Caltrain corridor to reduce crossing conflicts at CP TTC and reduce supplemental runtimes.

\*\*Infrastructure requirements to accommodate terminating slots at 4<sup>th</sup>/Townsend detailed on slide 35.

## Next Steps


This analysis verified the theoretical feasibility of various concepts using different service plans and alignment alternatives, given conservative planning parameters.

As a follow-up to this preliminary planning work, a perturbation analysis and simulation should be conducted in order to determine how concepts perform under various service disruption scenarios.

4<sup>th</sup>/Townsend Configuration Options  
Functional Goals → Infrastructure Requirements

# Concepts with 10-Slot Service at 4<sup>th</sup>/Townsend (all slots terminate at TTC)

## Legend:

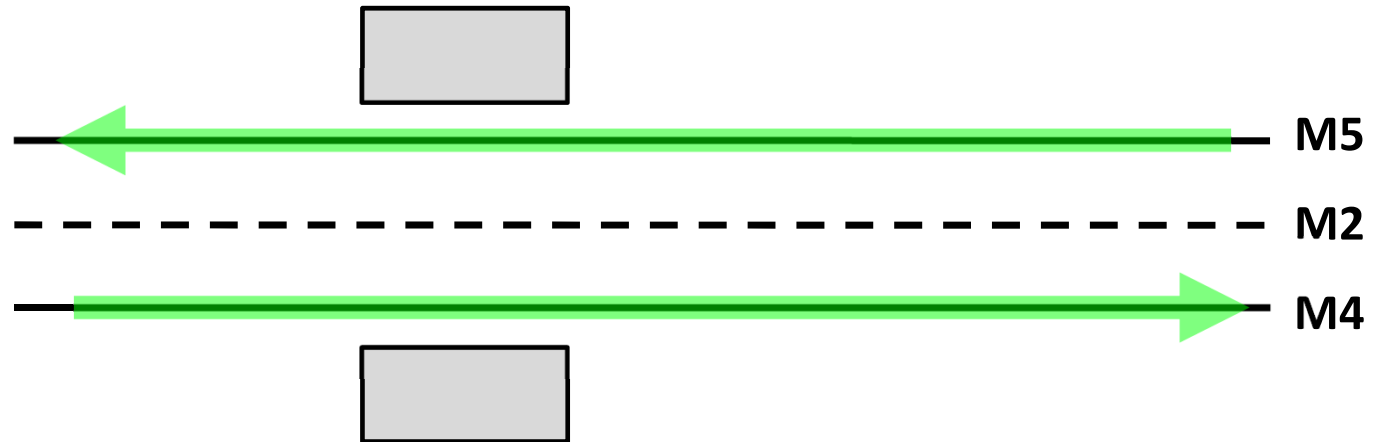
 Through Service

## Infrastructure Requirements:

- 2 through tracks (one per direction)

## Example Concept Requiring this Layout:

- NAPT-DTX-A



# Concepts with 11/12-Slot Service at 4<sup>th</sup>/Townsend (1/2 slots terminate at 4<sup>th</sup>/Townsend)

## Legend:

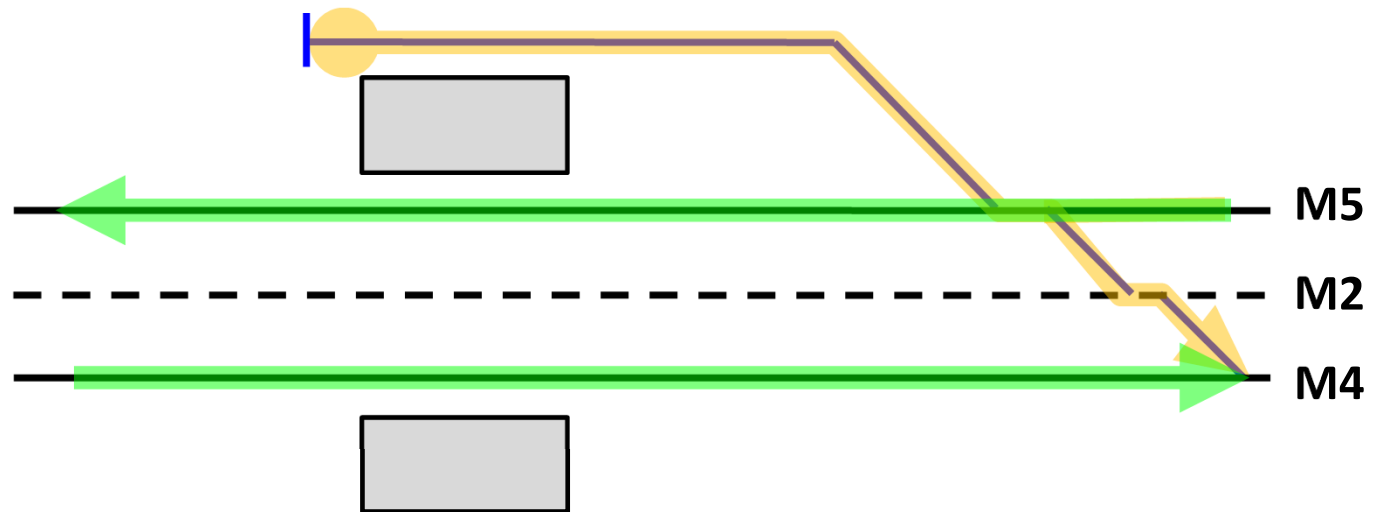
- Through Service
- Terminating Service

## Infrastructure Requirements:

- 2 through tracks (one per direction)
- 1 stub-end track
- Crossovers connecting stub-end track with M4

## Example Concept Requiring this Layout:

- LTK-DTX-D



# Concepts with 11/12-Slot Service at 4<sup>th</sup>/Townsend (1/2 slots terminate at 4<sup>th</sup>/Townsend) + Protect Unit

## Legend:

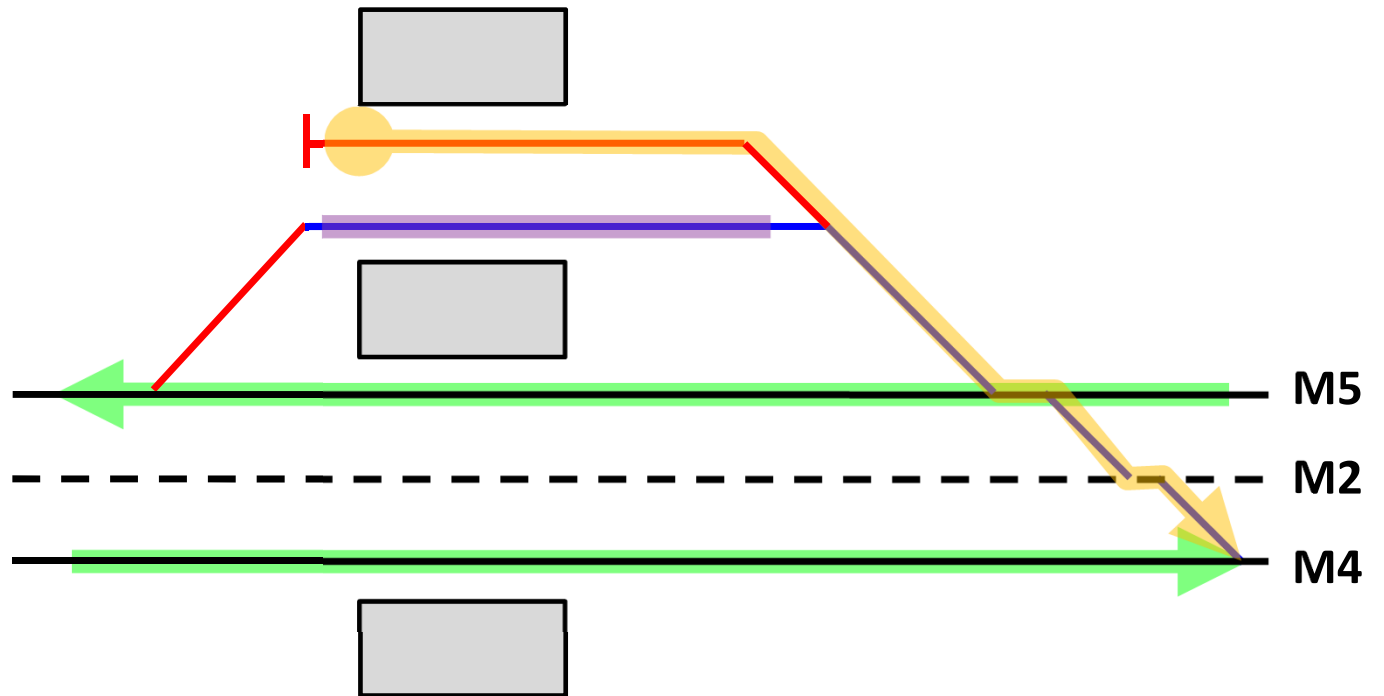
- Through Service
- Terminating Service
- Protect Unit

## Infrastructure Requirements:

- 2 through tracks (one per direction)
- 1 stub-end track
- 1 siding track
- Crossovers connecting stub-end and siding tracks with M4

## Example Concept Requiring this Layout:

- LTK-DTX-D (with protect unit)





# Concepts with 12-Slot Service at 4<sup>th</sup>/Townsend (all slots terminate at 4<sup>th</sup>/Townsend)\*

## Legend:

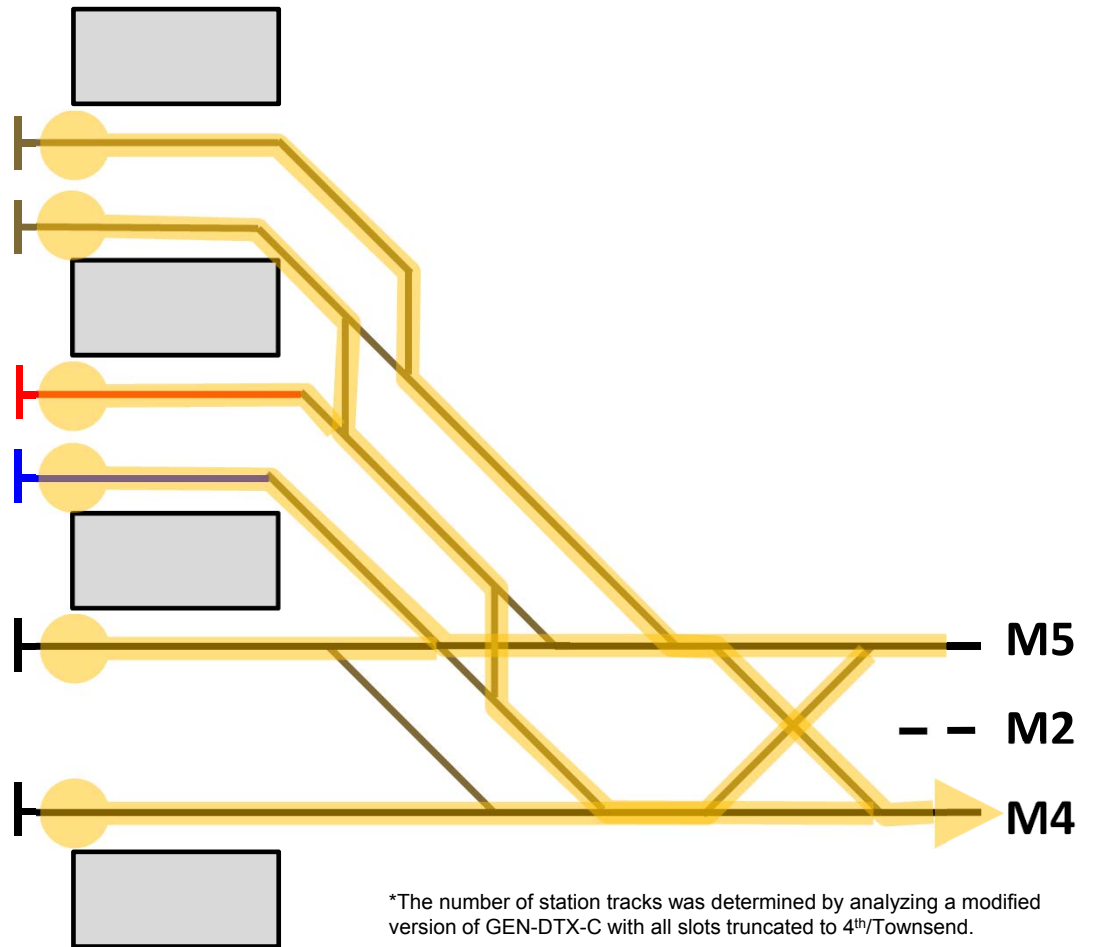
 Terminating Service

## Infrastructure Requirements:

- 6 stub-end tracks
- Universal crossovers connecting station stub-end tracks to mainline tracks

## Example Concept Requiring this Layout:

- No concepts terminate all trains at 4<sup>th</sup>/Townsend



\*The number of station tracks was determined by analyzing a modified version of GEN-DTX-C with all slots truncated to 4<sup>th</sup>/Townsend.

# HSR Stop at 4<sup>th</sup>/Townsend

# HSR Stop at 4<sup>th</sup>/Townsend

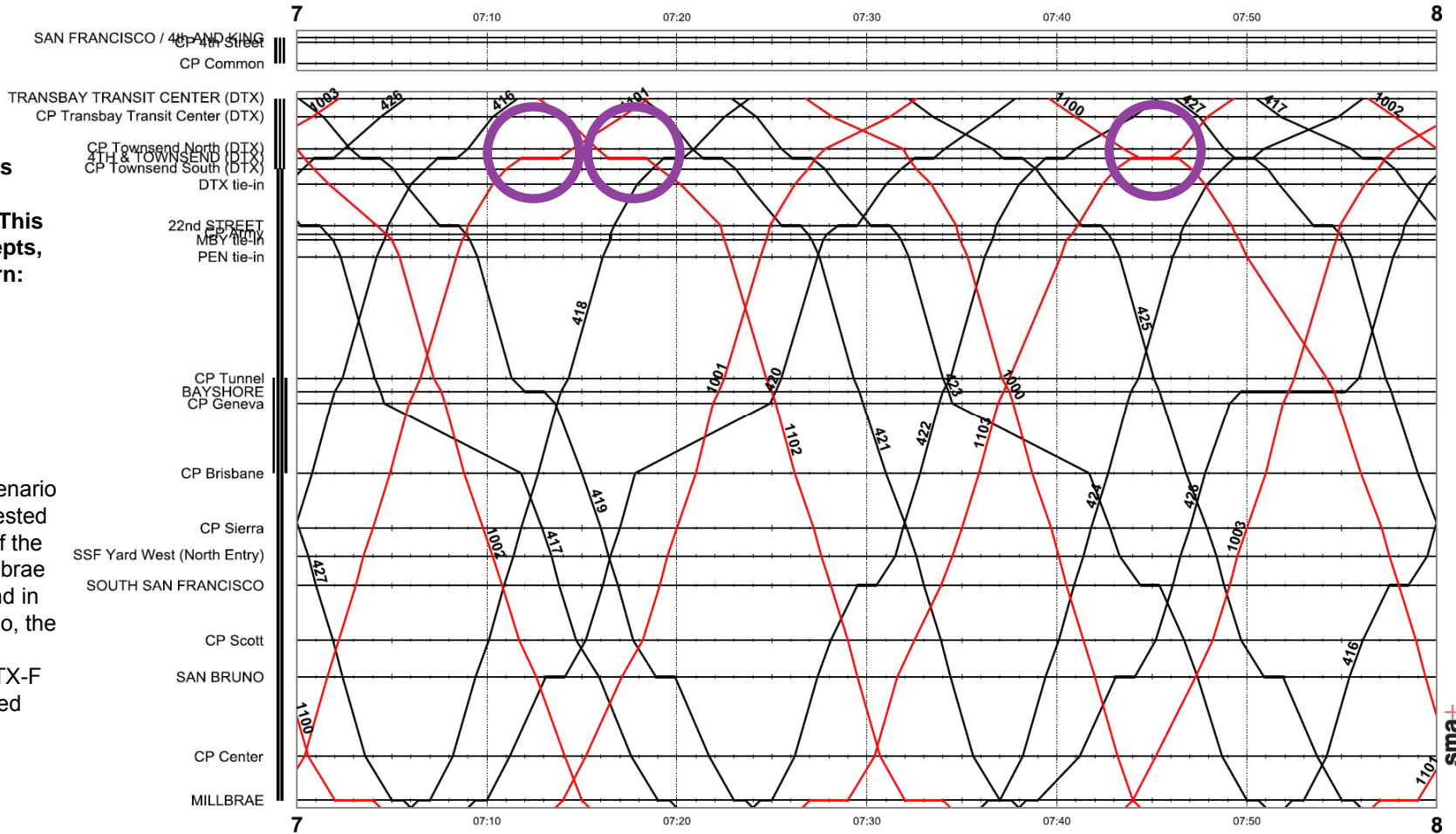
# NAPT-DTX-C

**A stop at 4<sup>th</sup>/Townsend was added for HSR trains also making a stop at Millbrae. This was applied in three concepts, one for each service pattern:**

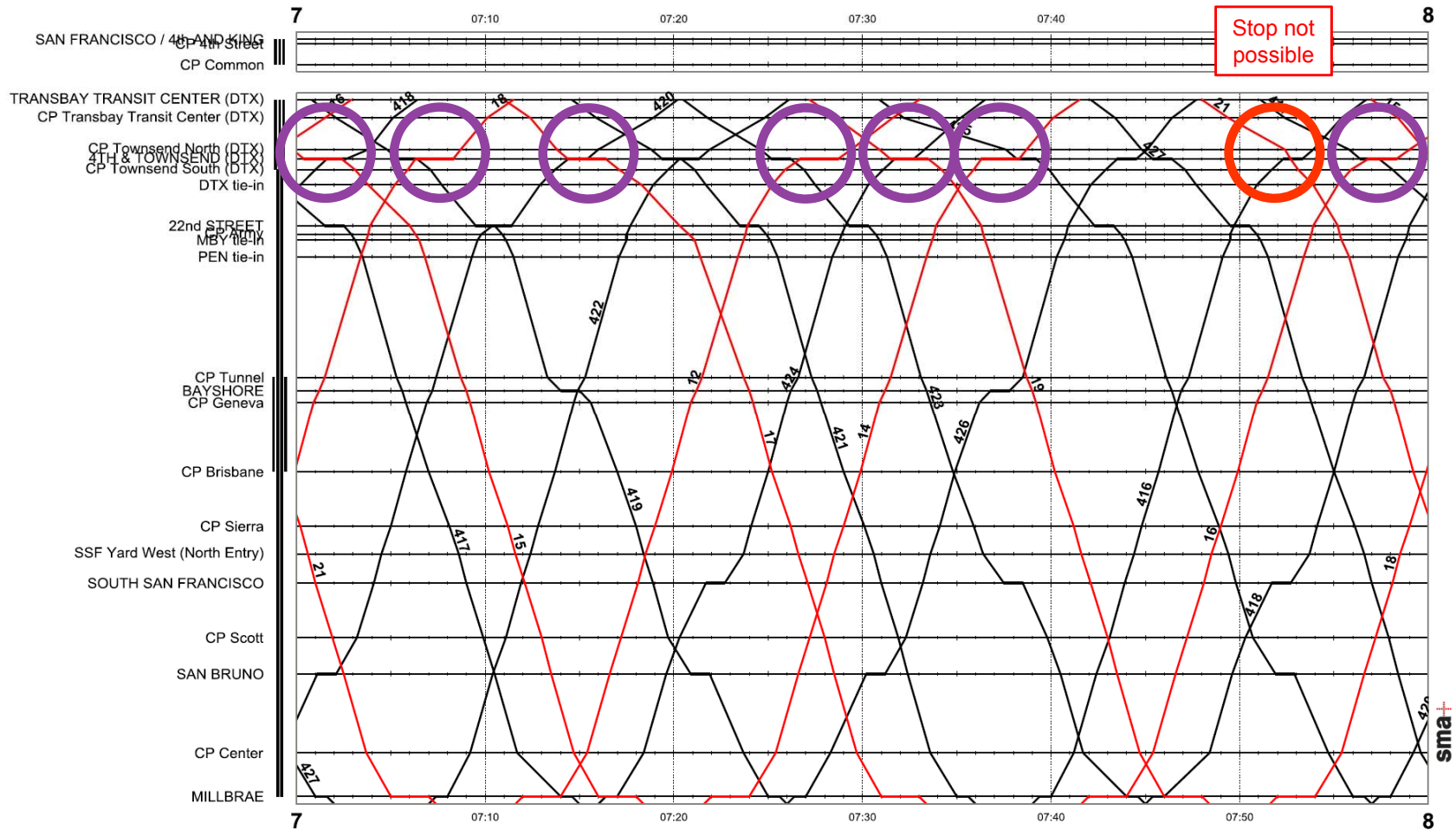
- NAPT-DTX-C
- LTK-DTX-C
- GEN-DTX-F

## Findings:

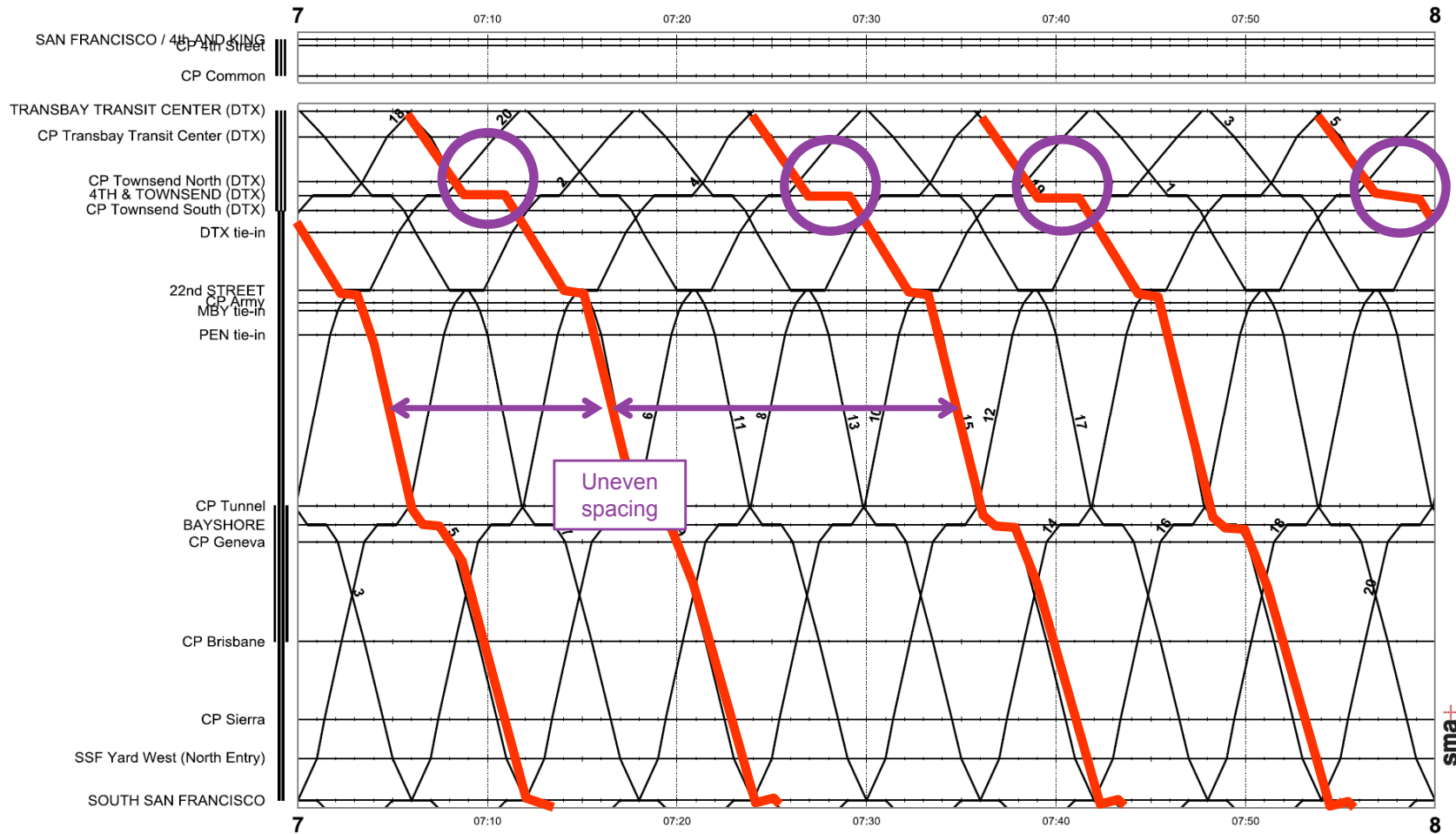
For the most part, such a scenario is possible under the three tested concepts. However, only 7 of the 8 HSR trains stopping at Millbrae can also stop at 4<sup>th</sup>/Townsend in the LTK-DTX-C concept. Also, the HSR trains stopping at 4<sup>th</sup>/Townsend in the GEN-DTX-F concept are not evenly spaced throughout the hour.



# LTK-DTX-C



# GEN-DTX-F



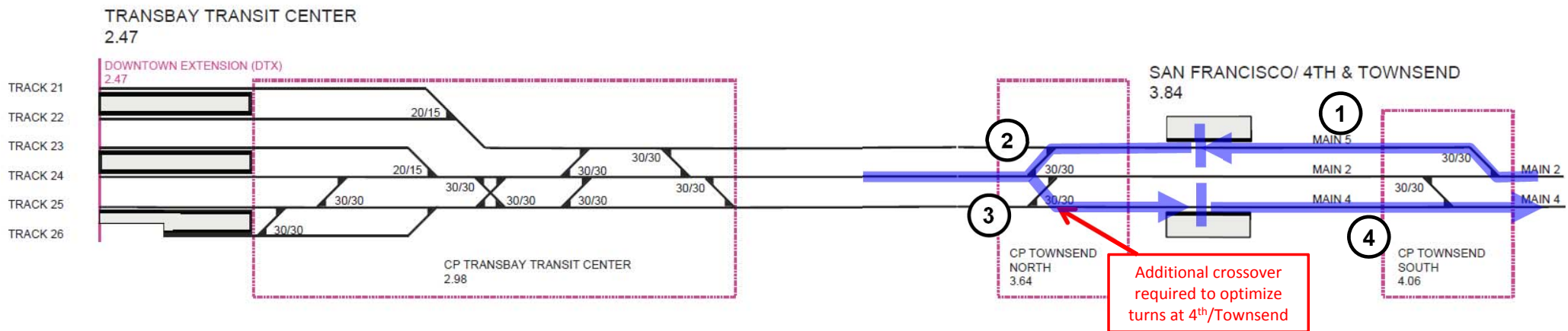
# Potential Uses of Third TTC Approach Track\*

# Turn at 4<sup>th</sup>/Townsend

## Legend:

█ Turning Train

The third approach track could be used to turn trains at 4<sup>th</sup>/Townsend without disturbing through services terminating at the TTC. However, the currently proposed layout for the third approach track is not optimal for a turn maneuver, as it unnecessarily requires turning trains to travel to CP TTC instead of remaining at CP Townsend North to make a turn. An additional crossover at CP Townsend North is required to optimize turns at 4<sup>th</sup>/Townsend.



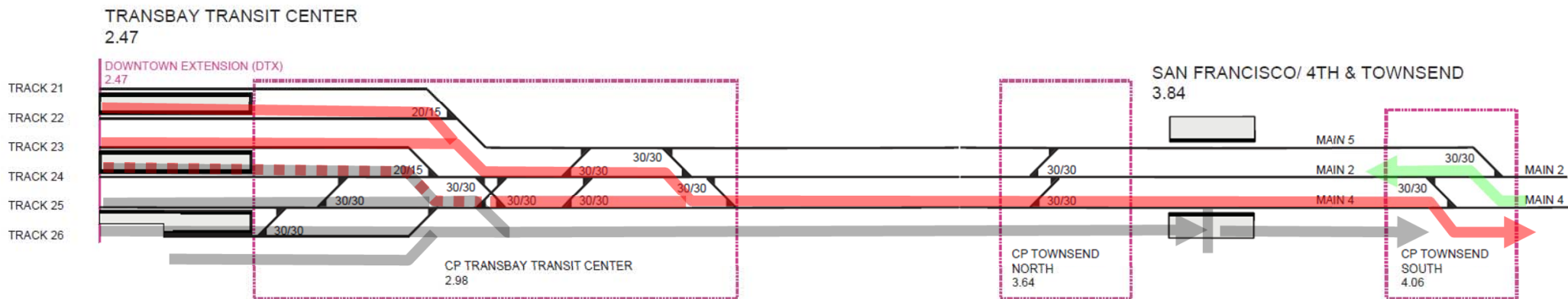


# Concurrent HSR/Caltrain Departures from TTC

## Legend:

- HSR Outbound Service
- Caltrain Outbound Service
- Inbound Service

The third approach track could be used for concurrent HSR/Caltrain departures from the TTC on main 2 and 4, potentially reducing supplemental time in trains' schedules. All HSR trains originate at station track 21, 22, or 23 and would use main 2 and bypass 4<sup>th</sup>/Townsend while all Caltrain trains originate at station track 23, 24, 25, or 26 and would use main 4 and stop at 4<sup>th</sup>/Townsend.



The ability to run trains as described above, allowed time savings only for the LTK pattern. Here, two of the southbound high-speed trains can save between 2-3 minutes, resulting in a total time savings of between 4.1 and 4.8 minutes, depending on the alignment. For all other service patterns no time savings could be realized.

# Concurrent HSR/Caltrain Arrivals at TTC

## Legend:

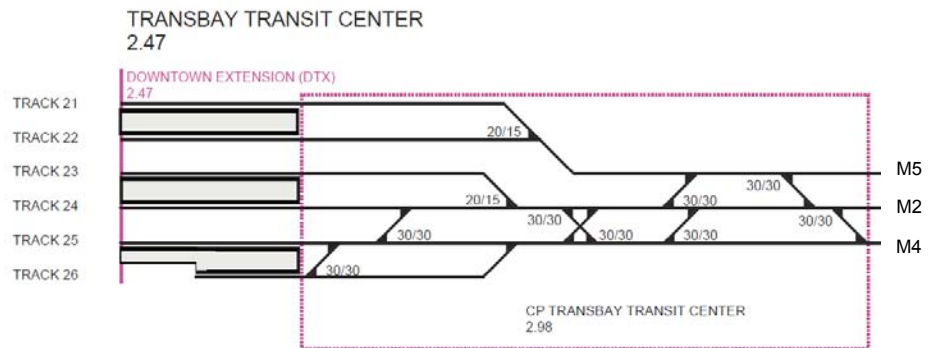
- █ HSR Inbound Service
- █ Caltrain Inbound Service
- █ Outbound Service

However, because this operation is only possible for train pairs without CP TTC crossing conflicts, it only works in the outbound direction (unless reverse track operations are used). In the inbound direction, HSR trains on main 2 going to station tracks 21, 22, and 23 would conflict with Caltrain trains on main 5 going to station tracks 23, 24, 25 and 26, requiring a three-minute separation and canceling out time saved under this operation.



# Proposed and Optimal TTC Topologies

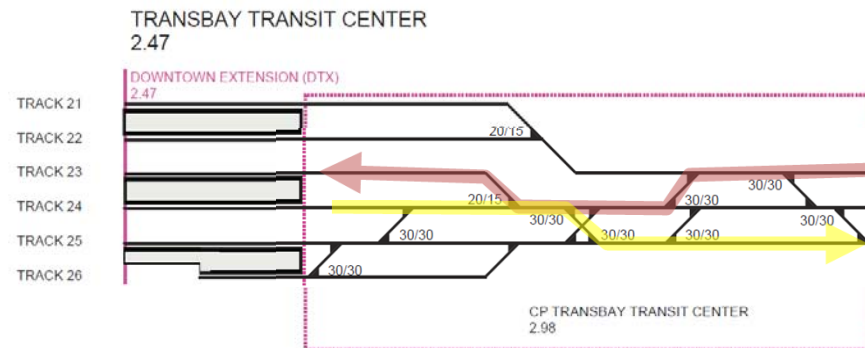
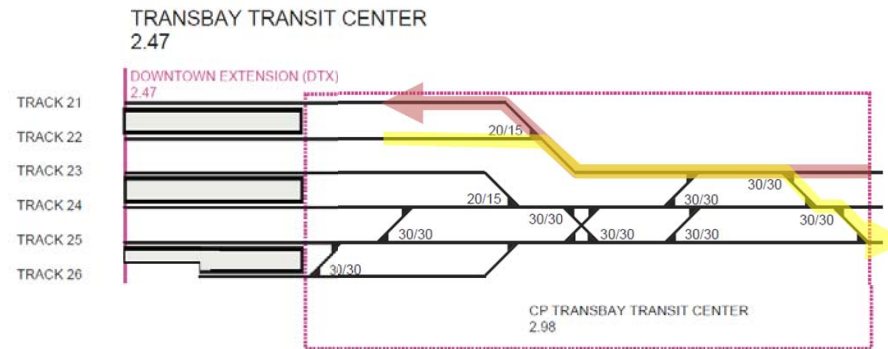
# Proposed TTC Topology



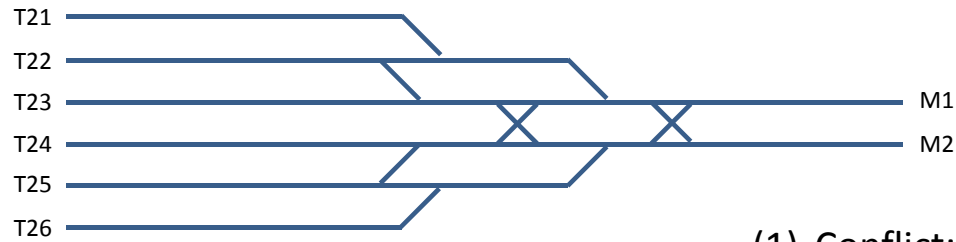
- Conflict: Same main line track
- Conflict: Same platform
- Conflict: Crossing paths
- Unnecessary conflict due to proposed topology

	Sect. track	M5	M5	M5	M5	M5	M5	M2	M2	M2	M2	M2	M2	M4	M4	M4	M4	M4	M4
Sect. track	St. Track	T-21	T-22	T-23	T-24	T-25	T-26	T-21	T-22	T-23	T-24	T-25	T-26	T-21	T-22	T-23	T-24	T-25	T-26
M5	T-21	Red	Red	Red	Red	Red	Red	Orange	Blue X					Orange	Blue X				
M5	T-22	Red	Red	Red	Red	Red	Red	Yellow	Orange					Yellow	Orange				
M5	T-23	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Orange	Blue X			Yellow	Yellow	Orange	Blue X		
M5	T-24	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Orange			Yellow	Yellow	Yellow	Orange		
M5	T-25	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Orange		Yellow	Yellow	Yellow	Yellow	Orange	
M5	T-26	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Orange		Yellow	Yellow	Yellow	Yellow	Yellow	Orange
M2	T-21	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Orange	Blue		
M2	T-22	Blue X	Orange	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Orange			
M2	T-23			Orange	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Orange	Blue	
M2	T-24			Blue X	Orange	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Orange	
M2	T-25					Orange	Yellow	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Orange
M2	T-26						Orange	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Orange
M4	T-21	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red
M4	T-22	Blue X	Orange	Yellow	Yellow	Yellow	Yellow	Blue	Orange	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red
M4	T-23			Orange	Yellow	Yellow	Yellow		Orange	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Red	Red	Red
M4	T-24			Blue X	Orange	Yellow	Yellow			Blue	Orange	Yellow	Yellow	Red	Red	Red	Red	Red	Red
M4	T-25					Orange	Yellow					Orange	Yellow	Red	Red	Red	Red	Red	Red
M4	T-26						Orange						Orange	Red	Red	Red	Red	Red	Red

# Unnecessary Conflicts Due to Proposed Topology



# Optimal TTC Topology

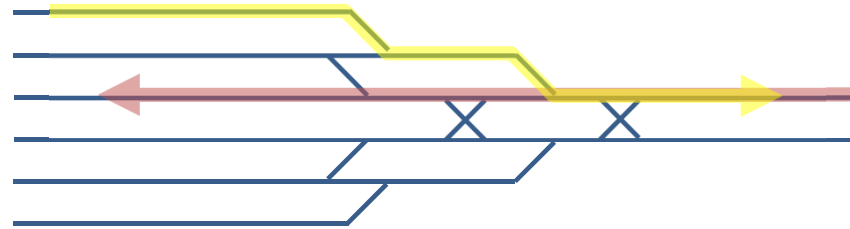


- (1) Conflict: Same platform / main line track
- (2) Conflict: Crossing paths

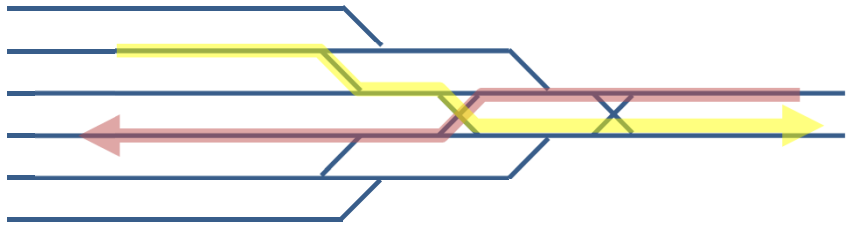
	M1 – T21	M1 – T22	M1 – T23	M1 – T24	M1 – T25	M1 – T26	M2 – T21	M2 – T22	M2 – T23	M2 – T24	M2 – T25	M2 – T26
T21 – M1	X	(1)	(1)	(1)	(1)	(1)	(1)					
T22 – M1	(1)	X	(1)	(1)	(1)	(1)	(2)	(1)				
T23 – M1	(1)	(1)	X	(1)	(1)	(1)	(2)	(2)	(1)			
T24 – M1	(1)	(1)	(1)	X	(1)	(1)	(2)	(2)	(2)	(1)		
T25 – M1	(1)	(1)	(1)	(1)	X	(1)	(2)	(2)	(2)	(2)	(1)	
T26 – M1	(1)	(1)	(1)	(1)	(1)	X	(2)	(2)	(2)	(2)	(2)	(1)
T21 – M2	(1)	(2)	(2)	(2)	(2)	(2)	X	(1)	(1)	(1)	(1)	(1)
T22 – M2		(1)	(2)	(2)	(2)	(2)	(1)	X	(1)	(1)	(1)	(1)
T23 – M2			(1)	(2)	(2)	(2)	(1)	(1)	X	(1)	(1)	(1)
T24 – M2				(1)	(2)	(2)	(1)	(1)	(1)	X	(1)	(1)
T25 – M2					(1)	(2)	(1)	(1)	(1)	(1)	X	(1)
T26 – M2						(1)	(1)	(1)	(1)	(1)	(1)	X

# Conflict Types

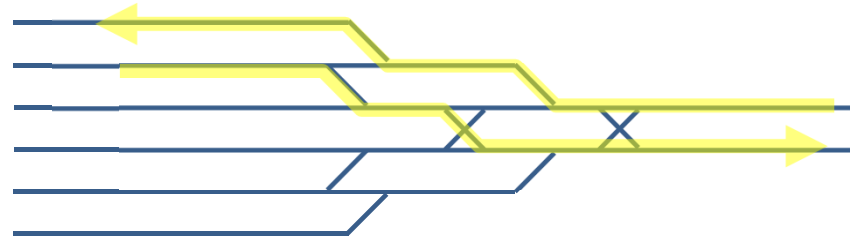
(1) Conflict: Same platform / main line track



(2) Conflict: Crossing paths



No conflicts



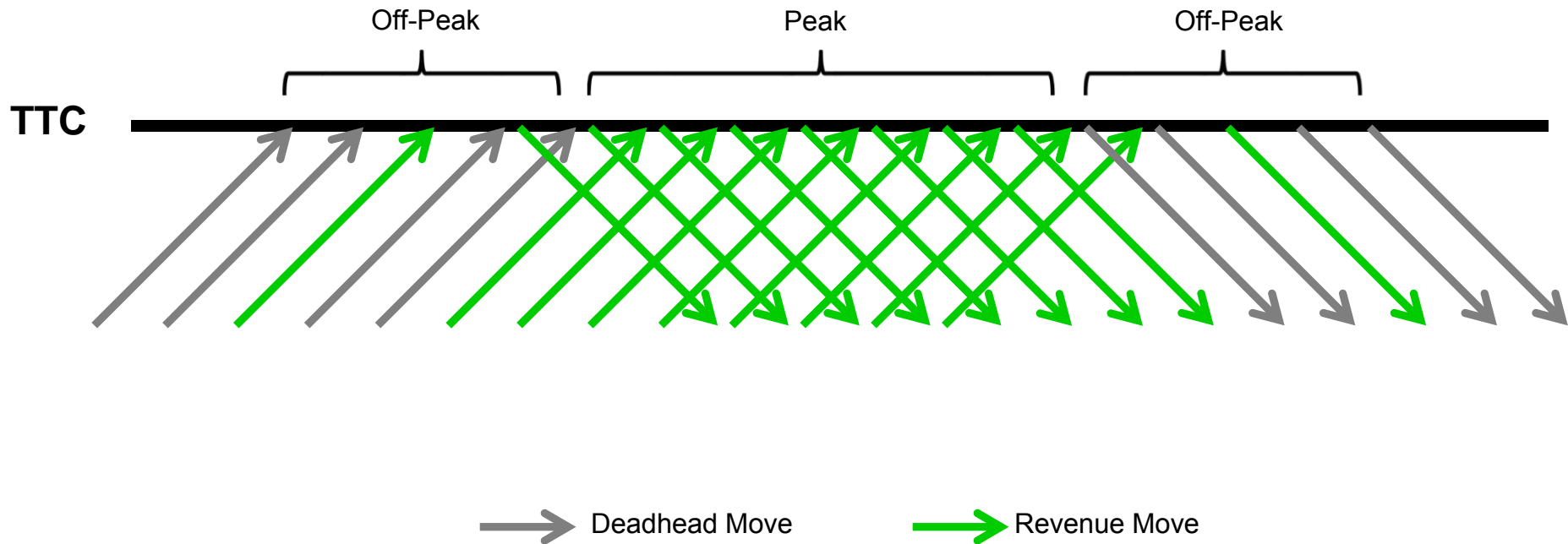
# Railyard Analysis



## Introduction

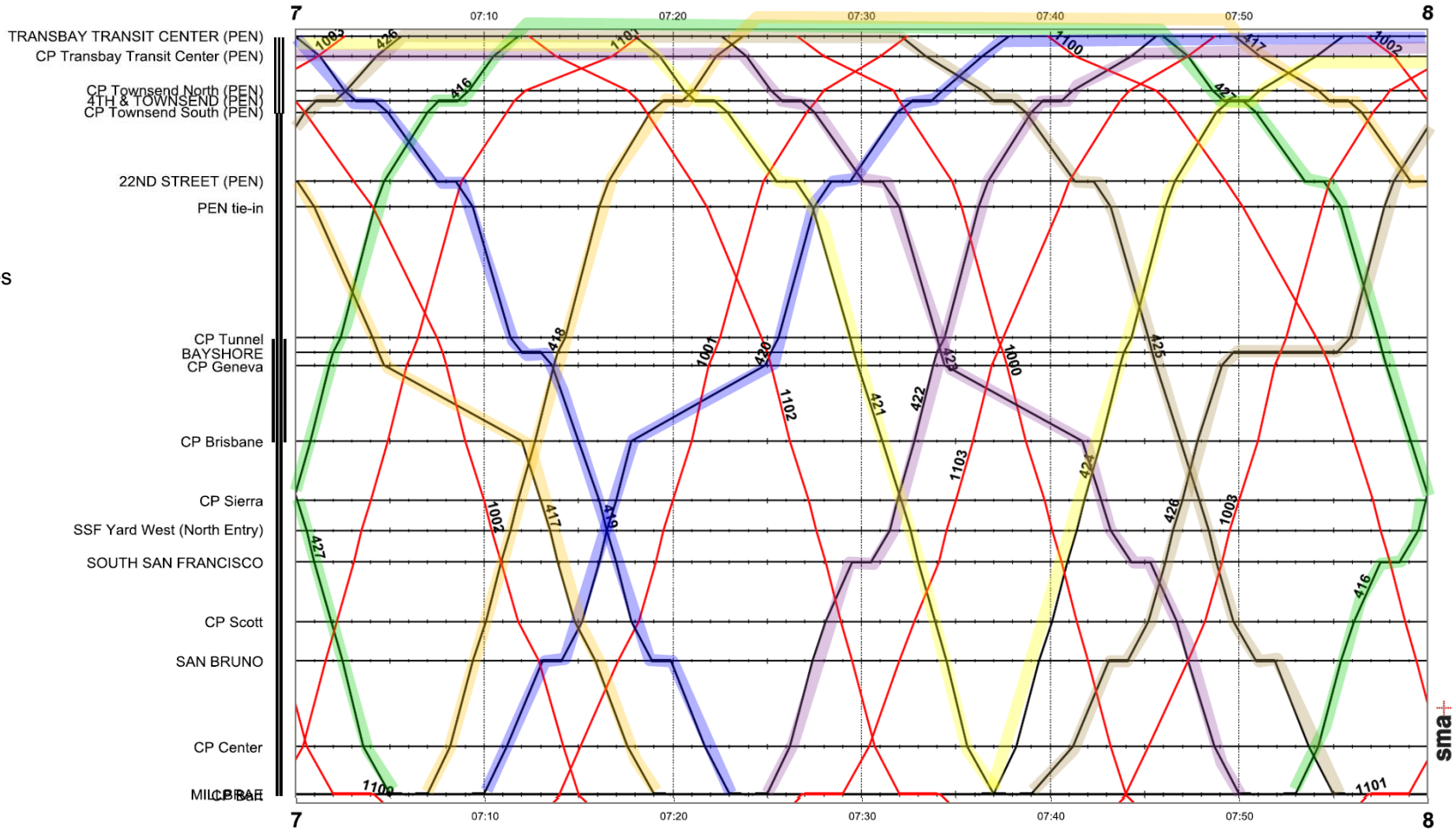
The purpose of this analysis was to look at the accessibility of the proposed railyard sites (Site 1 and Site 2). Deadhead moves into and out of the yards were analyzed for conflicts to determine whether the proposed locations and tie-in configurations are feasible under proposed service patterns. Determining yard feasibility in preliminary planning will help to better inform potential constraints during the perturbation analysis and simulation.

# Methodology: Off-Peak to Peak Transition

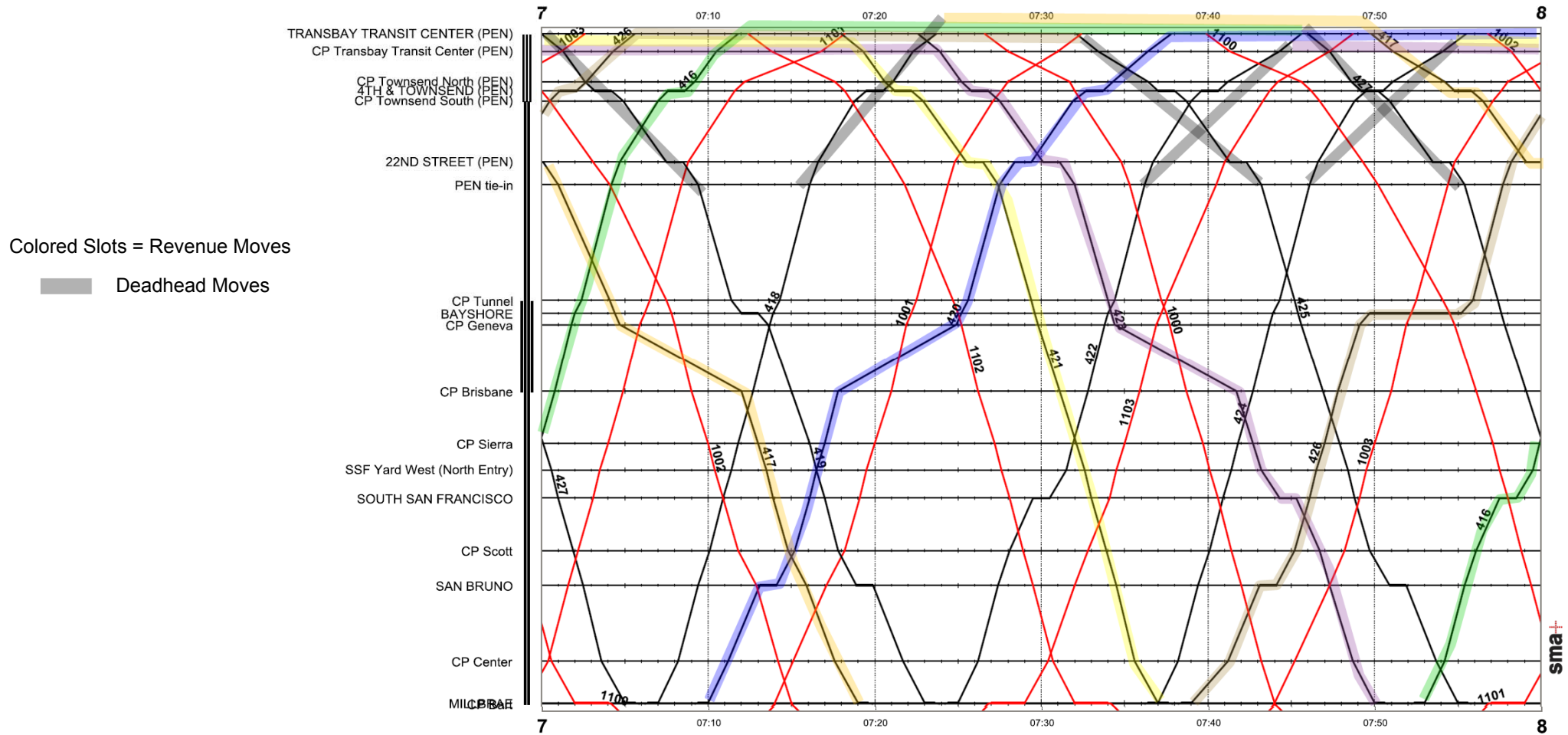


# Peak Operations

Colored Slots = Revenue Moves



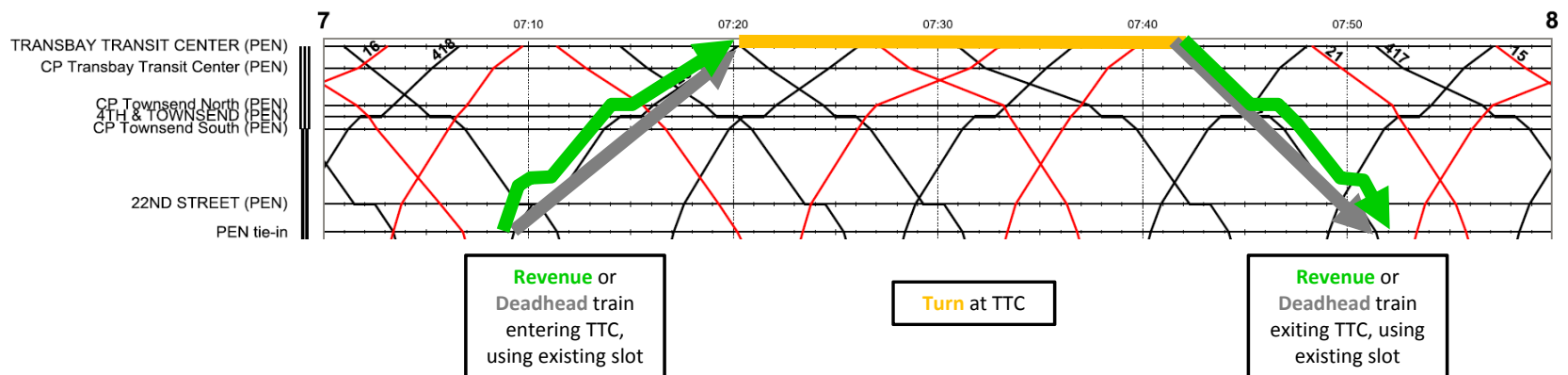
# Off-Peak Operations



# No Trainset Coupling/Splitting

All Caltrain service will use 8-car EMU units, which is the longest consist supported in the Peninsula Corridor. Therefore, EMUs will not be coupled or split from one another.

Given no trainset coupling or splitting, all trains require one slot to enter and one slot to exit the TTC, regardless of whether the train enters or exits as a revenue or deadhead move.

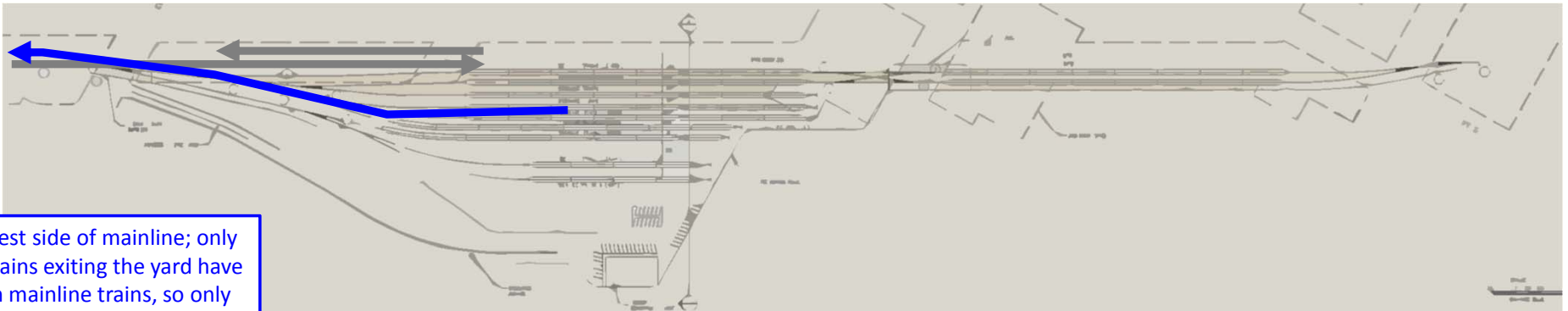


## Slot Assignment

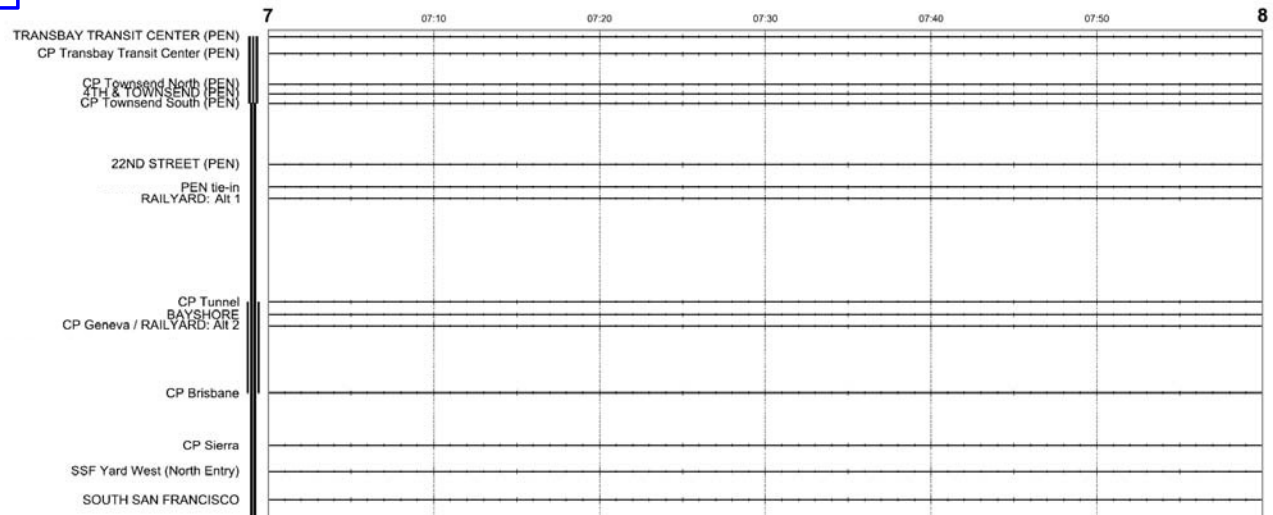
This railyard analysis assigns Caltrain deadhead moves between the TTC and proposed yard locations to existing slots defined in the LTK, NAPT, and Generic service patterns for the Pennsylvania Avenue alignment. Slot conflicts entering/exiting the TTC were mitigated earlier in the conceptual planning process; therefore, the only remaining conflicts to mitigate in the railyard analysis are those occurring as trains enter/exit the mainline at the railyard. 3-minute separation times are maintained between conflicting moves, and 3-minute headways are maintained between trains traveling in the same direction.

Deadhead moves were classified as “unconditional” if they could be integrated into the service pattern (following all planning parameters) without conflicting with another slot and “conditional” if a slot cancellation was necessary.

# Potential Railyard Sites Site 1 Alternative\*

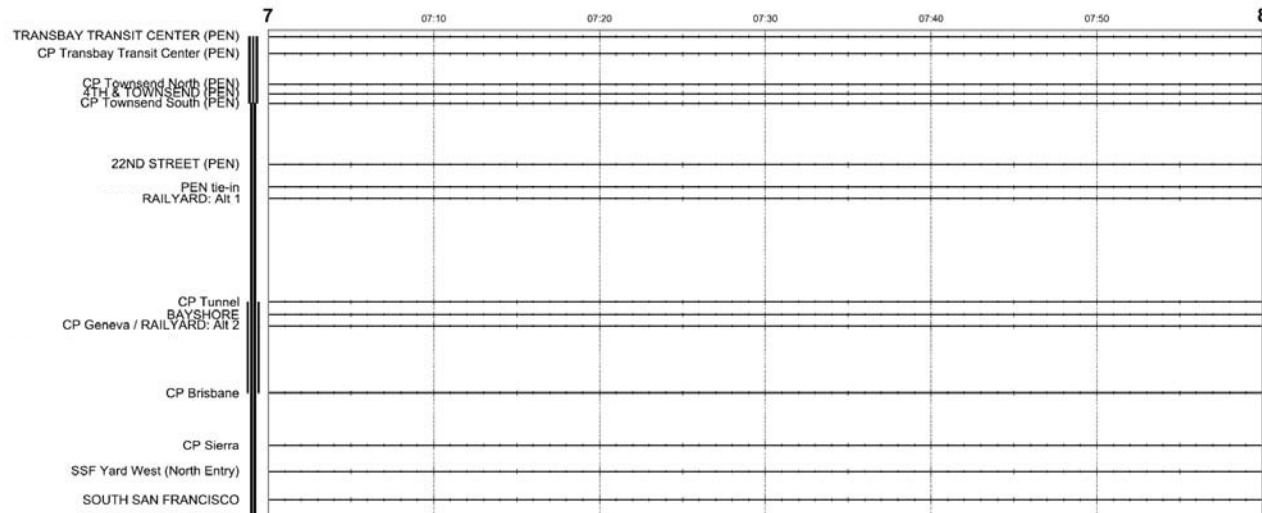
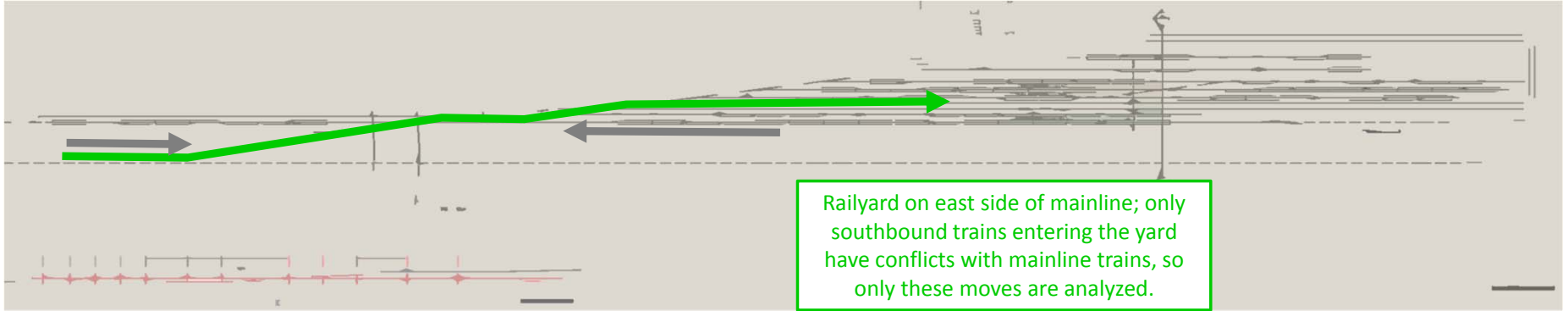


Railyard on west side of mainline; only northbound trains exiting the yard have conflicts with mainline trains, so only these moves are analyzed.



\*The railyard planset only depicts a crossover between the southbound mainline track and the yard; this analysis assumes an additional crossover between the northbound and southbound mainline tracks to allow for all possible moves into and out of the yard.

# Potential Railyard Sites Site 2 Alternative\*



\*The railyard planset only depicts a crossover between the outer northbound mainline track and the yard; this analysis assumes additional crossovers linking all mainline tracks to allow for all possible moves into and out of the yard.



## Findings

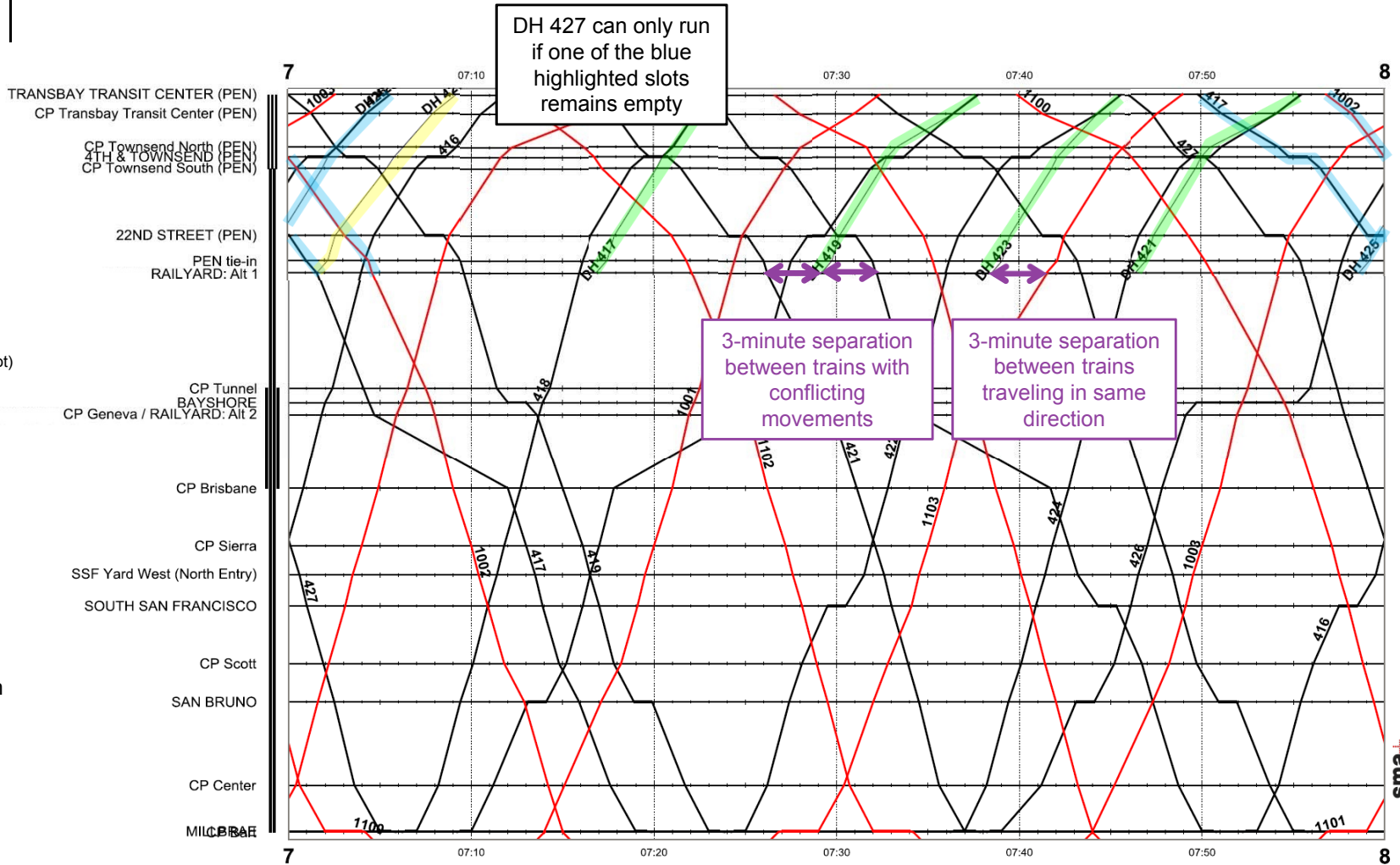
With one exception, all Caltrain deadhead moves to/from the Site 1 and Site 2 railyard sites in the LTK-PEN, NAPT-PEN, and GEN-PEN scenarios were “unconditional”; that is, they could be assigned to an existing slot without conflicting with other existing slots. This finding indicates that there should be no issues transitioning from peak service with all slots being used for revenue moves to off-peak service with only some slots being used for revenue moves.

The only “conditional” deadhead move was TTC-bound DH 427 exiting the Site 1 yard under the NAPT-PEN scenario. In this case, either the slot for Caltrain 417, DH 425, or HSR 1002 would have to remain empty in order to run DH 427 without any conflicts. Alternatively, all slots can be used, but there will be some train delay.

# PEN-NAPT-Site 1

- Caltrain Deadhead Move  
(uses adjacent existing Caltrain slot)
- Existing HSR Slot
- Existing Caltrain Slot

Note: Deadhead moves do not precisely follow the existing slots to which they are assigned since they do not make intermediate station stops and conflict mitigation may have been necessary at the railyard tie-in.



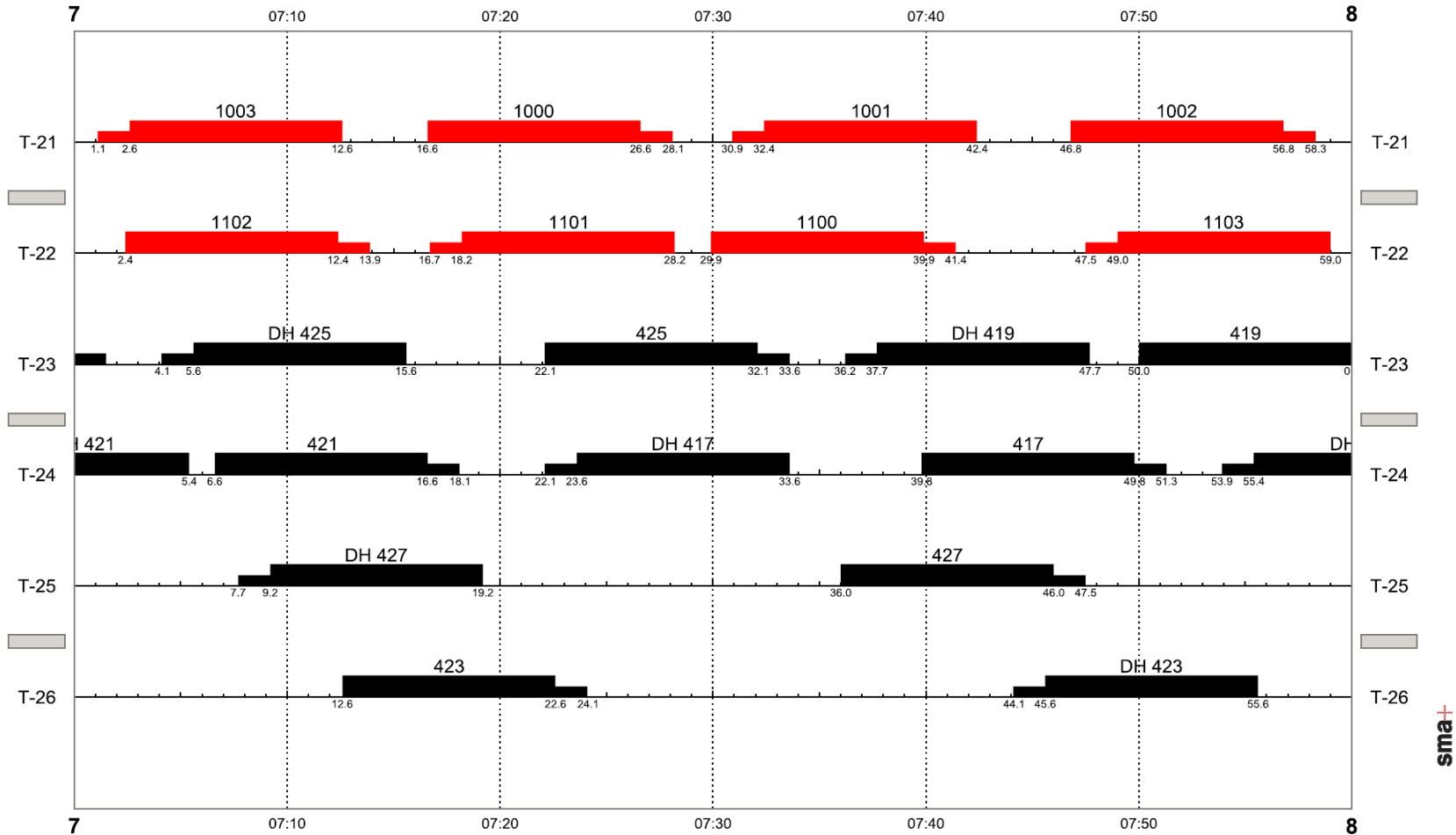
# PEN-NAPT-Site 1

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

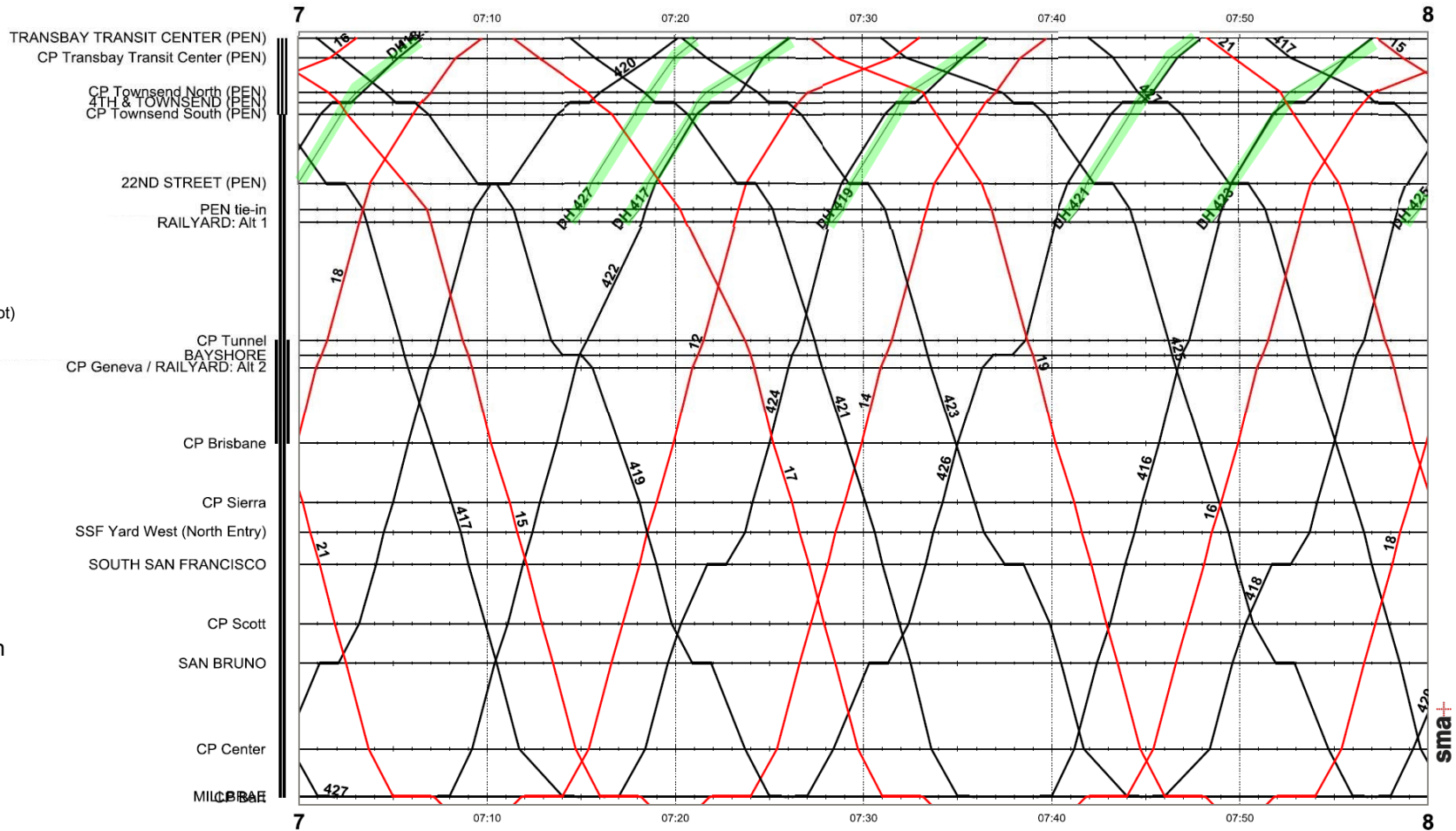
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# PEN-LTK-Site 1

- █ Caltrain Deadhead Move  
(uses adjacent existing Caltrain slot)
- █ Existing HSR Slot
- █ Existing Caltrain Slot

Note: Deadhead moves do not precisely follow the existing slots to which they are assigned since they do not make intermediate station stops and conflict mitigation may have been necessary at the railyard tie-in.



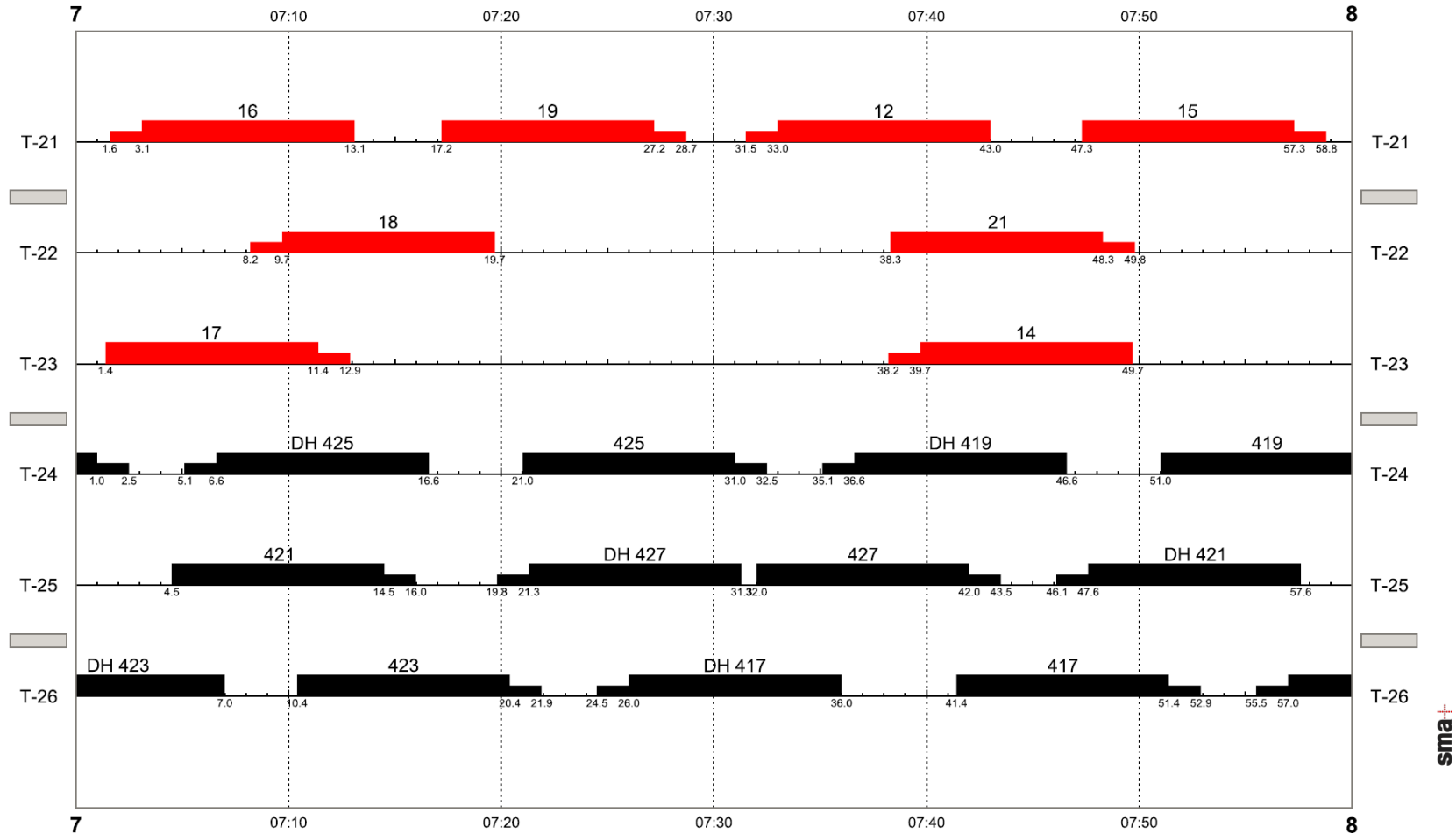
# PEN-LTK-Site 1

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

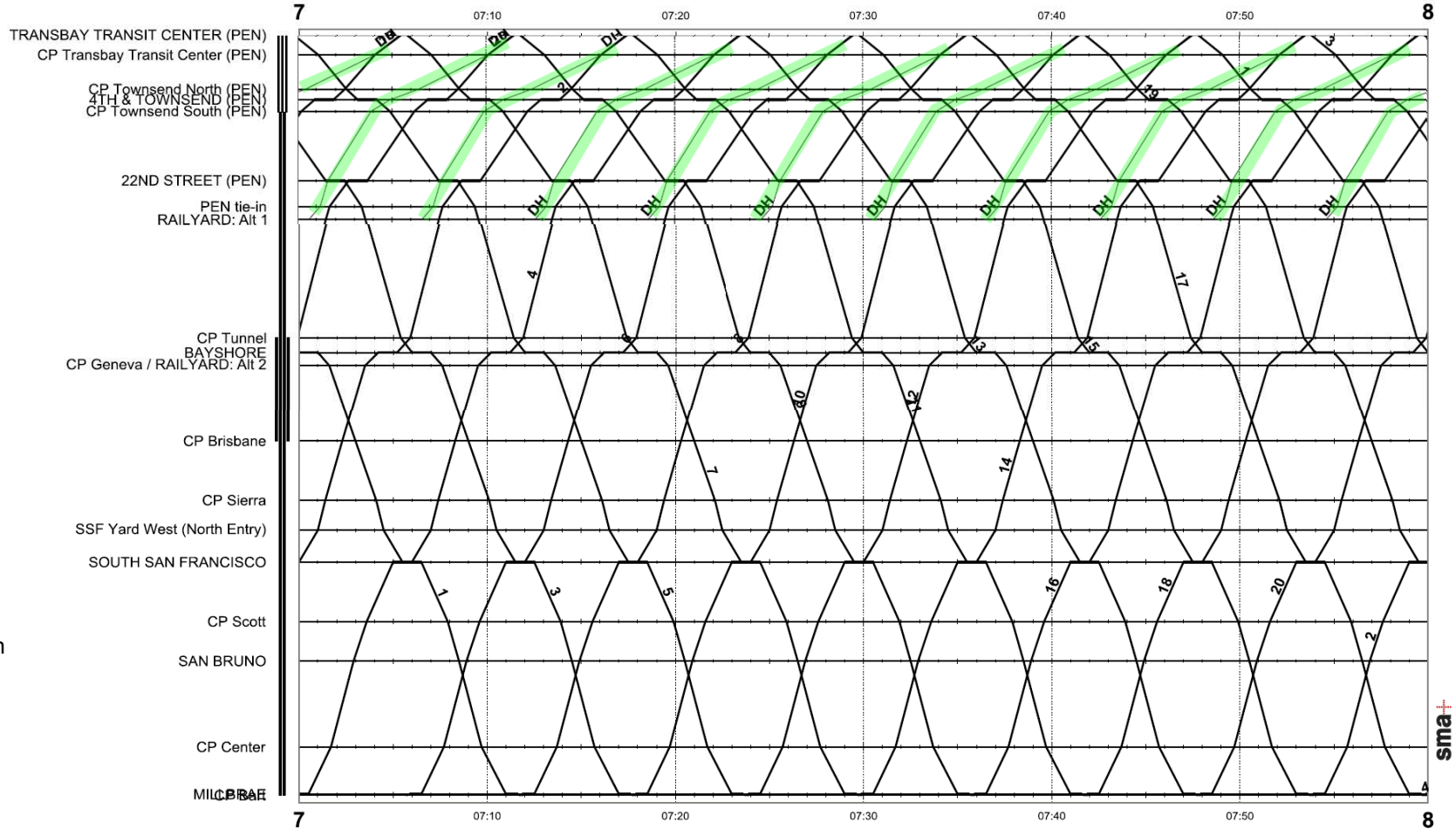
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# PEN-GEN-Site 1

- █ Caltrain Deadhead Move  
(uses adjacent existing slot)
- █ Existing Slot

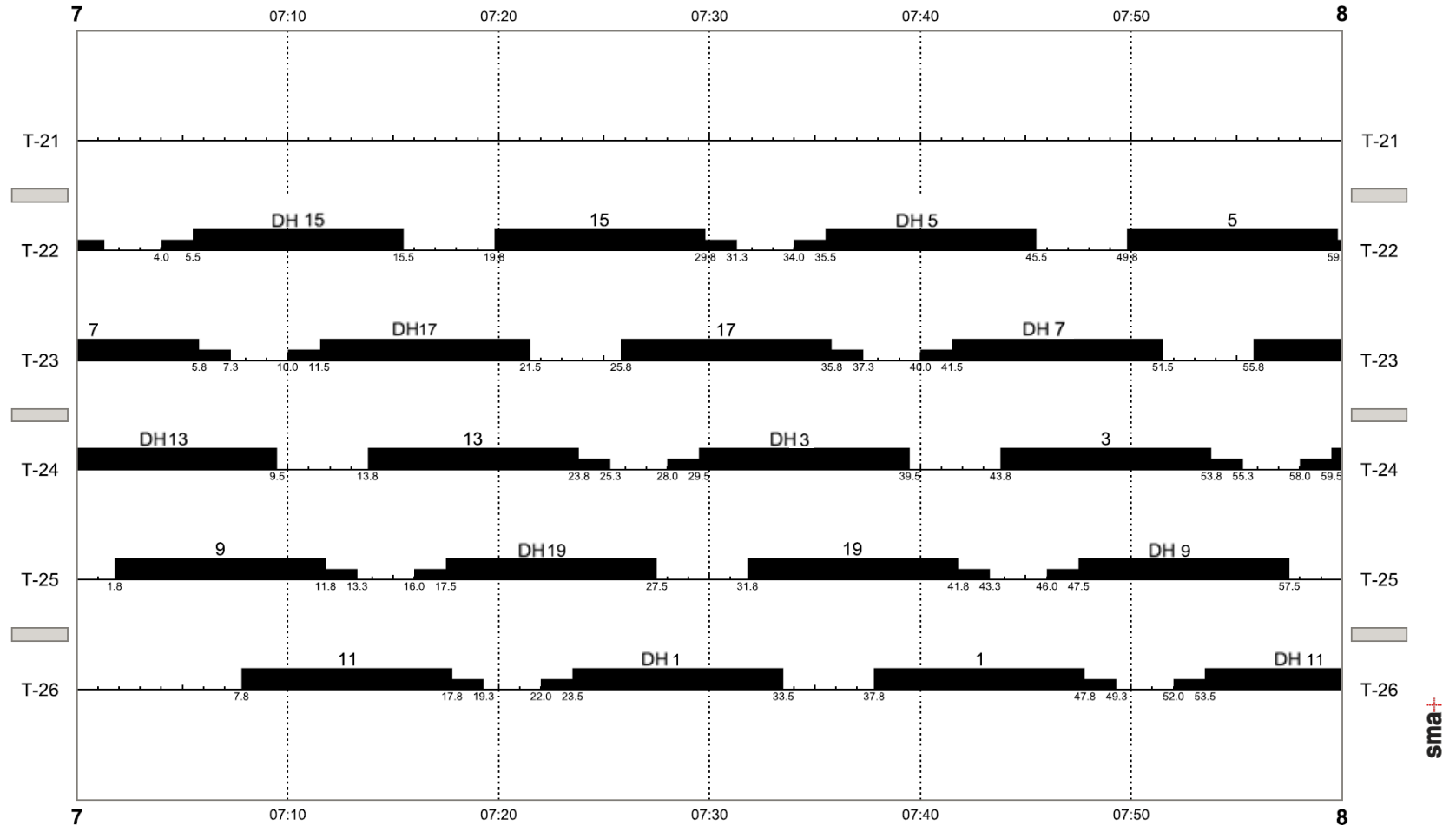
Note: Deadhead moves do not precisely follow the existing slots to which they are assigned since they do not make intermediate station stops and conflict mitigation may have been necessary at the railyard tie-in.



# PEN-GEN-Site 1

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

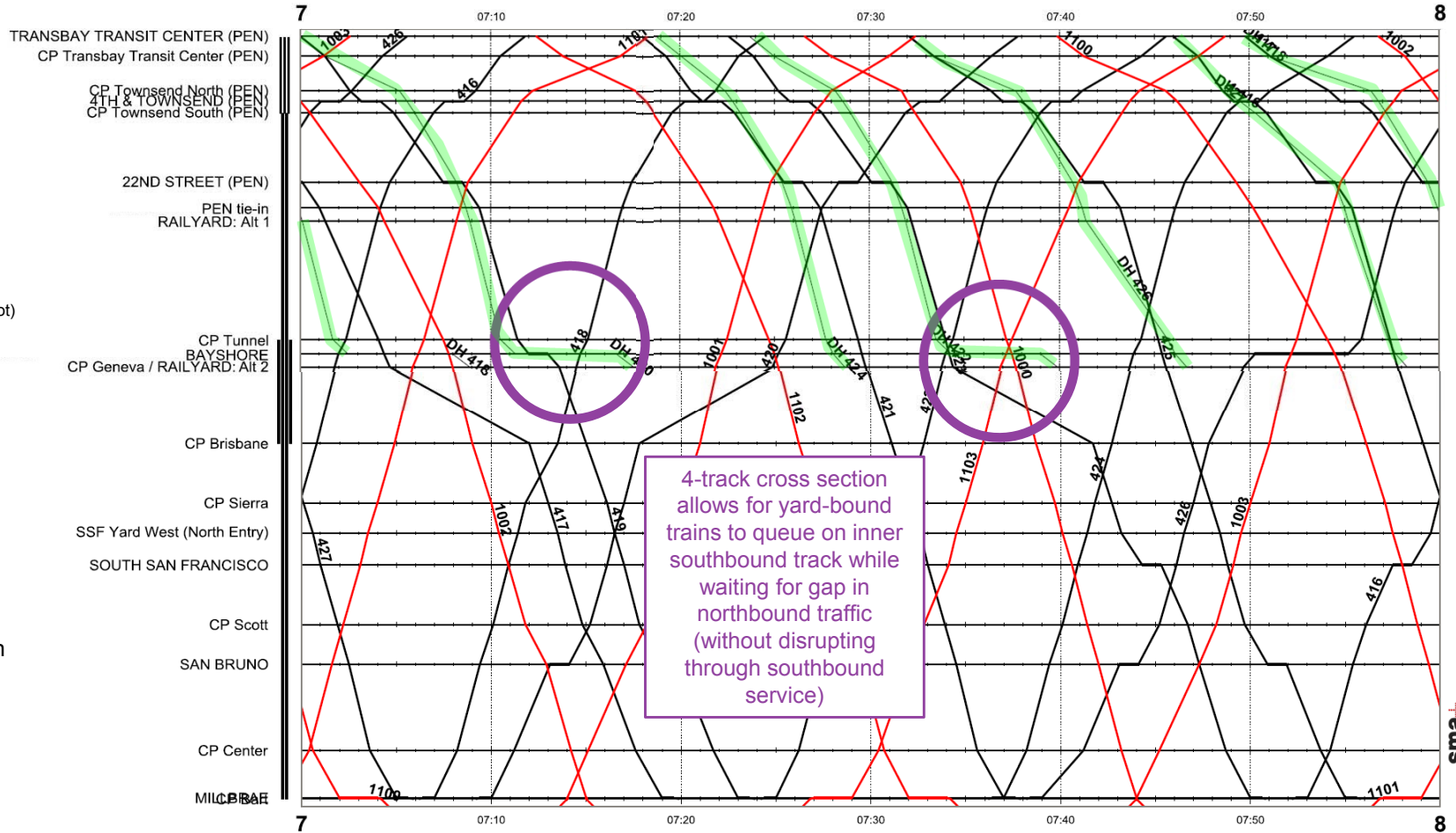
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# PEN-NAPT-Site 2

- Caltrain Deadhead Move  
(uses adjacent existing Caltrain slot)
- Existing HSR Slot
- Existing Caltrain Slot

Note: Deadhead moves do not precisely follow the existing slots to which they are assigned since they do not make intermediate station stops and conflict mitigation may have been necessary at the railyard tie-in.





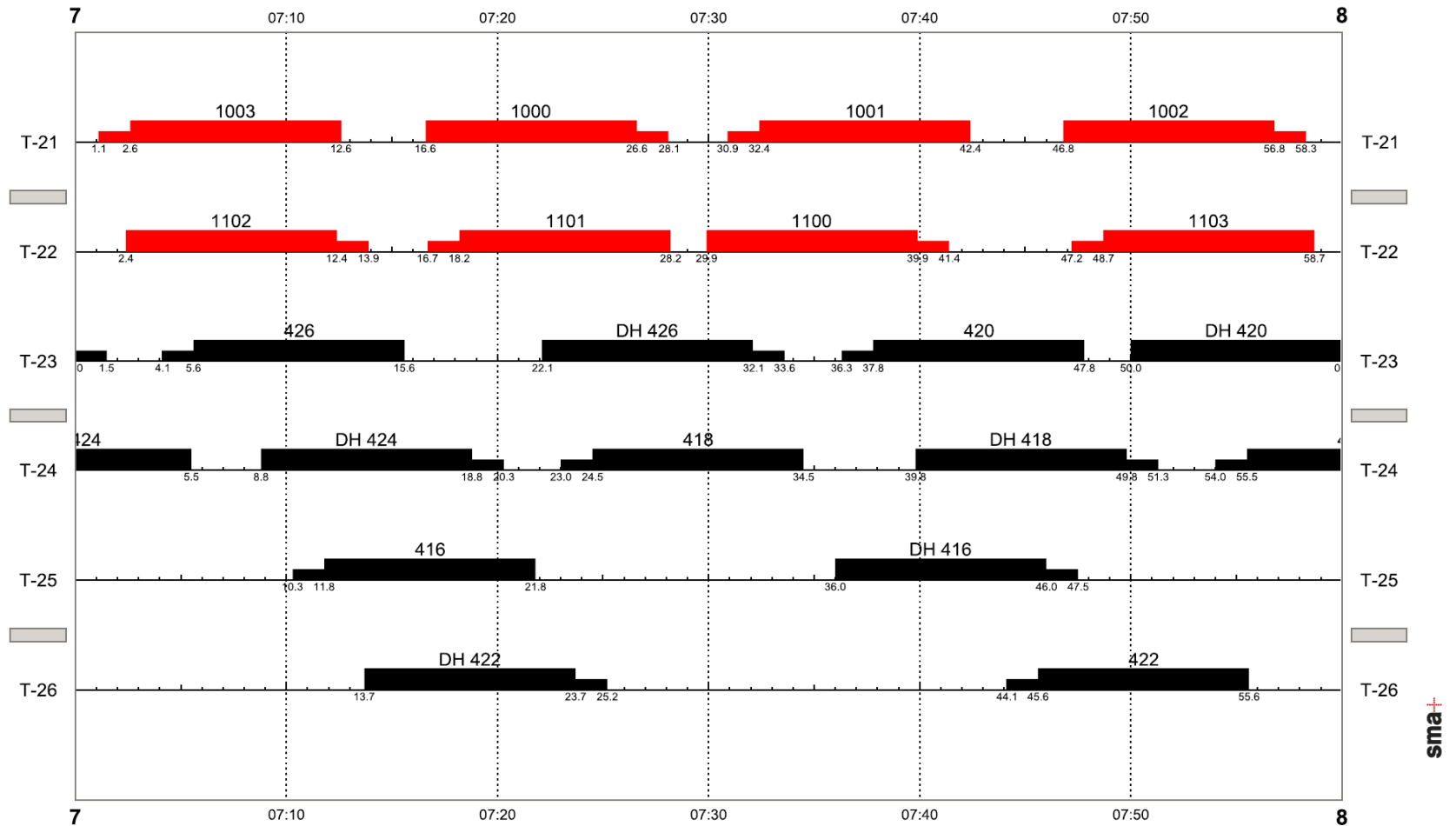
# PEN-NAPT-Site 2

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

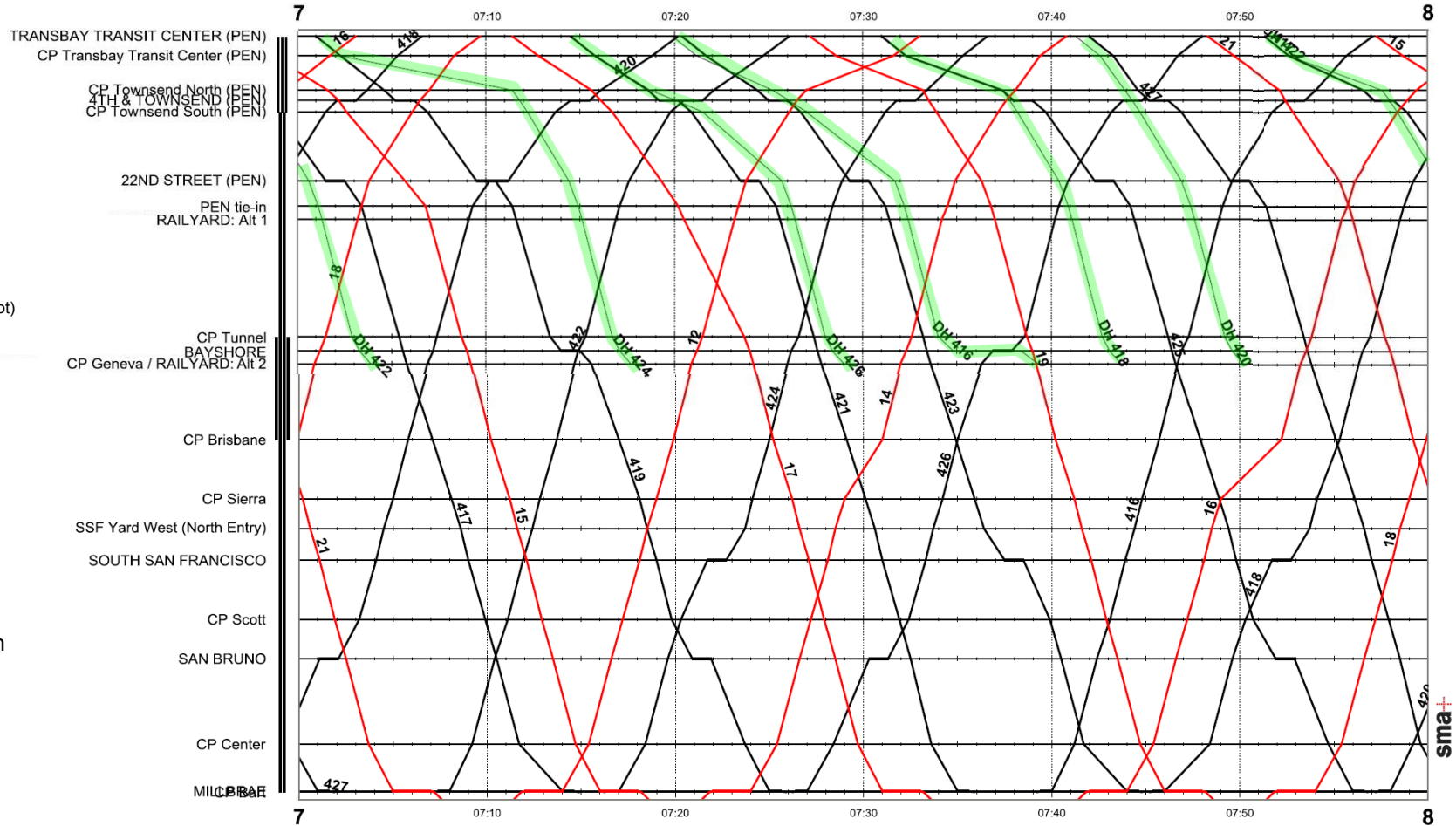
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# PEN-LTK-Site 2

- Caltrain Deadhead Move  
(uses adjacent existing Caltrain slot)
- Existing HSR Slot
- Existing Caltrain Slot

Note: Deadhead moves do not precisely follow the existing slots to which they are assigned since they do not make intermediate station stops and conflict mitigation may have been necessary at the railyard tie-in.



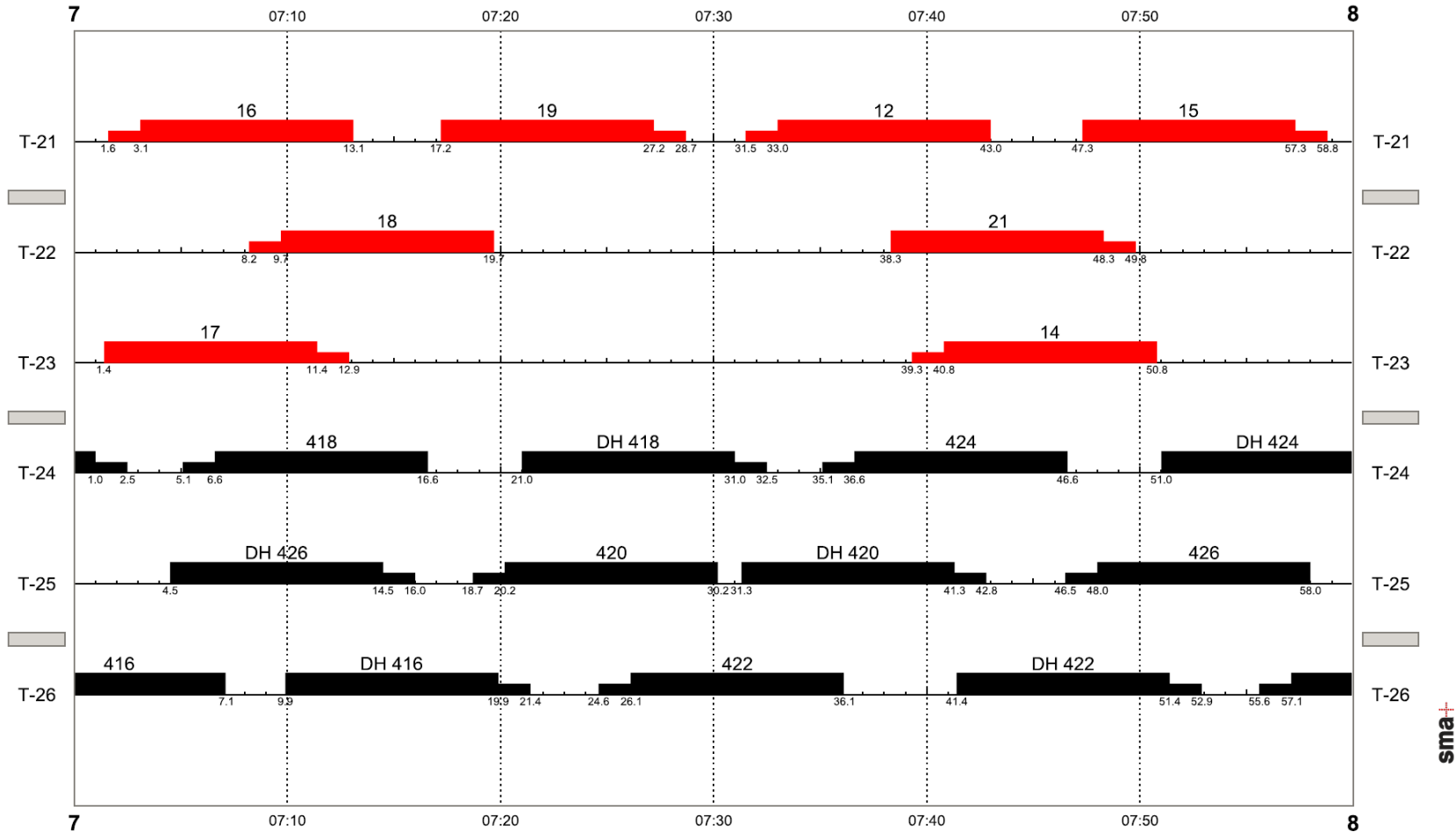
# PEN-LTK-Site 2

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

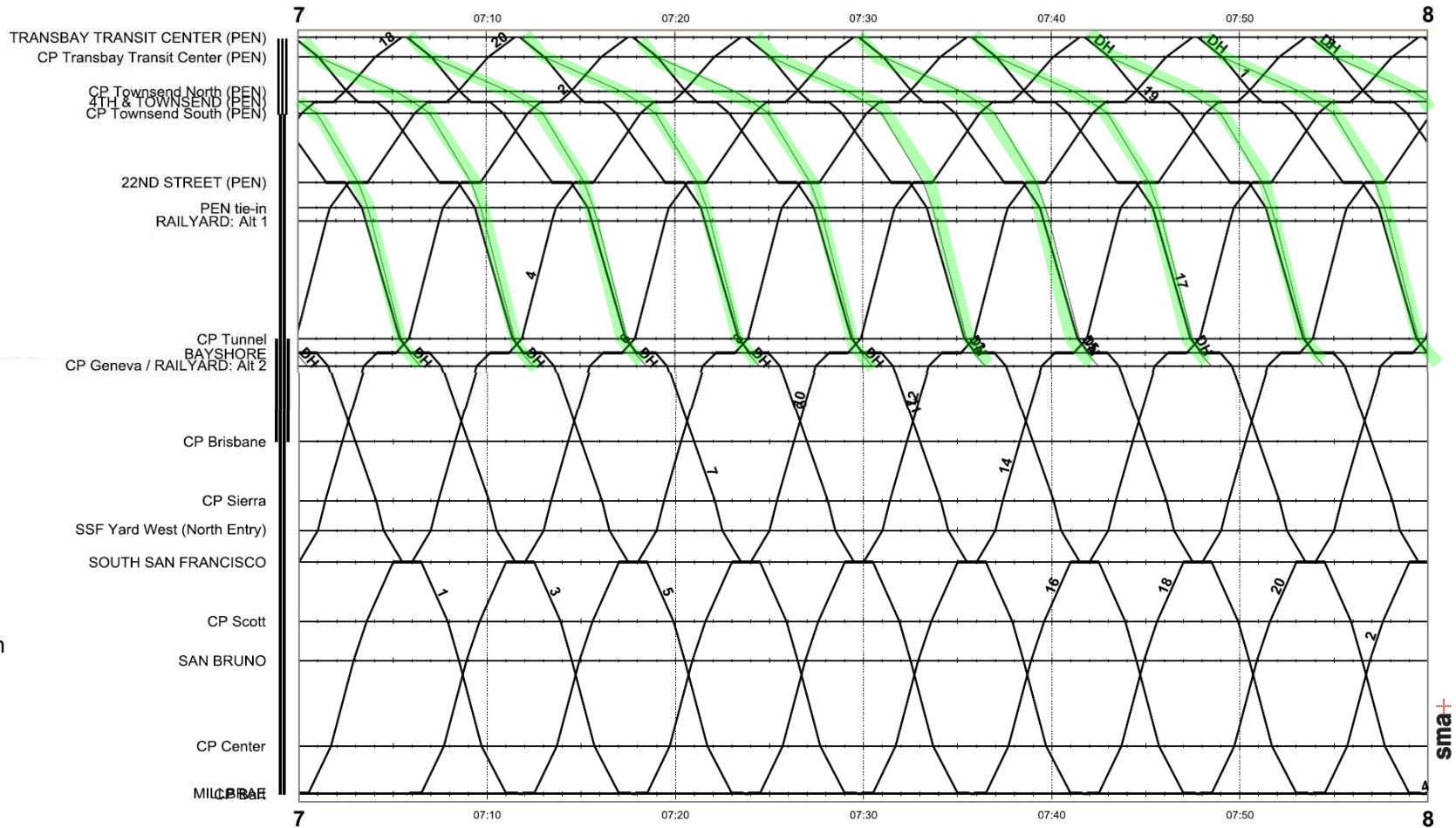
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# PEN-GEN-Site 2

- Caltrain Deadhead Move  
(uses adjacent existing slot)
- Existing Slot

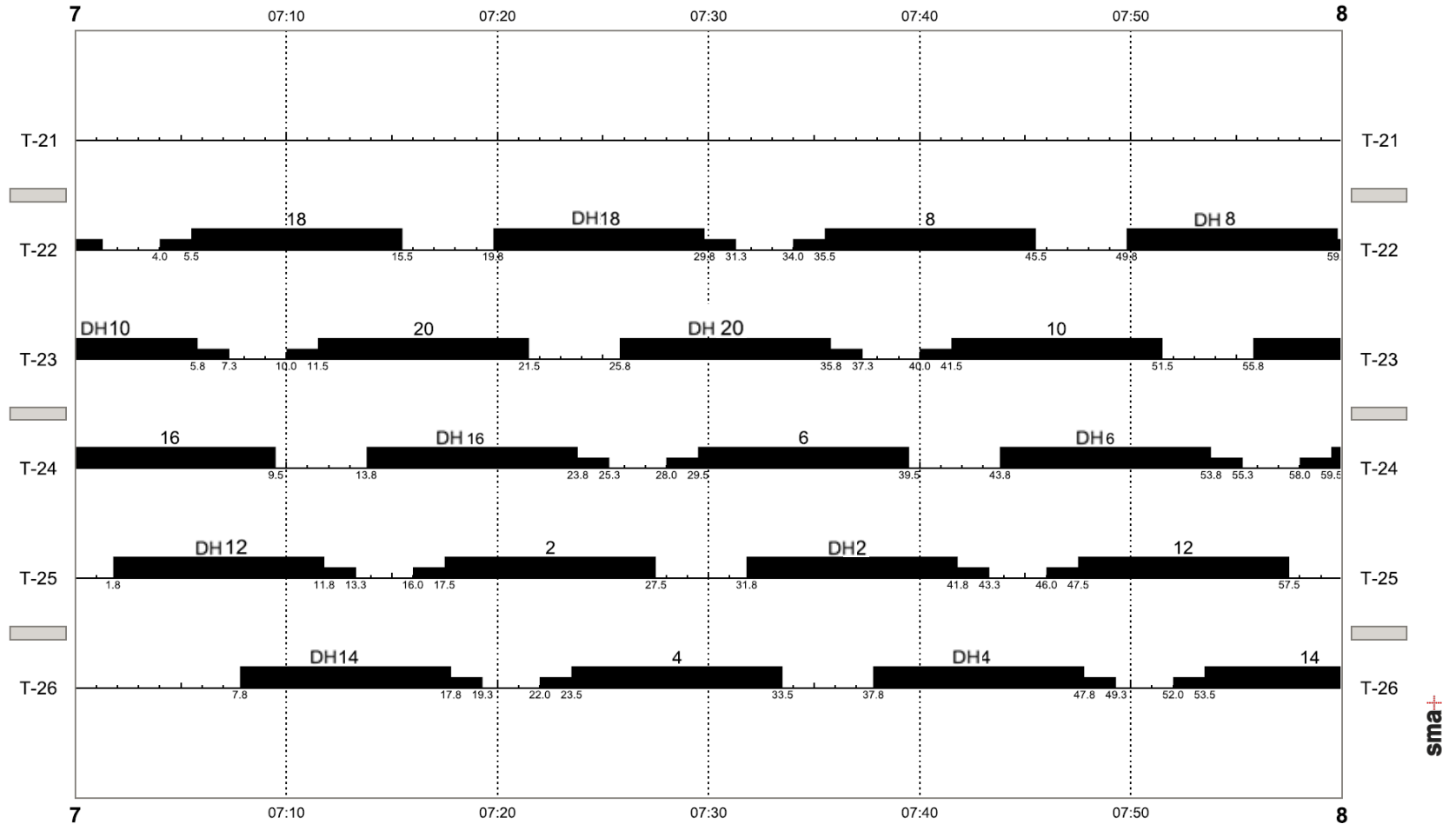
Note: Deadhead moves do not precisely follow the existing slots to which they are assigned since they do not make intermediate station stops and conflict mitigation may have been necessary at the railyard tie-in.



# PEN-GEN-Site 2

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# Railyard Tie-In Configuration Options

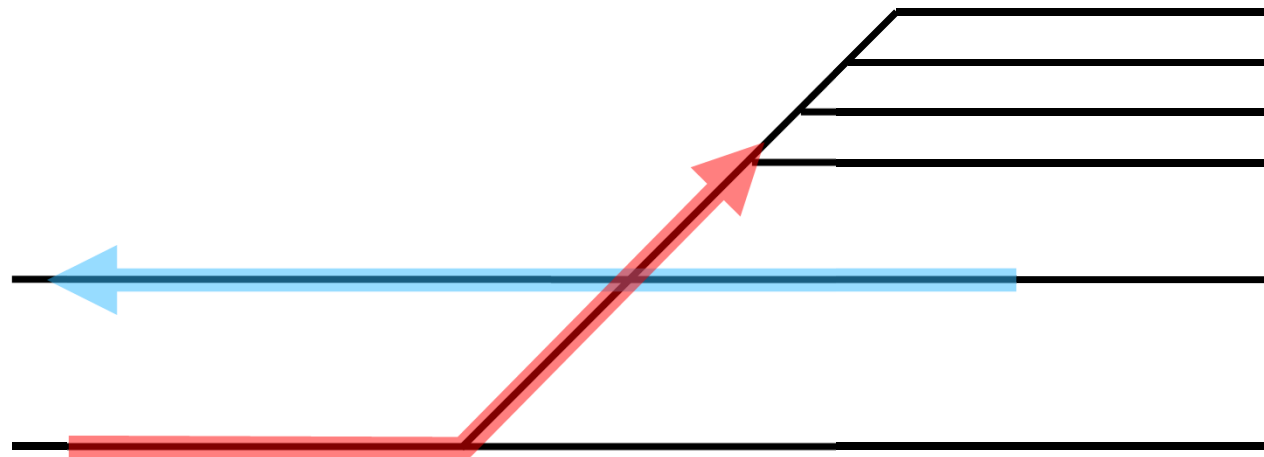
# Crossovers Connecting Mainline with Railyard (Currently Proposed)

## Pros:

- Least expensive configuration and requires the least amount of space

## Cons:

- Creates conflicts between yard-bound trains and through trains
  - In some cases, conflict mitigation may not be possible and one of two conflicting slots must remain empty



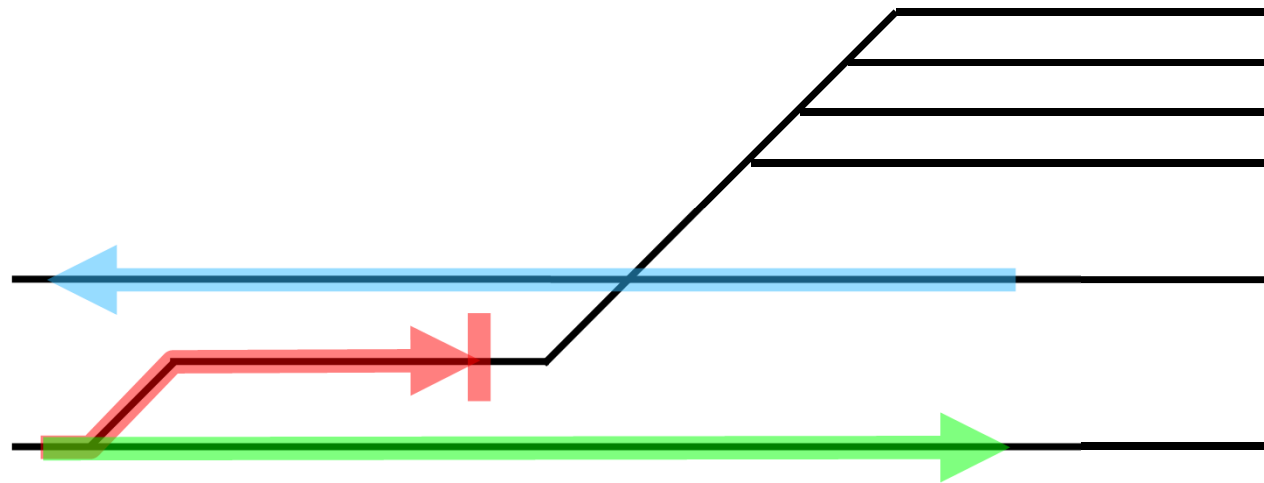
# Crossovers Connecting Mainline with Railyard + Queuing Track

## Pros:

- Conflicts remain between yard-bound trains and through trains, but yard-bound trains can wait for a gap in opposing traffic without disrupting through service

## Cons:

- More expensive and requires more space than configuration without queuing track





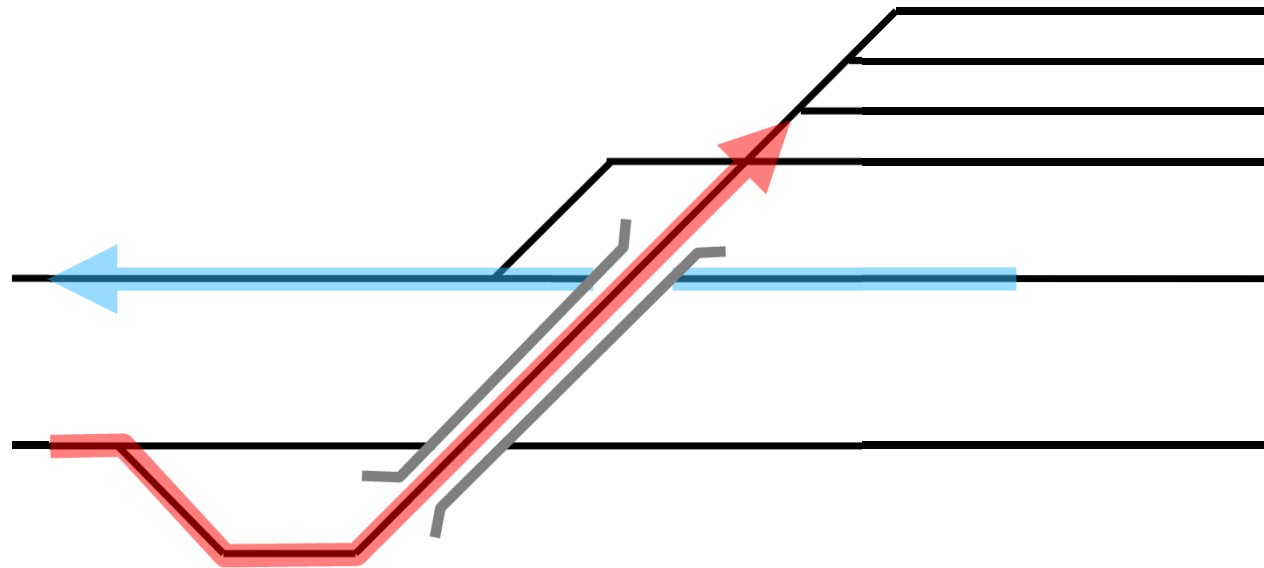
# Flyovers Connecting Mainline with Railyard

## Pros:

- Eliminates conflicts between yard-bound trains and through trains

## Cons:

- Most expensive configuration and requires the most space



# Estimation of Supported Tunnel Headways

Communication Based Overlay Signaling System (CBOSS) and Tunnel Vent Sections

# Introduction

This assessment is based on the understanding of the CBOSS characteristics that were developed as part of the HSR/Caltrain Blended Operations Planning.

Supported headways were analyzed for the Downtown Rail Extension (DTX) alignment only, assuming that the tunnel vent sections and signal blocks on the Pennsylvania Avenue (PEN) and Mission Bay (MBY) alignments will be designed to meet minimum performance criteria needed to support reliable operation.

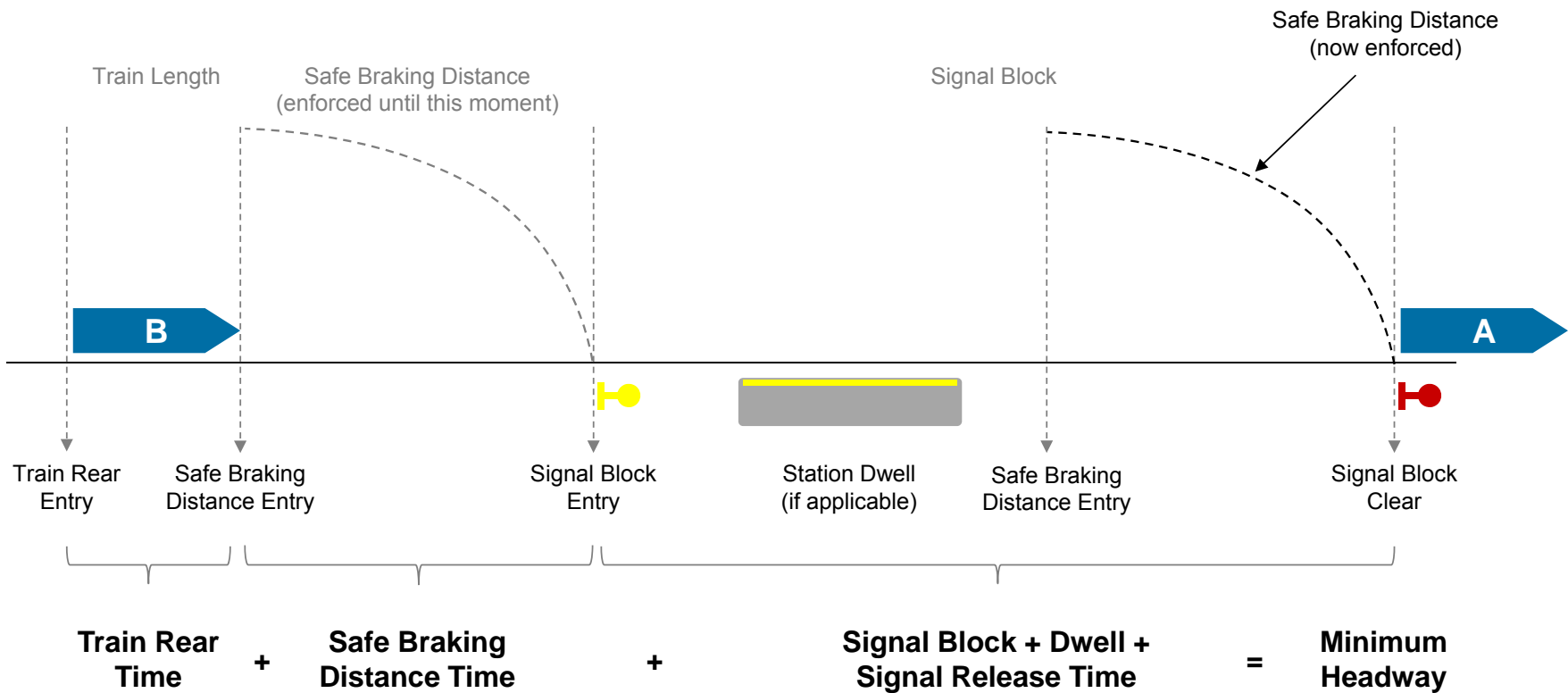
For the DTX alignment, tunnel signal blocks and vent sections have already been defined and therefore act as a constraint on operation. The supported train headways were estimated to validate the headway separation parameter used in conceptual planning (3.0 minutes). Signal blocks coincide with the tunnel vent sections:

- Signal Block 1 / Vent Section 1: CP TTC to CP Townsend North
- Signal Block 2 / Vent Section 2: CP Townsend North to CP Townsend South
- Signal Block 3 / Vent Section 3: CP Townsend South to Intermediate Signal (new)

A new intermediate signal was assumed between the Tunnel Portal and 22<sup>nd</sup> Street station at MP 1.2 (0.4 miles before 22<sup>nd</sup> Street Station) for this analysis.

# Signal Headway Calculation Diagram

This diagram depicts the very moment that train A clears the signal block, causing the signal in front of that block to change from red to a less restrictive indication.



## Steps

- Signal blocks were defined in Viriato using Control Point locations as the assumed signal locations
- Using Viriato train performance calculations, which output train speeds and locations by second, the following were defined:
  - The safe braking distance (SBD) at each signal
  - The second at which the train crosses the SBD threshold
  - The second at which the train enters the signal block
  - The second at which the train clears the signal block
  - The second at which the train is one train length away from the SBD (this is called the “Train Rear Time”)

# Signal Headway Workbook

The Signal Headway Workbook contains the estimated headway at each signal for all Caltrain and HSR stopping patterns.

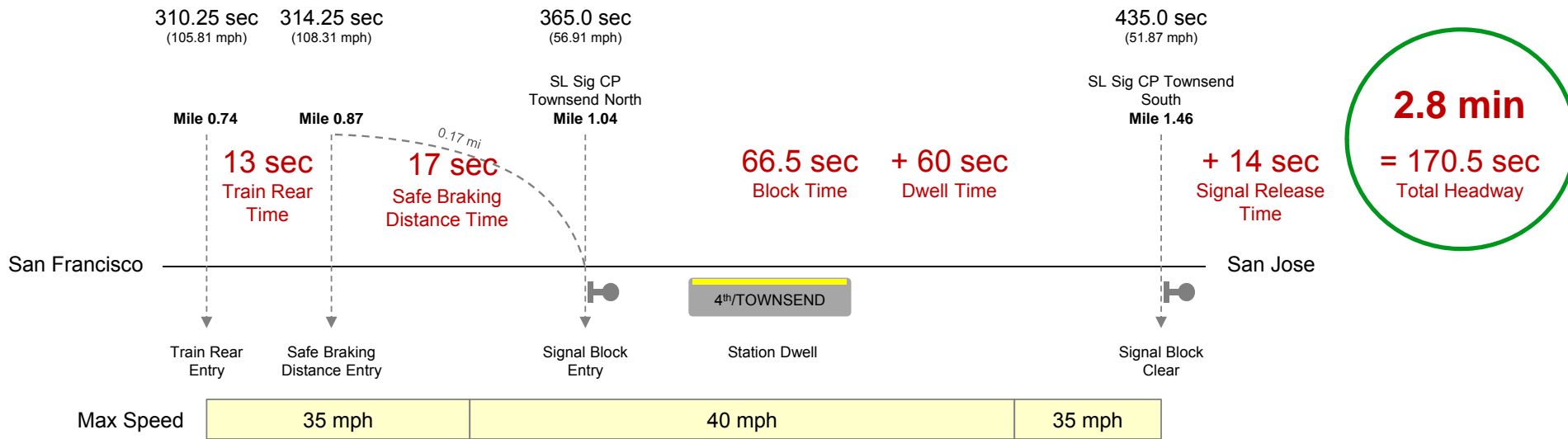
Signal Block Start and End

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Signal Block Start	Mile	Signal Block End	Mile	Station in Signal Block	MP	Distance (ft)	SBD (mi)	Train Lenth (mi)	Train Rear Entry (sec)	Train Rear Time (sec)	SBD Entry Time (sec)	SBD Time (sec)	Block Entry Time (sec)	Block Exit Time (sec)	Block Time (sec)	Signal Block Release Time (sec)	Dwell Time (sec)	Technical Headway (sec)	Technical Headway (min)
2	TTC	0																		
3	SL Sig CP TTC	0.38	SL Sig CP Townsend North	1.04			3484.8	0	0.125	40	21	61	0	61	135	74.00	14.00	60	109.00	1.8
4	SL Sig CP Townsend North	1.04	SL Sig CP Townsend South	1.46	4th/TOWNSEND	1.24	2217.6	0.17	0.125	105	13	118	17	135	201.5	66.50	14.00	60	170.50	2.8
5	SL Sig CP Townsend South	1.46	Int Sig Tunnel Portal (DTX tie-in)	2.20			3907.2	0.17	0.125	148	20.25	168.25	33.25	201.5	282.5	81.00	14.00		148.50	2.5

Headway

# Signal Headway Calculation Detailed

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	
1	Signal Block Start	Mile	Signal Block End	Mile	Station in Signal Block	MP	Distance (ft)	SBD (mi)	Train Lenth (mi)	Train Rear Entry (sec)	Train Rear Time (sec)	SBD Entry Time (sec)	SBD Time (sec)	Block Entry Time (sec)	Block Exit Time (sec)	Block Time (sec)	Signal Block Release Time (sec)	Dwell Time (sec)	Technical Headway (sec)	Technical Headway (min)	
2	TTC	0																			
3	SL Sig CP TTC	0.56	SL Sig CP Townsend North	1.04			3464.6	0.17	0.185	40	21	91	0	91	135	74.00	14.00		108.00	1.8	
4	SL Sig CP Townsend North	1.04	SL Sig CP Townsend South	1.46	4th/TOWNSEND	1.24	2217.6	0.17	0.125	105	13	118	17	135	201.5	66.50	14.00	60	170.50	2.8	
5	SL Sig CP Townsend South	1.46	Int Sig Tunnel Portal (QTX tie-in)	2.20			3907.2	0.17	0.125	148	20.25	168.25	33.25	201.5	282.5	81.00	14.00		148.50	2.5	

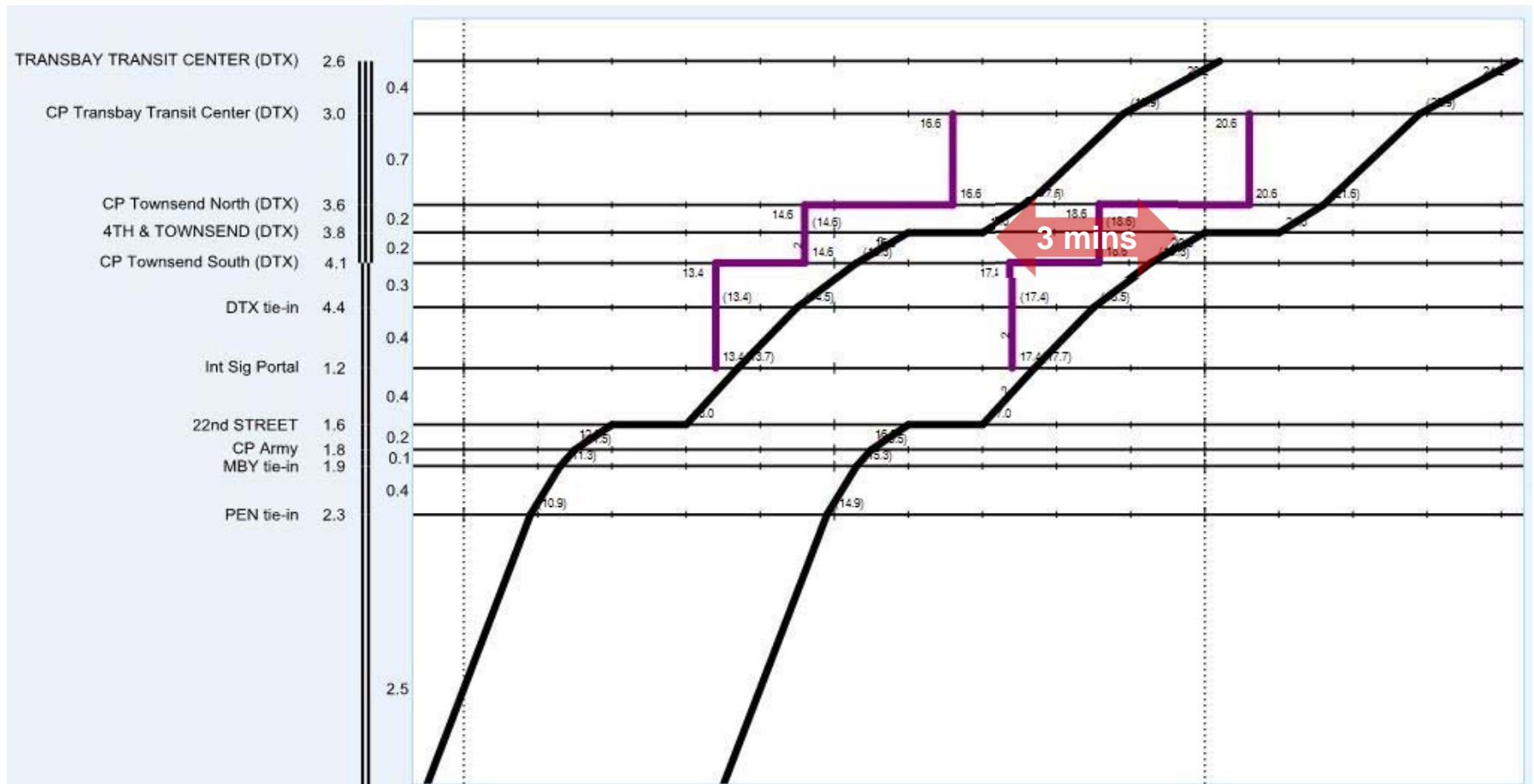


Headway Combinations  
Northbound and Southbound



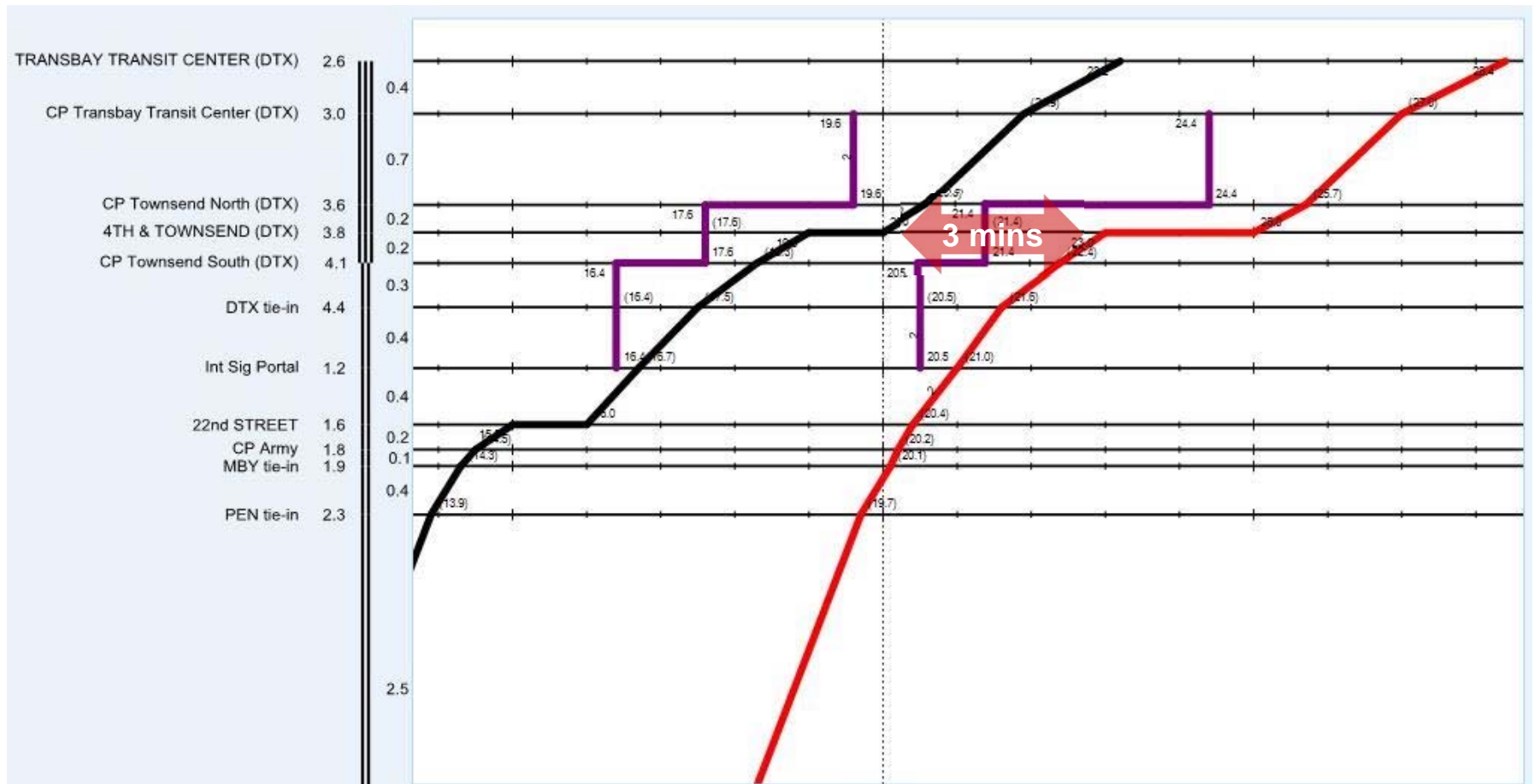
# Northbound Headway: Caltrain-Caltrain

■ Headway Limits     
 — Caltrain     
 — HSR     
 ↔ 3 mins Headway Planning Parameter

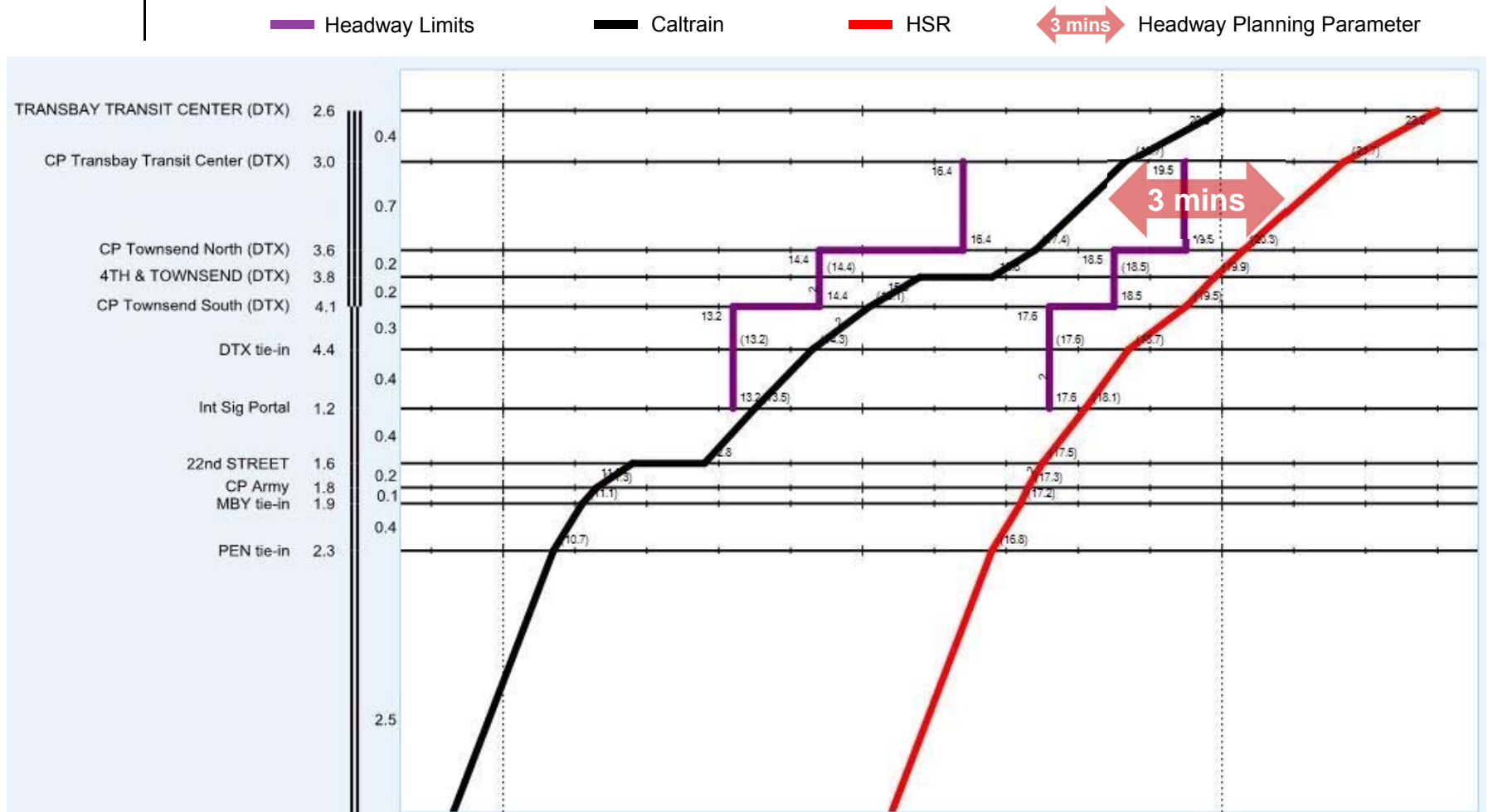


# Northbound Headway: Caltrain-HSR(1-stop)

■ Headway Limits     
 — Caltrain     
 — HSR     
 ↔ 3 mins Headway Planning Parameter

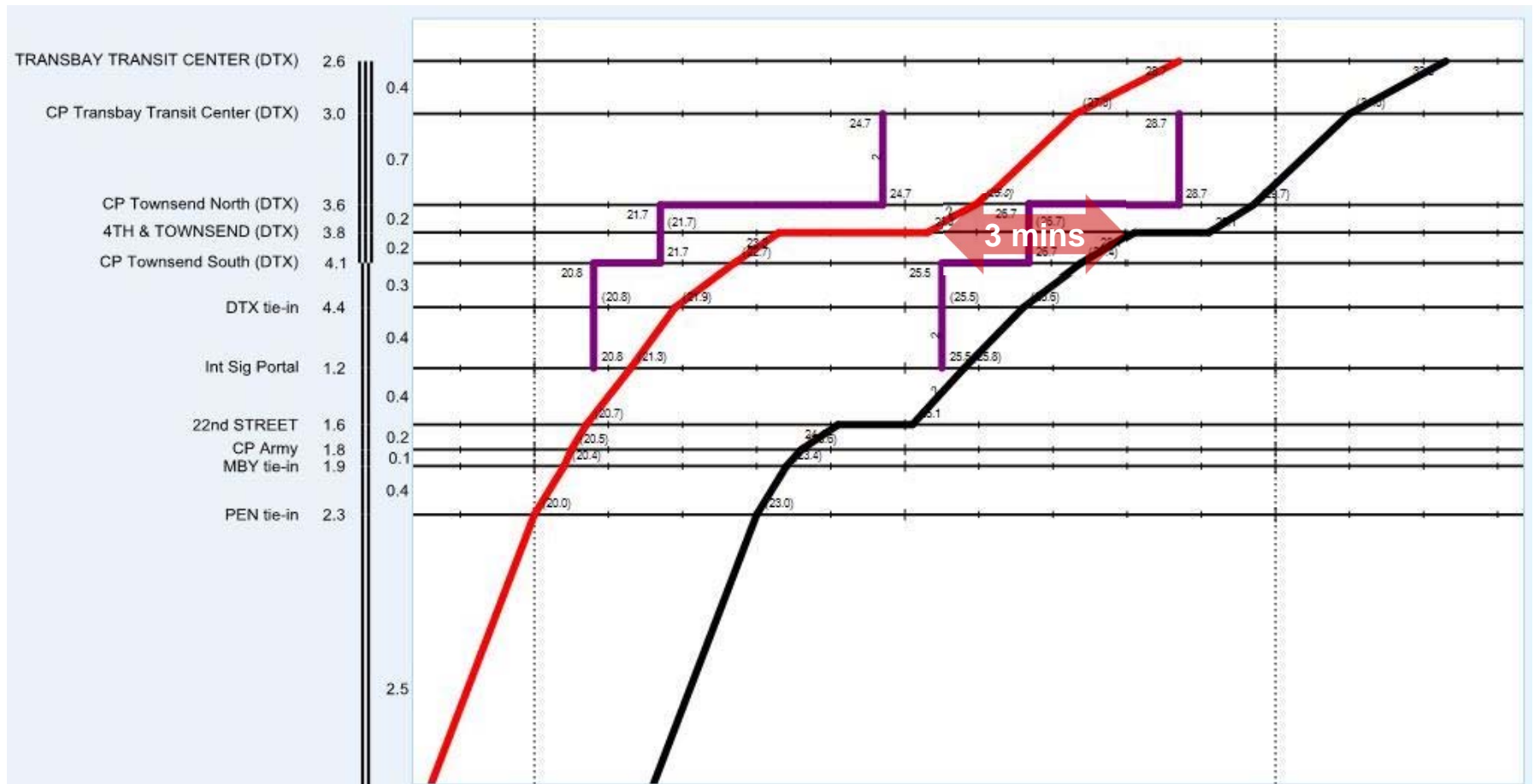


# Northbound Headway: Caltrain-HSR

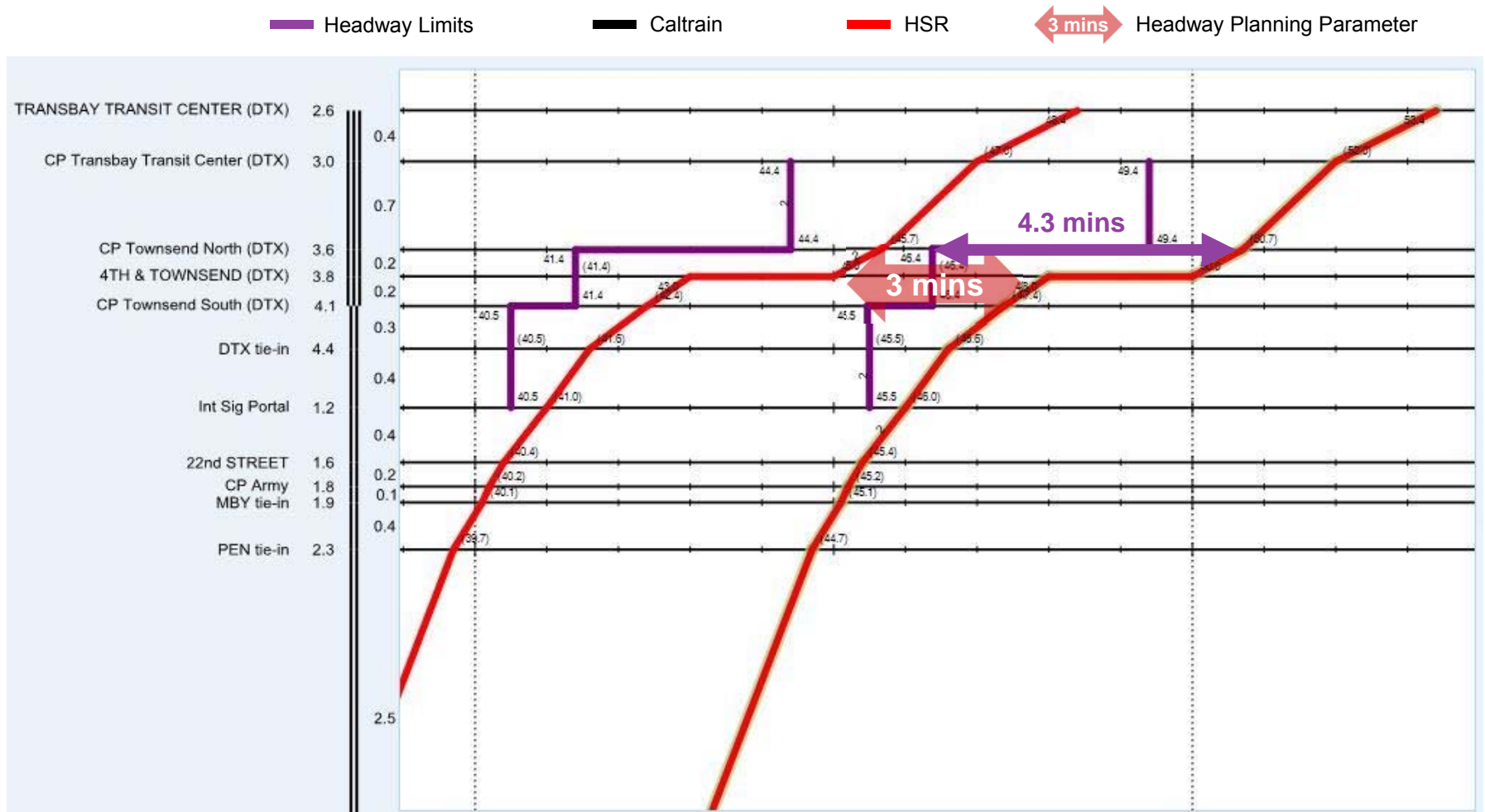


# Northbound Headway: HSR(1-stop)-Caltrain

■ Headway Limits     
 — Caltrain     
 — HSR     
 ↔ 3 mins Headway Planning Parameter



# Northbound Headway: HSR(1-stop)-HSR(1-stop)



# Northbound Headway: HSR(1-stop)-HSR

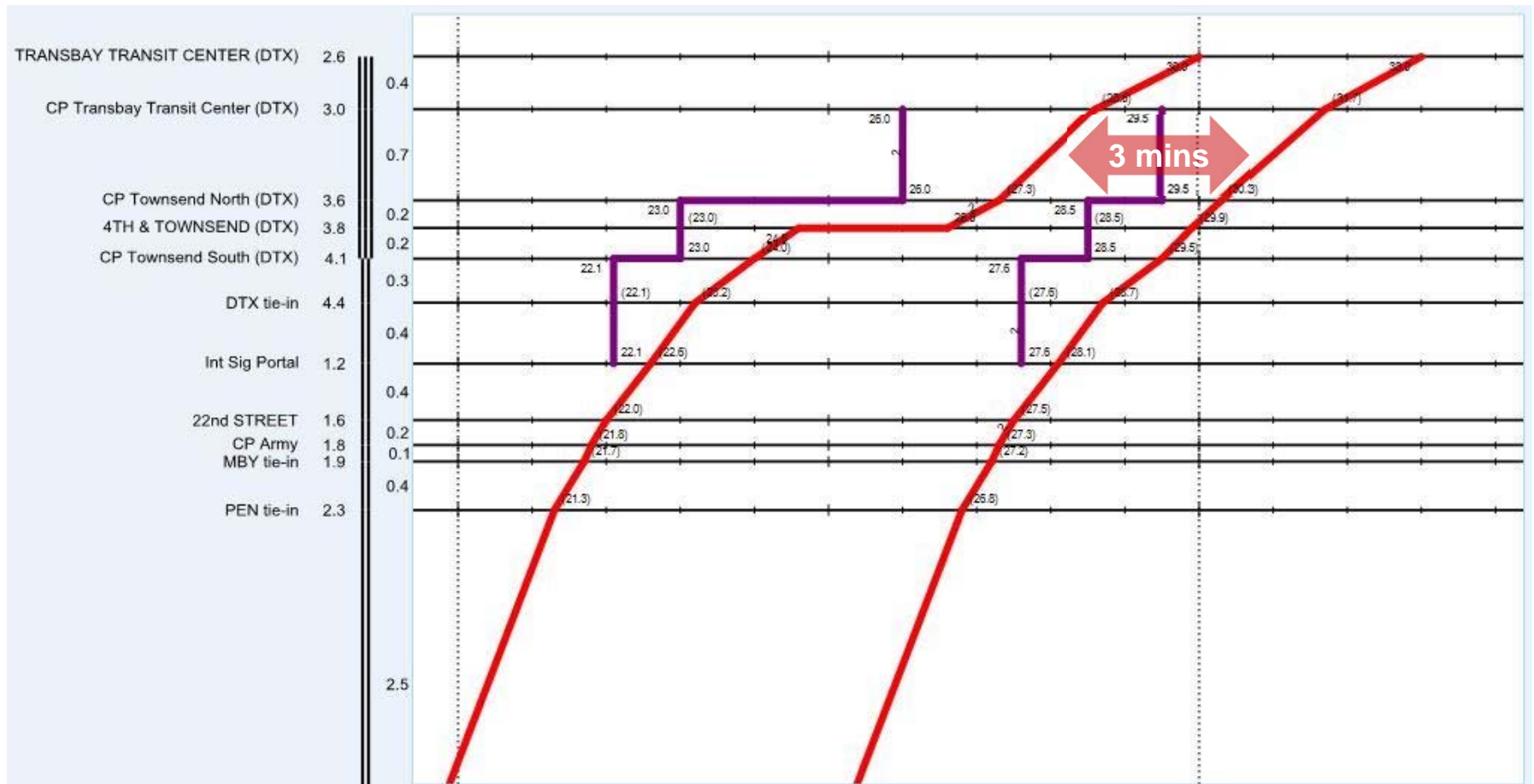
Headway Limits

Caltrain

HSR

3 mins

Headway Planning Parameter



# Northbound Headway: HSR-HSR

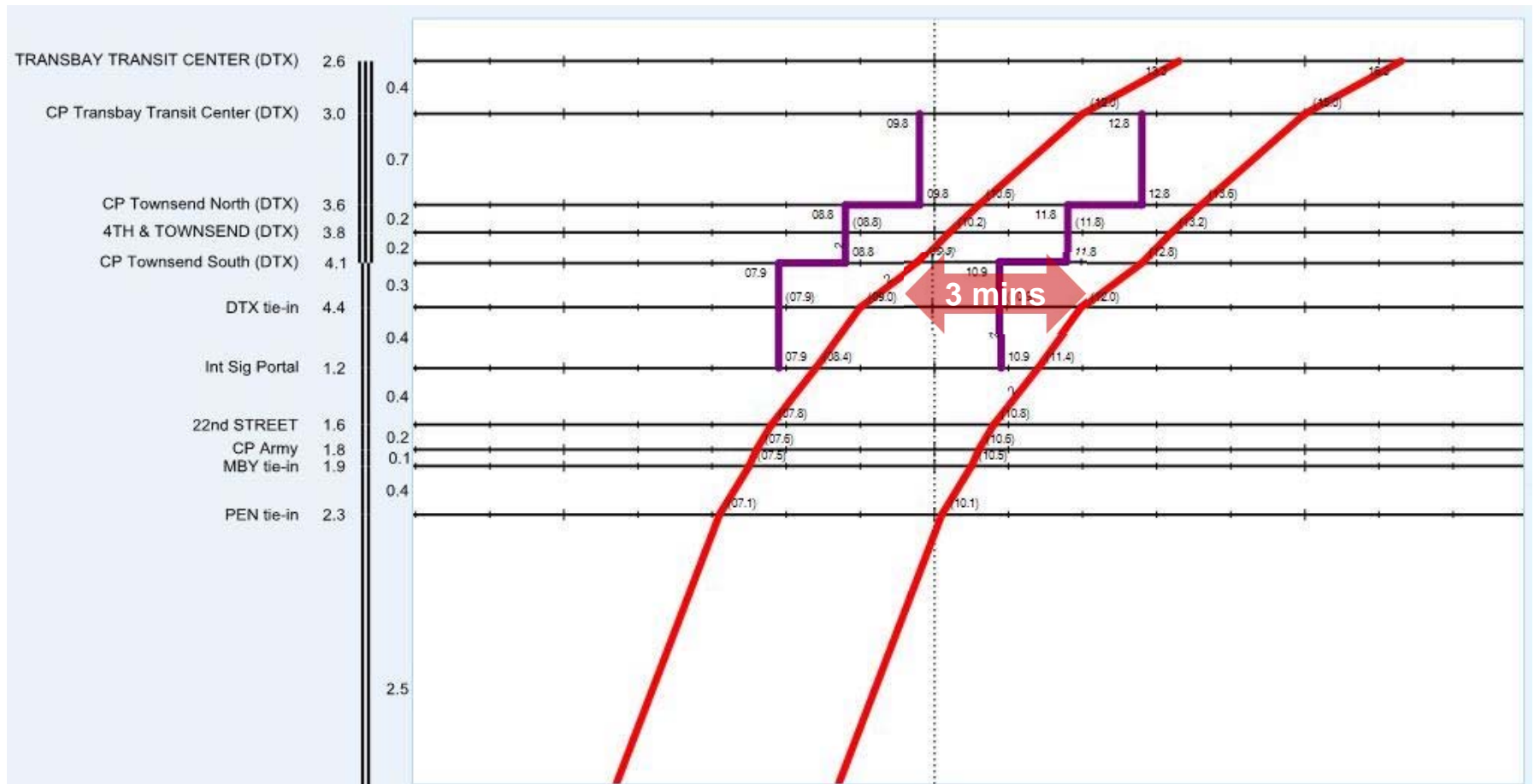
Headway Limits

Caltrain

HSR

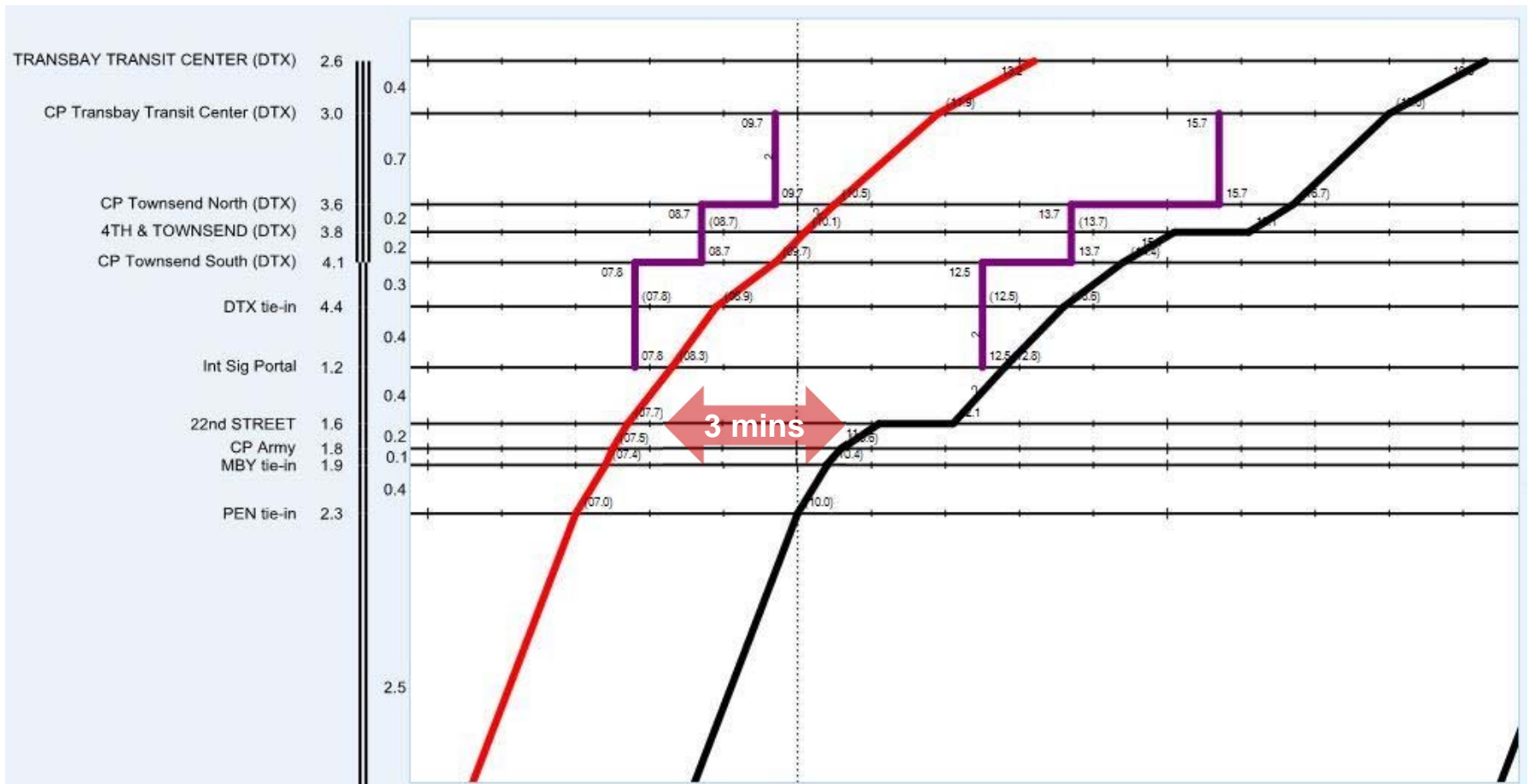
3 mins

Headway Planning Parameter



# Northbound Headway: HSR-Caltrain

■ Headway Limits     
 — Caltrain     
 — HSR     
 ↔ 3 mins Headway Planning Parameter

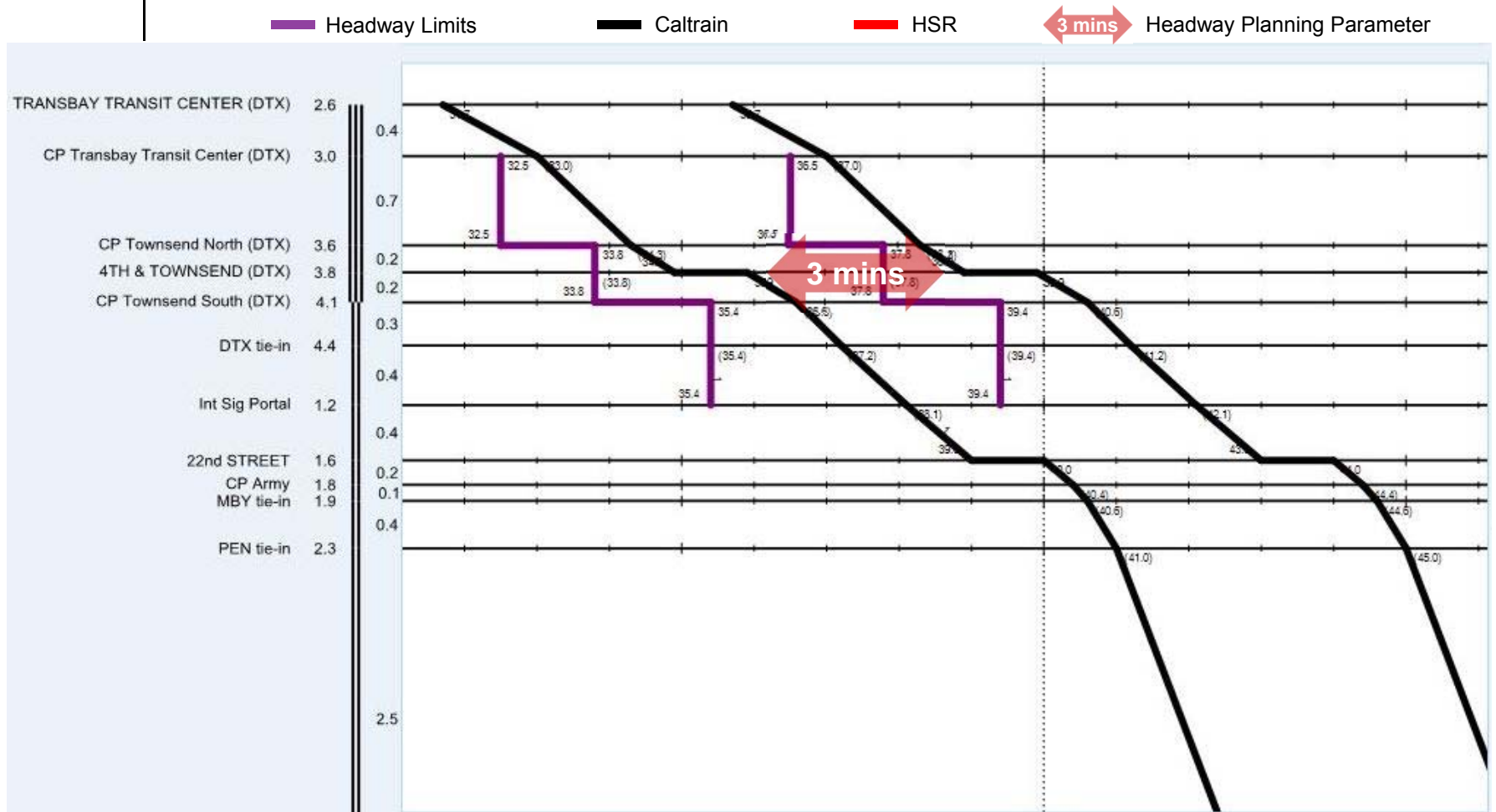




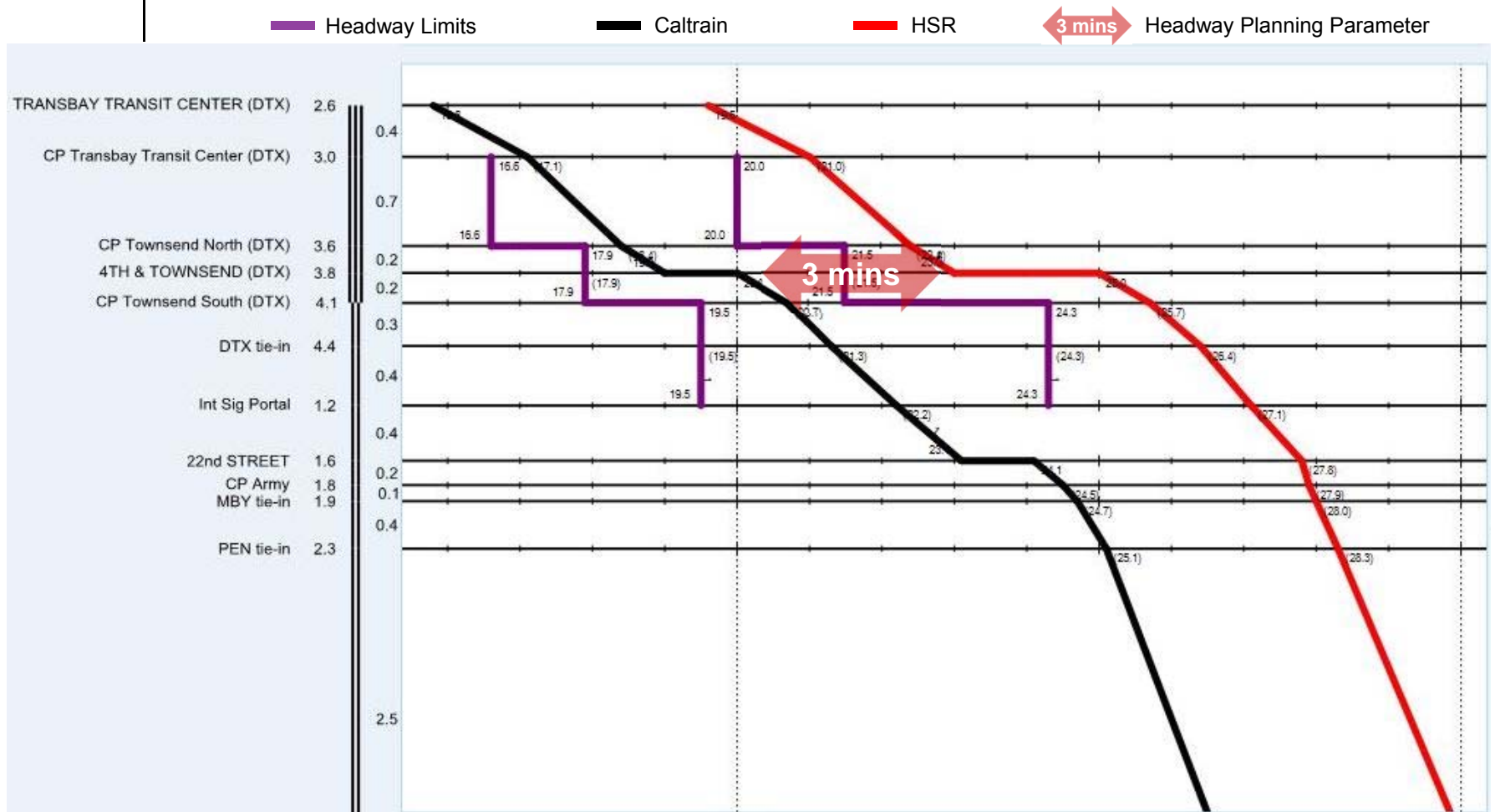
# Northbound Headway: HSR-HSR(1-stop)



# Southbound Headway: Caltrain-Caltrain



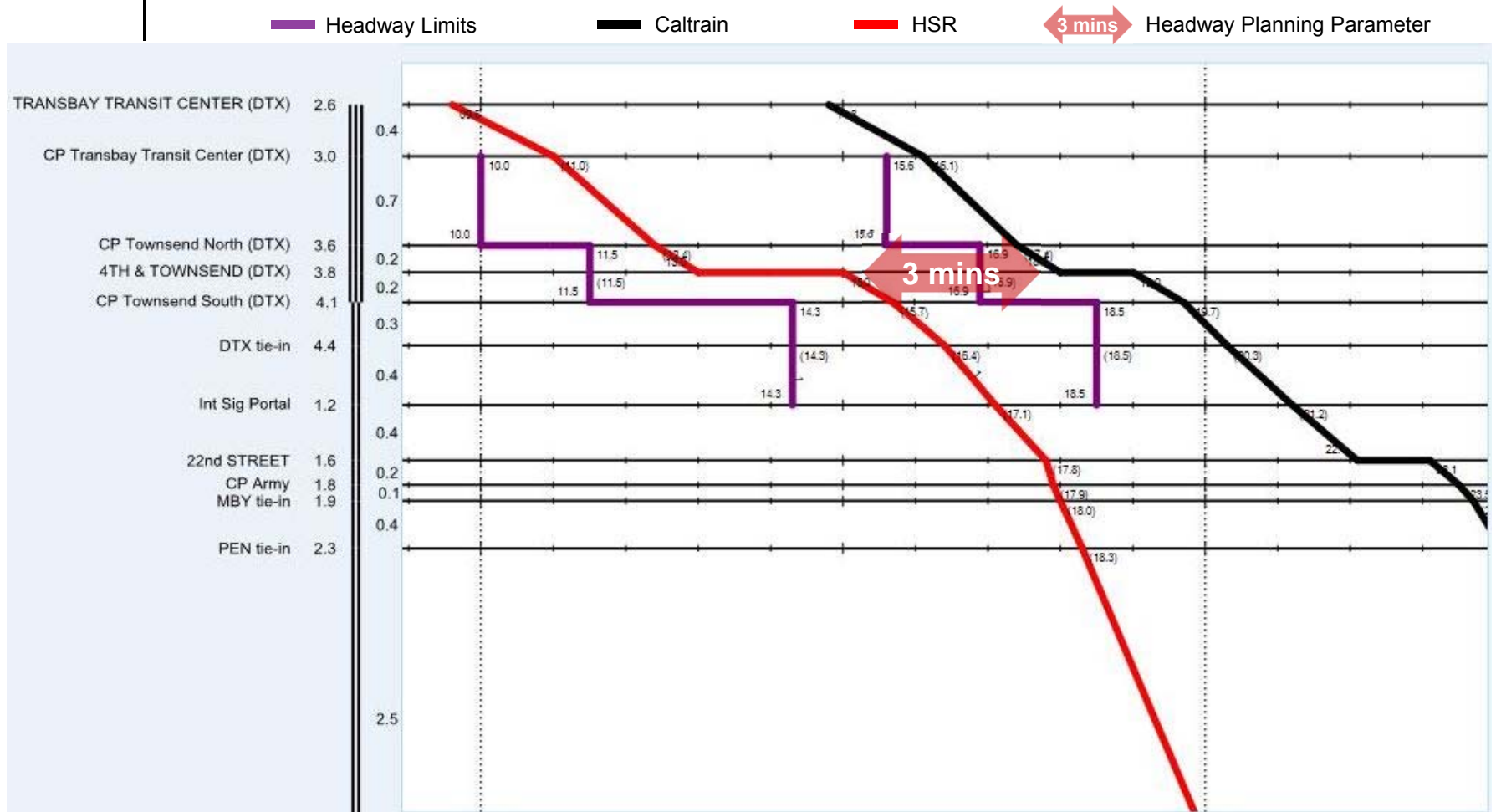
# Southbound Headway: Caltrain-HSR(1-stop)



# Southbound Headway: Caltrain-HSR



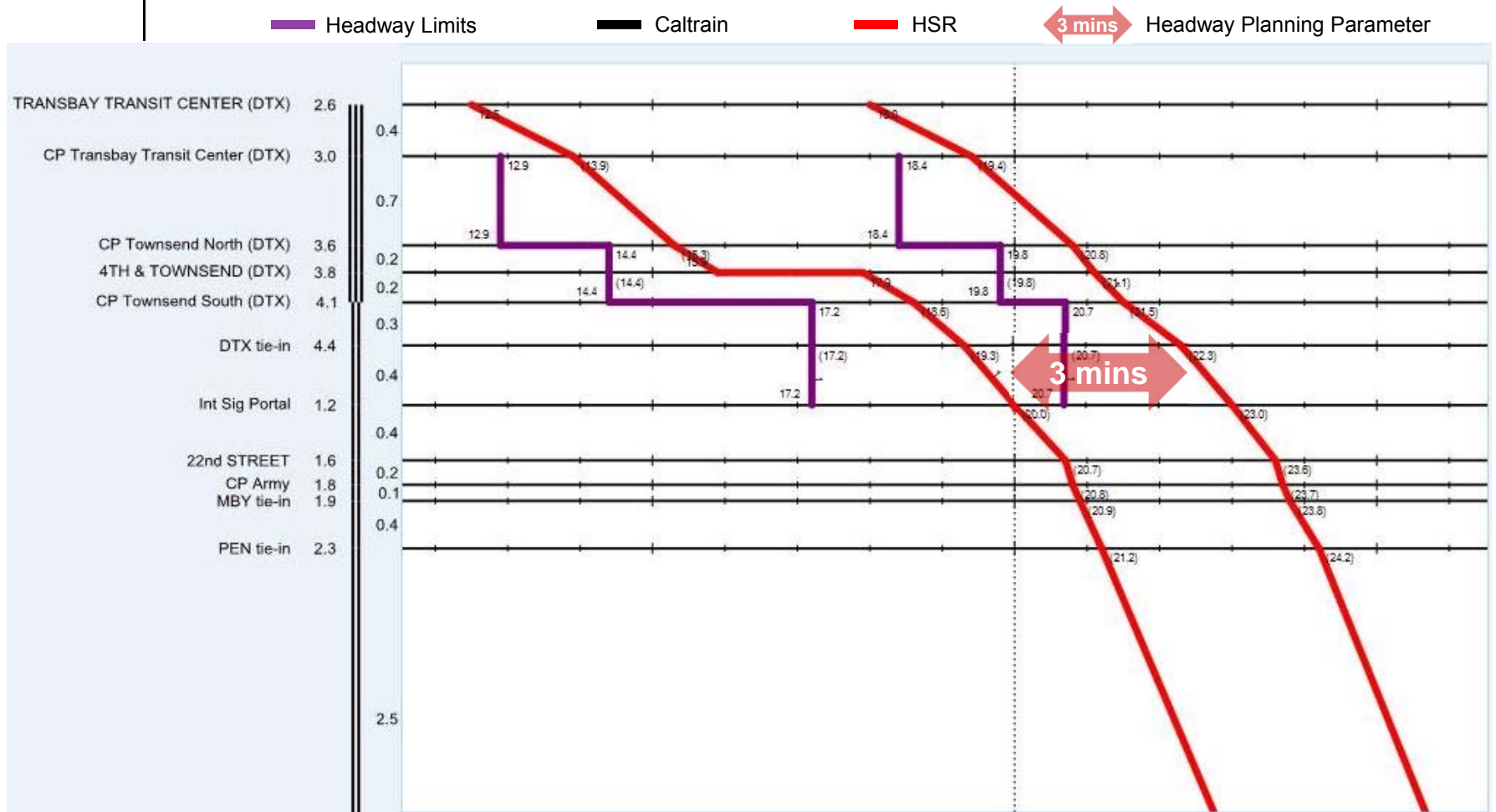
# Southbound Headway: HSR(1-stop)-Caltrain



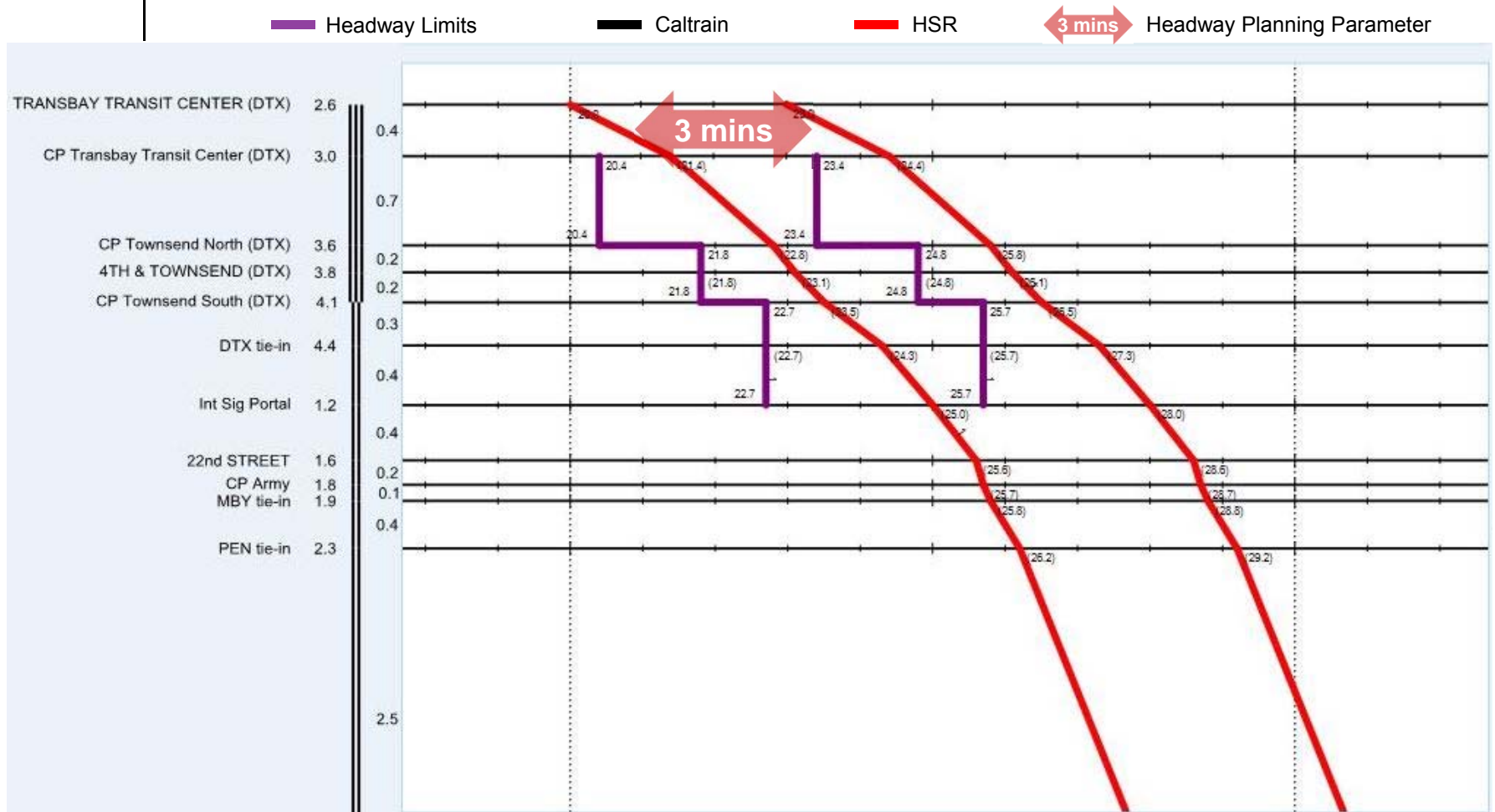
# Southbound Headway: HSR(1-stop)-HSR(1-stop)



# Southbound Headway: HSR(1-stop)-HSR

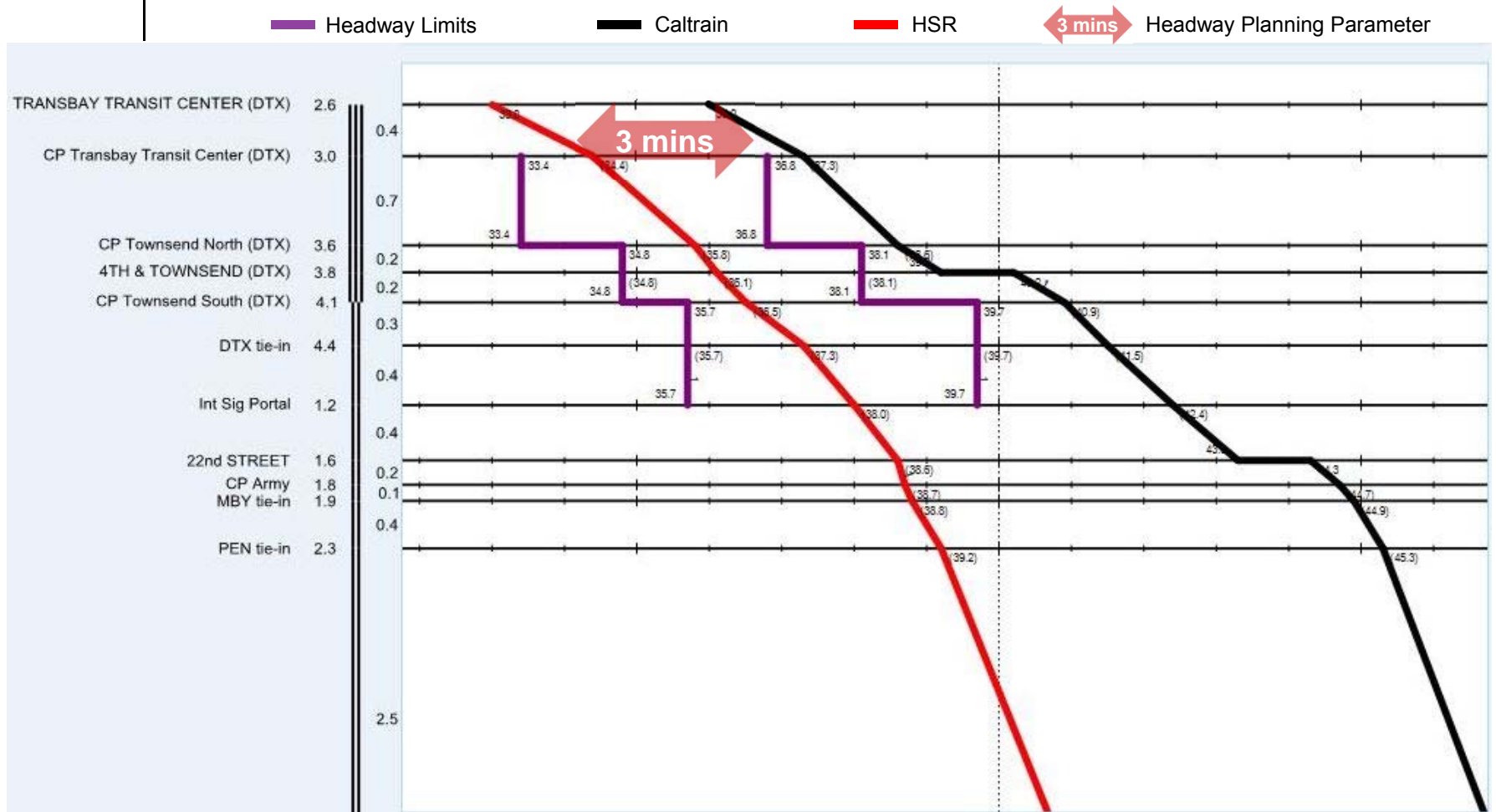


# Southbound Headway: HSR-HSR

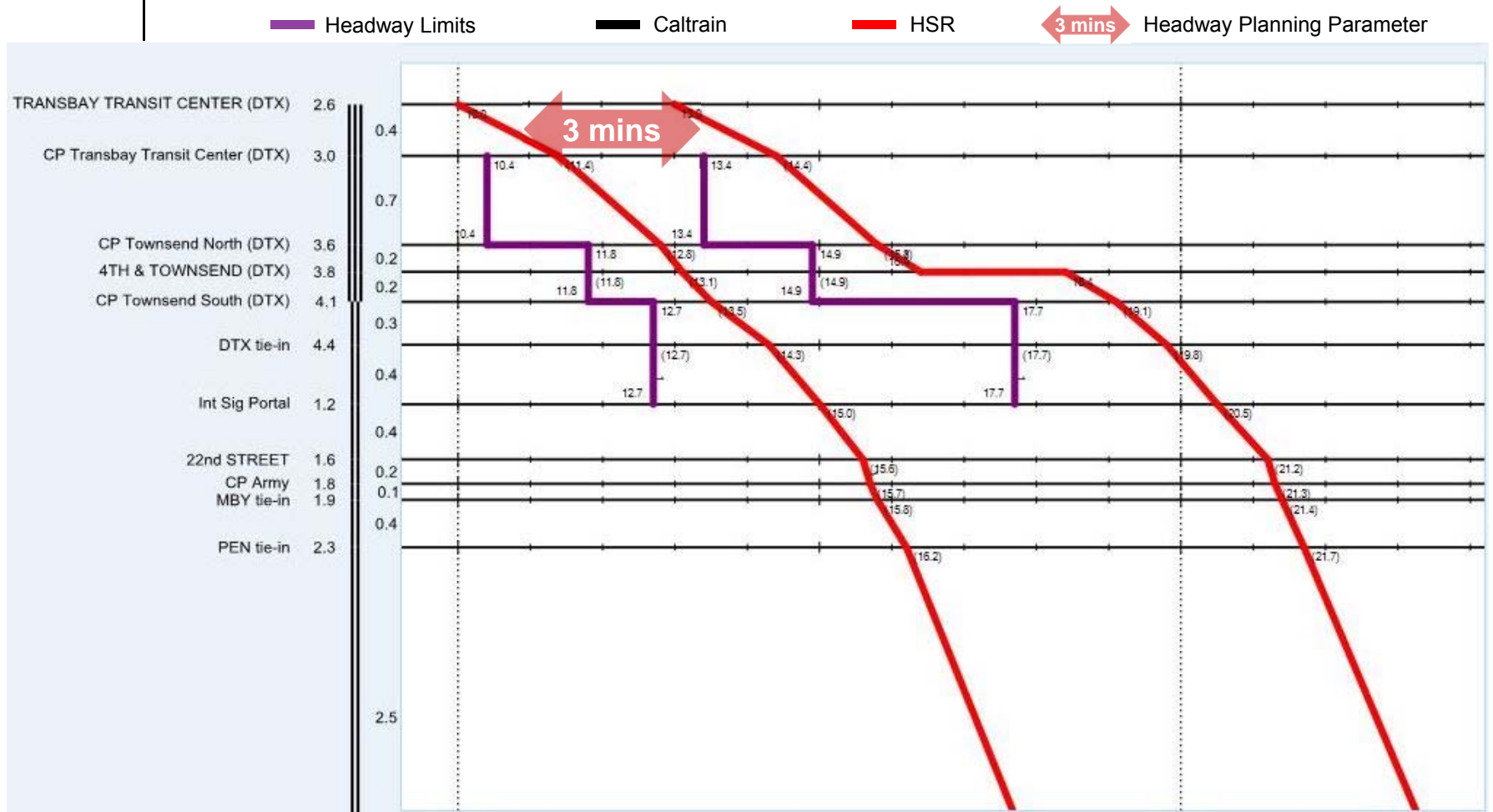




# Southbound Headway: HSR-Caltrain



# Southbound Headway: HSR-HSR(1-stop)

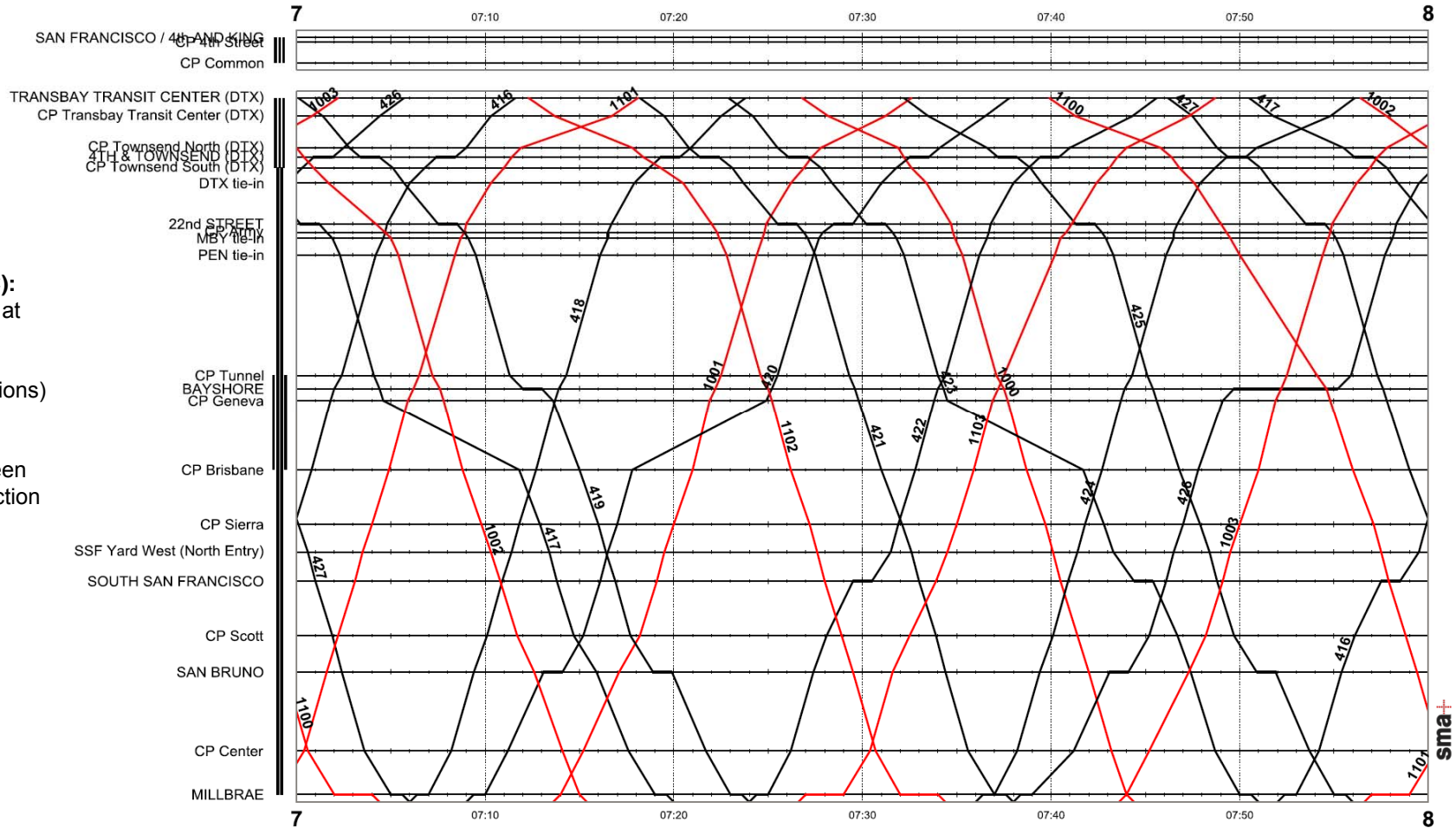


# Appendix: Stringlines, Tabular Timetables, and Platform Occupations

# NAPT-DTX-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# NAPT-DTX-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

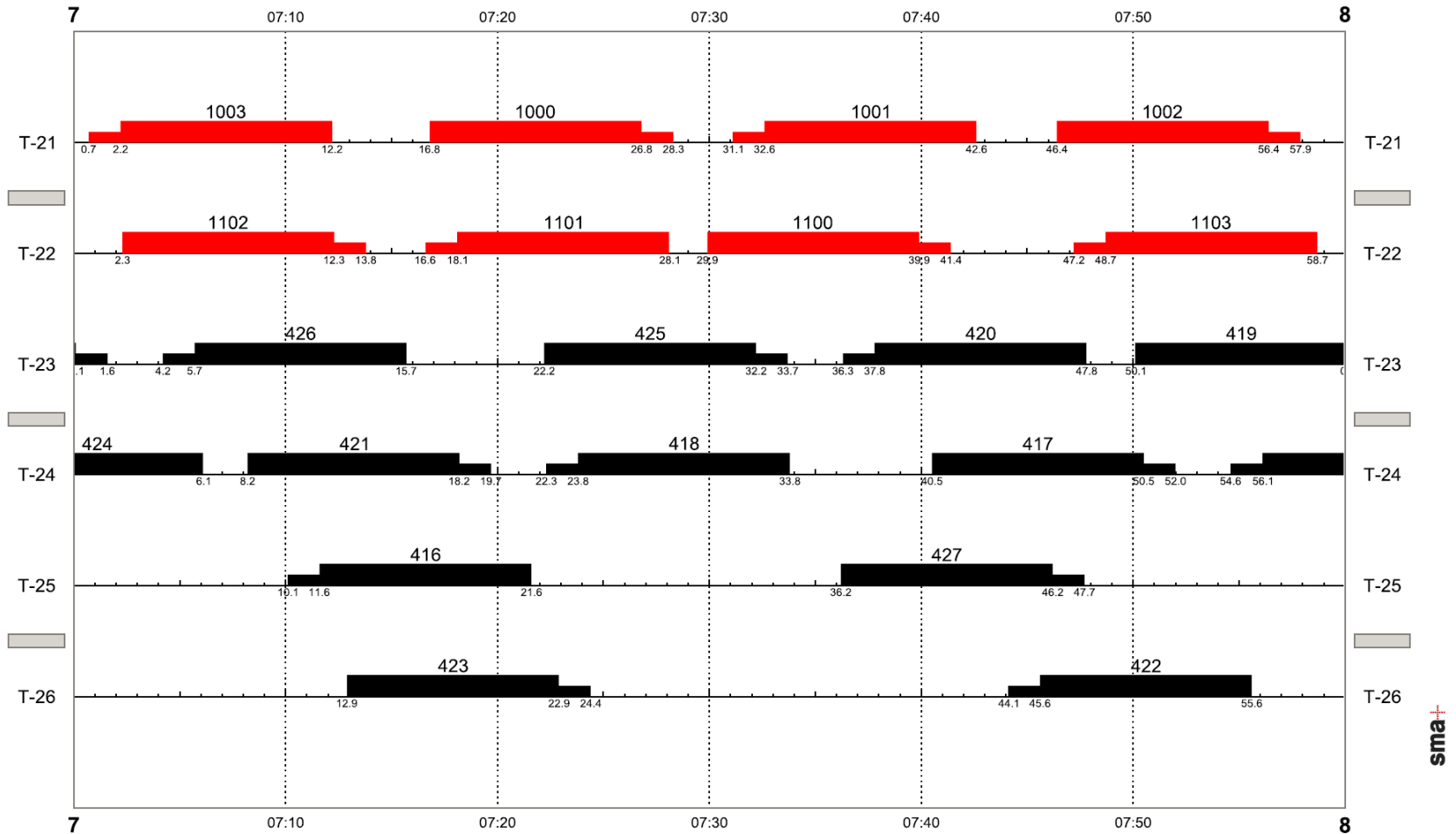
Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (DTX)	6:39	6:46	6:50	6:56	7:00	7:12	7:18	7:22	7:26	7:32
4TH & TOWNSEND (DTX)		6:50	6:57		7:04		7:22	7:27		7:38
22nd STREET		6:54	7:01		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:19					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22nd STREET			7:29							
4TH & TOWNSEND (DTX)	7:20		7:33	7:40		7:50		8:01	8:08	
TRANSBAY TRANSIT CENTER (DTX)	7:23	7:32	7:37	7:45	7:48	7:56	8:02	8:05	8:11	8:18

# NAPT-DTX-A

**Turn Times:**  
 ≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

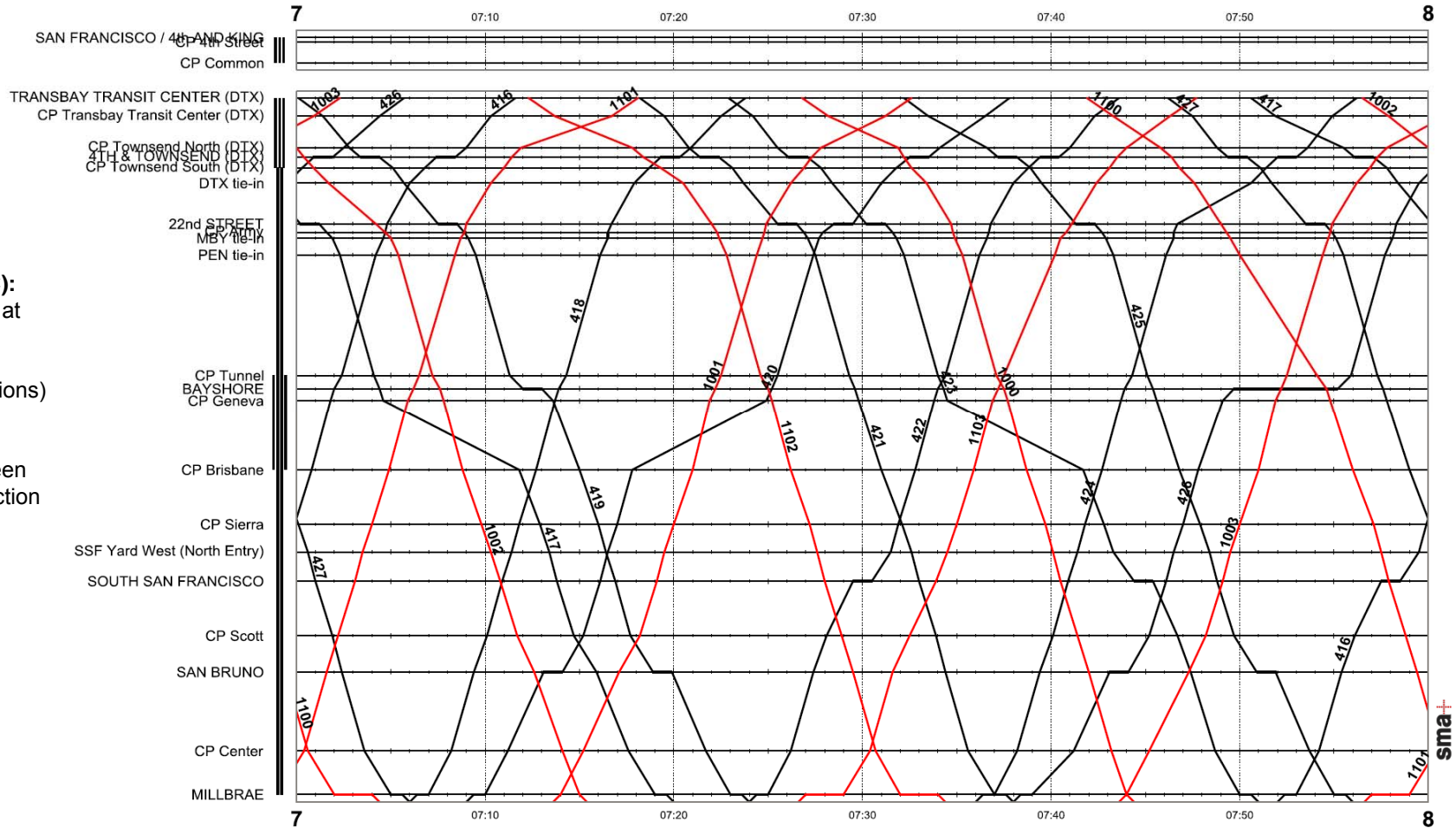
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# NAPT-DTX-B

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# NAPT-DTX-B

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (DTX)	6:41	6:46	6:50	6:56	7:00	7:12	7:18	7:22	7:26	7:32
4TH & TOWNSEND (DTX)		6:50	6:57		7:04		7:22	7:27		7:38
22nd STREET		6:54	7:01		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:19					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22nd STREET			7:29							
4TH & TOWNSEND (DTX)	7:20		7:33	7:40		7:53		8:01	8:08	
TRANSBAY TRANSIT CENTER (DTX)	7:23	7:32	7:37	7:43	7:47	7:56	8:02	8:05	8:11	8:18

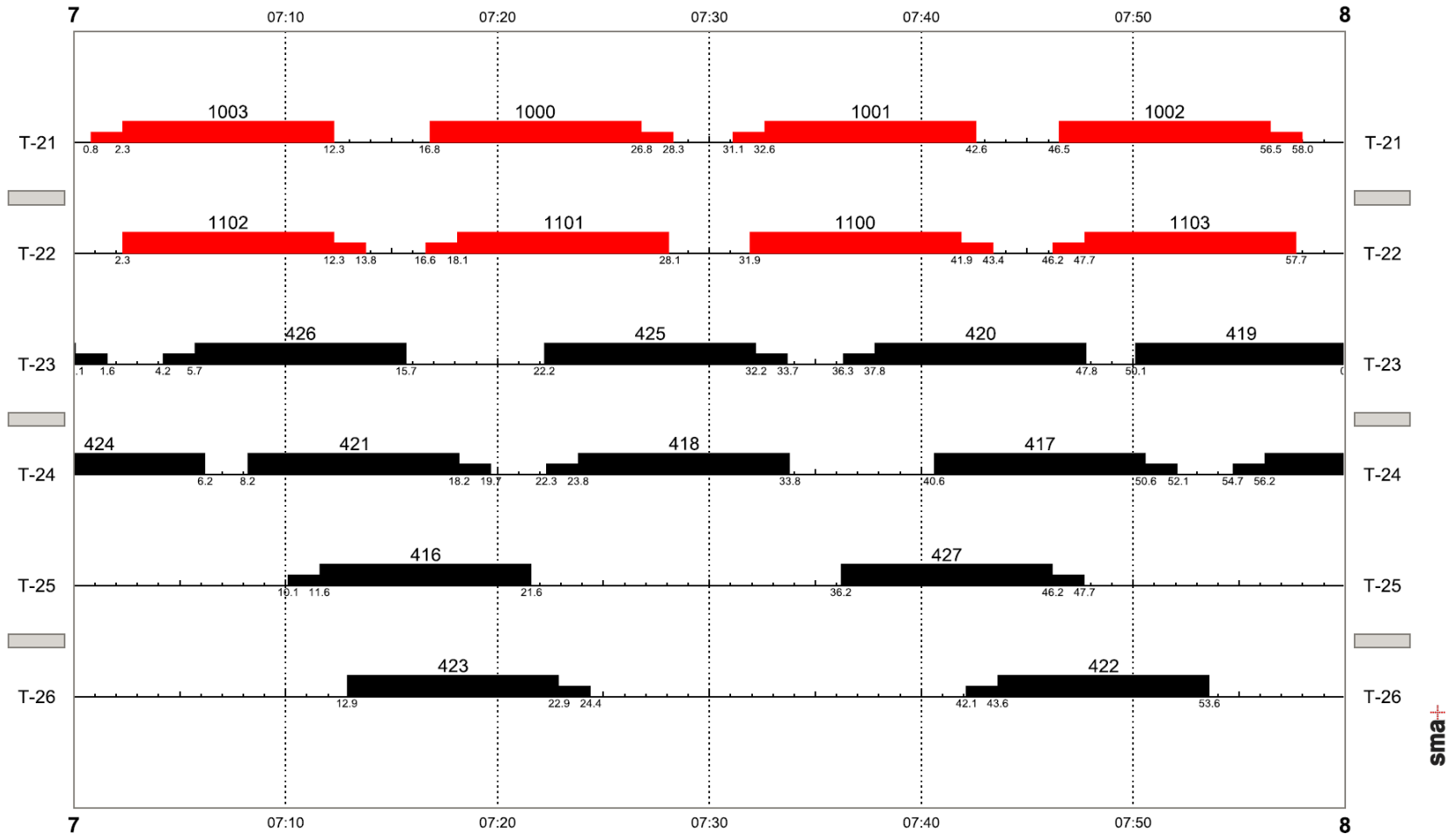


# NAPT-DTX-B

**Turn Times:**  
 ≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

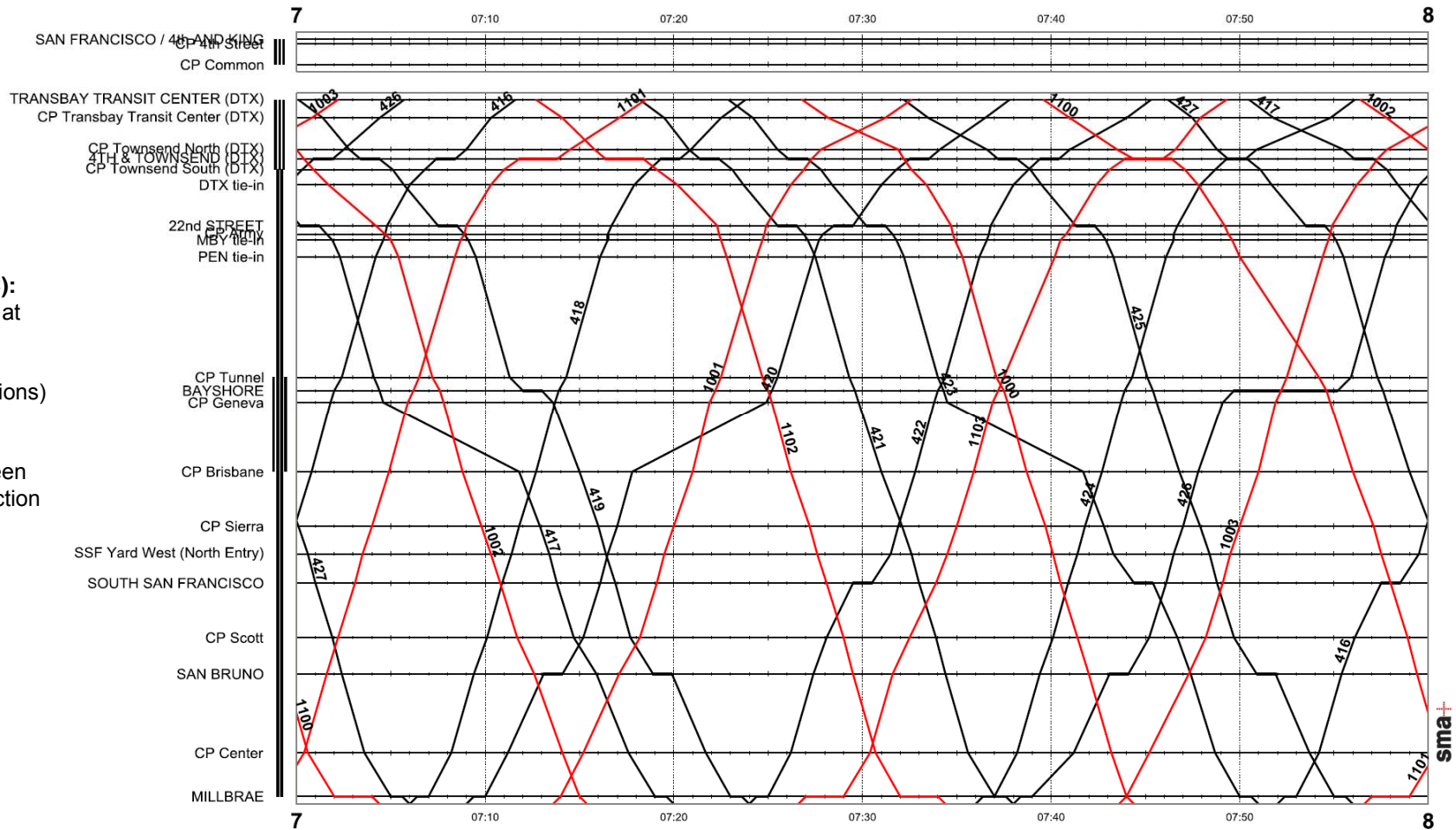
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# NAPT-DTX-C

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# NAPT-DTX-C

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

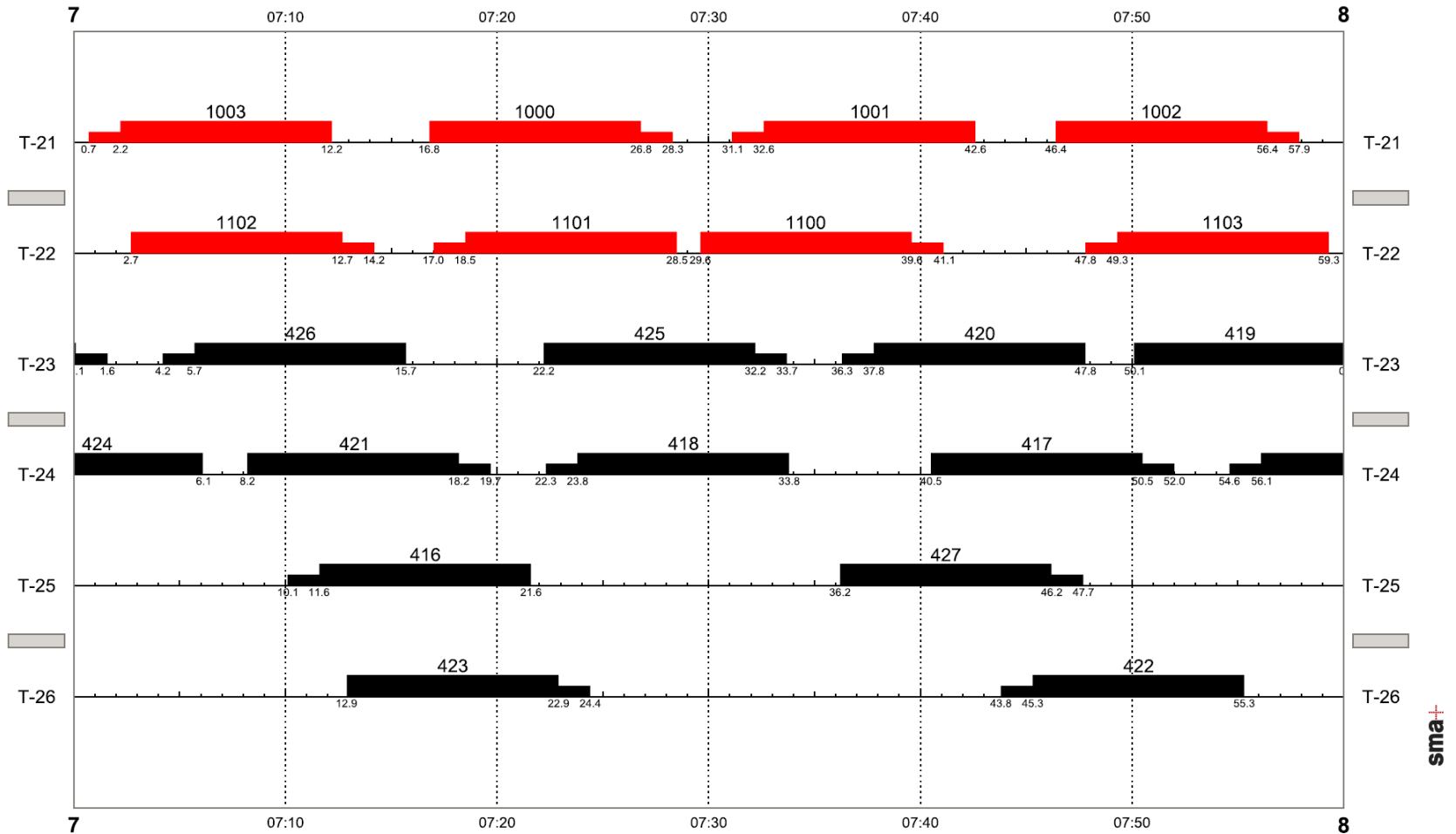
Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (DTX)	6:39	6:46	6:50	6:56	7:00	7:12	7:18	7:22	7:26	7:32
4TH & TOWNSEND (DTX)	6:46	6:50	6:57		7:04	7:18	7:22	7:27		7:38
22nd STREET		6:54	7:01		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:44		
SAN BRUNO					7:19					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22nd STREET			7:29							
4TH & TOWNSEND (DTX)	7:20		7:33	7:40	7:45	7:50		8:01	8:08	8:13
TRANSBAY TRANSIT CENTER (DTX)	7:23	7:32	7:37	7:45	7:49	7:56	8:02	8:05	8:11	8:18

# NAPT-DTX-C

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

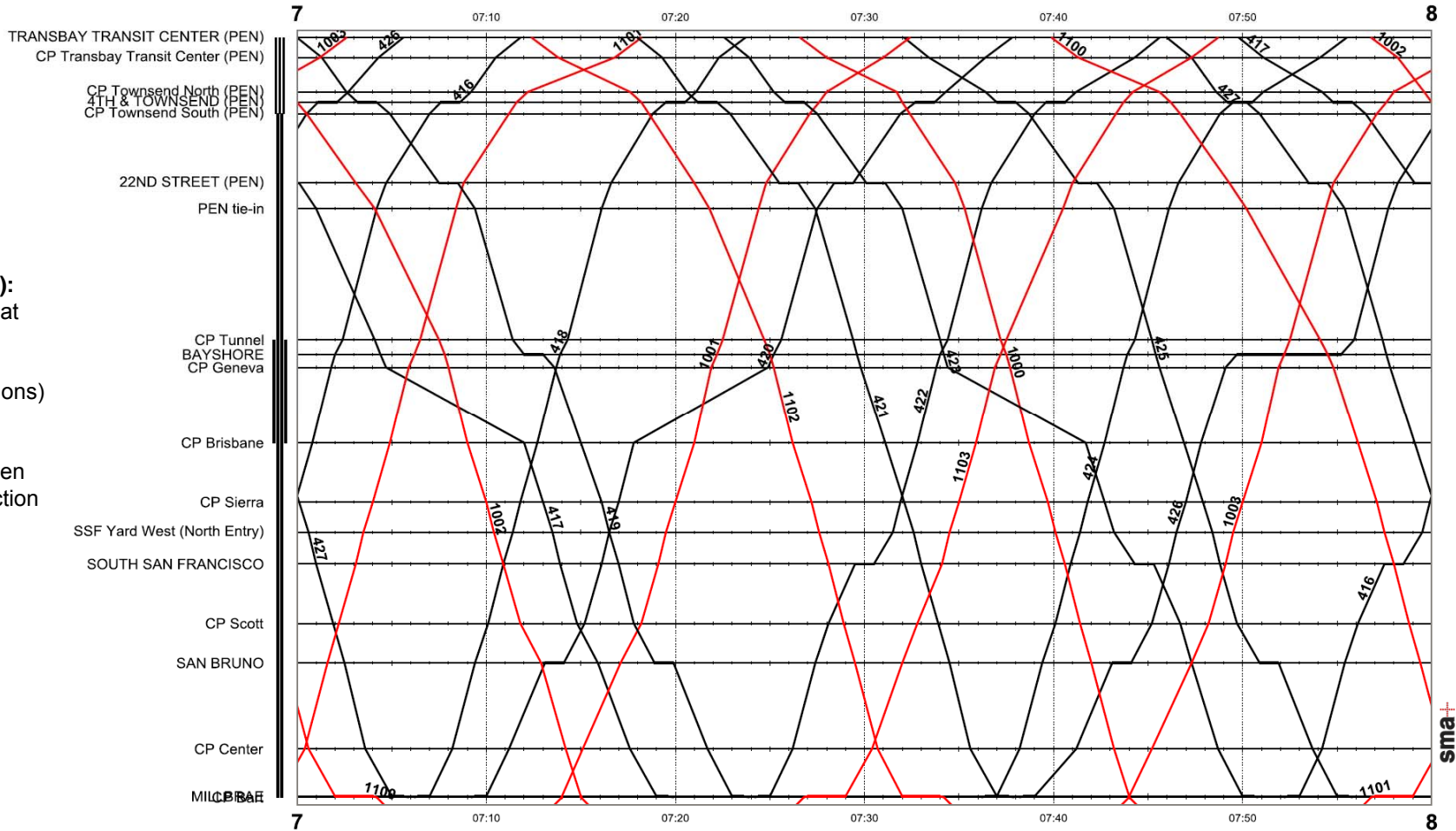
Note: This occupation chart  
 shows platform tracks  
 exclusively being used by  
 either HSR or Caltrain;  
 however, operations are not  
 limited to this pattern and  
 either service could use any  
 platform track.



# NAPT-PEN-A

**Separation Times (CP TTC):**  
3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
3.0-minute separation between trains traveling in same direction on same track



# NAPT-PEN-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

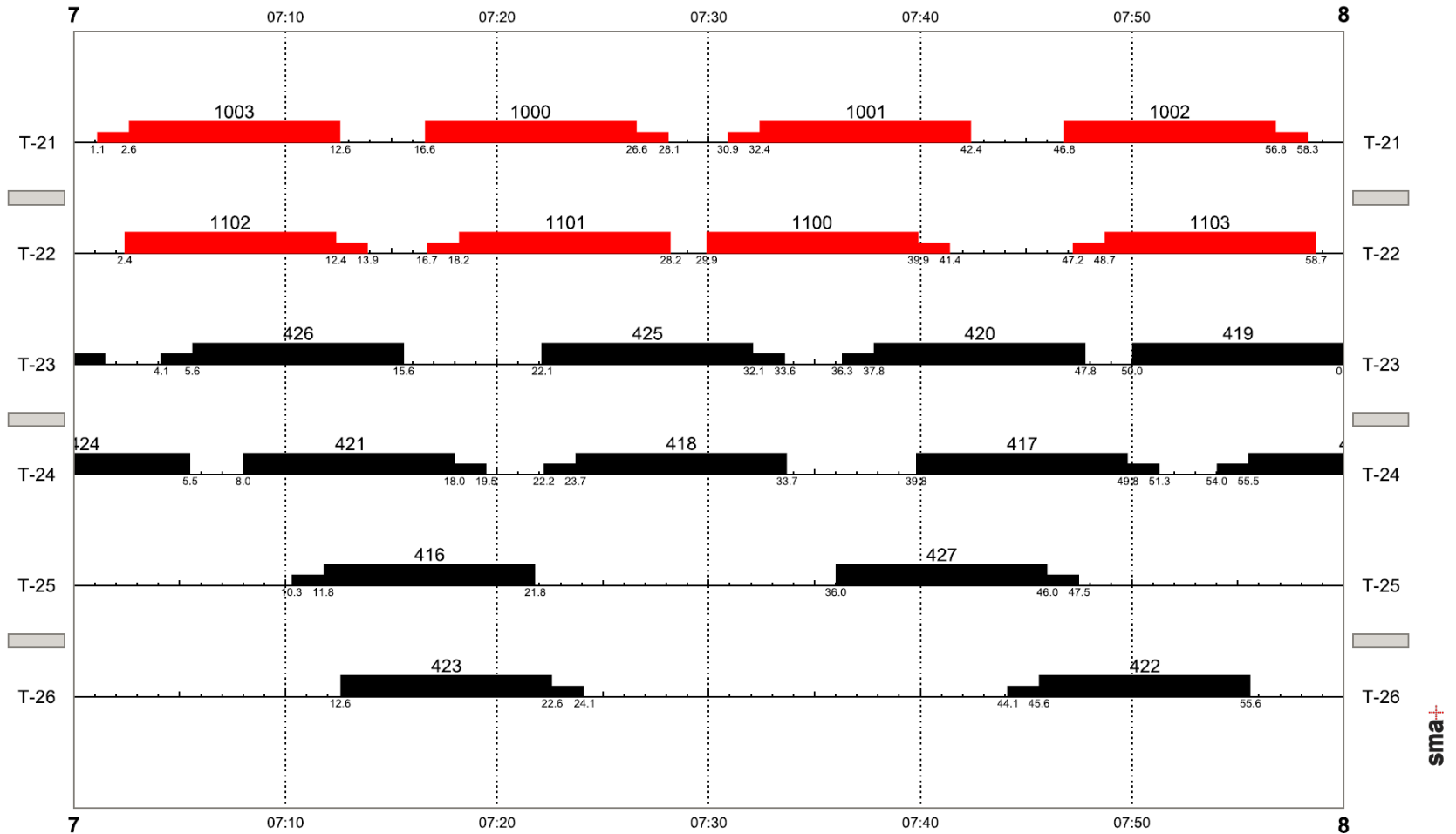
Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (PEN)	6:39	6:46	6:49	6:56	7:00	7:12	7:18	7:22	7:26	7:32
4TH & TOWNSEND (PEN)		6:50	6:55		7:04		7:22	7:26		7:38
22ND STREET (PEN)		6:54	7:00		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:19					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22ND STREET (PEN)			7:29							
4TH & TOWNSEND (PEN)	7:20		7:33	7:40		7:50		8:02	8:08	
TRANSBAY TRANSIT CENTER (PEN)	7:23	7:32	7:37	7:45	7:48	7:55	8:02	8:05	8:11	8:18

# NAPT-PEN-A

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

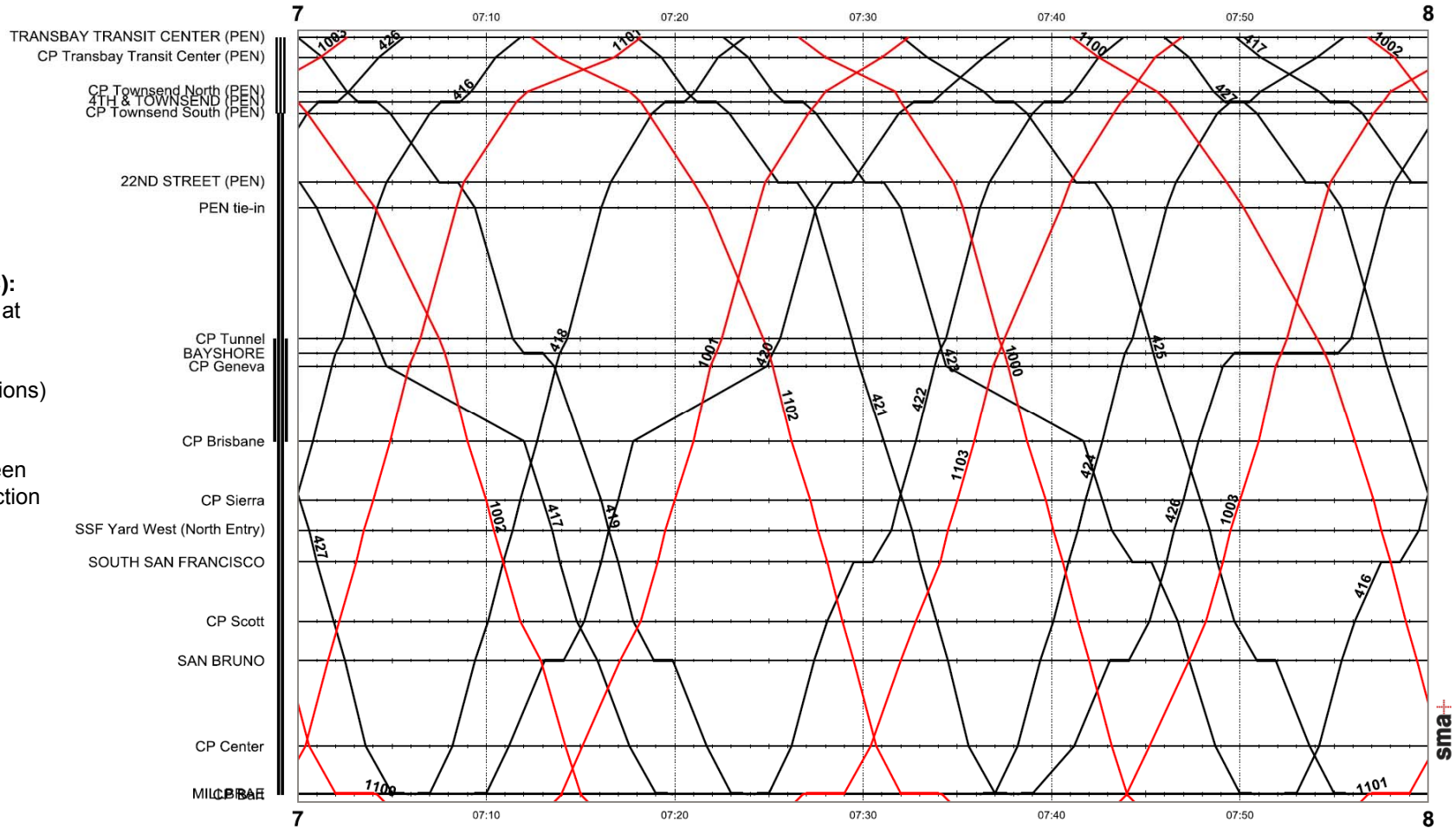
Note: This occupation chart  
 shows platform tracks  
 exclusively being used by  
 either HSR or Caltrain;  
 however, operations are not  
 limited to this pattern and  
 either service could use any  
 platform track.



# NAPT-PEN-B

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track





# NAPT-PEN-B

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

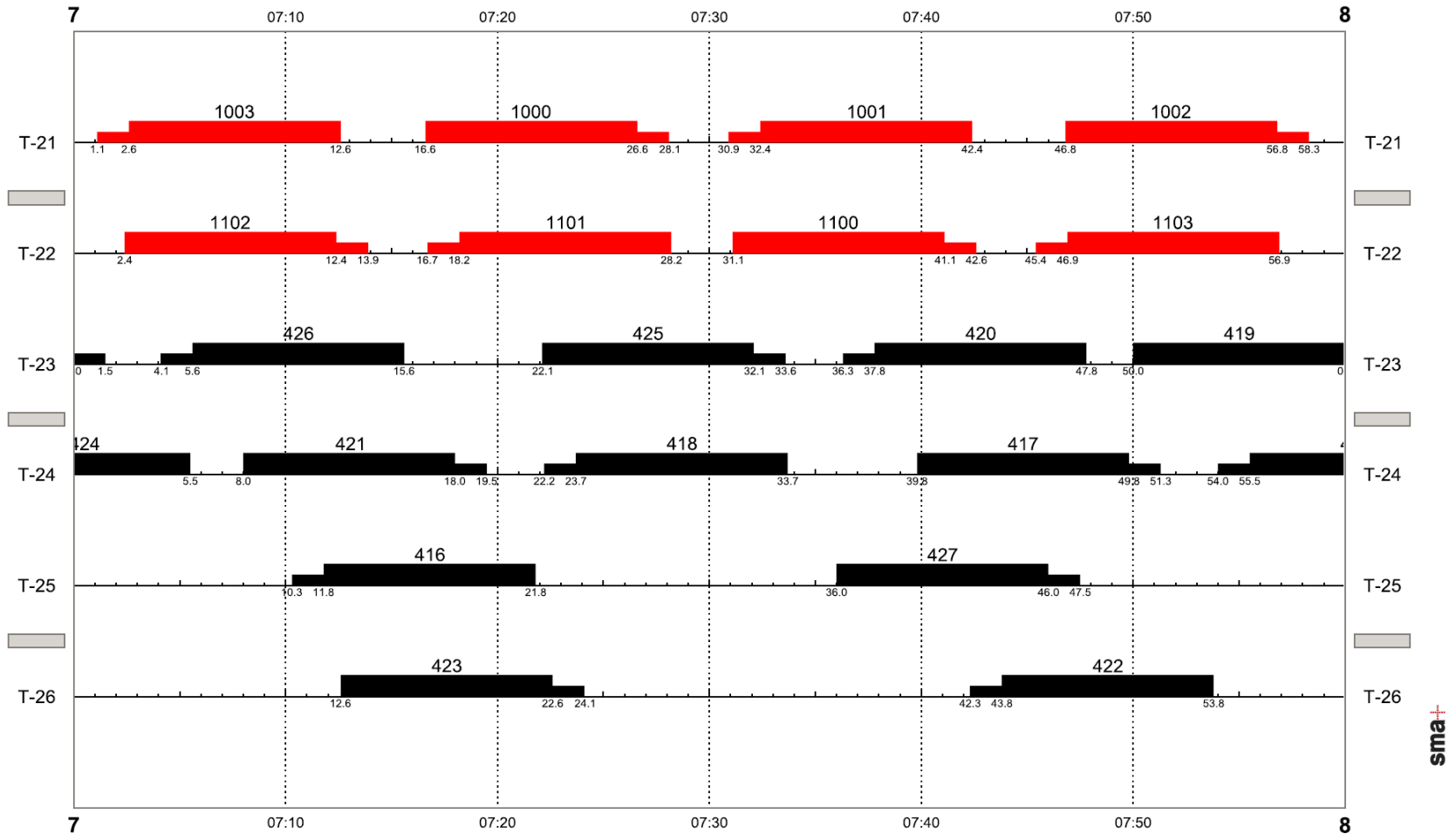
Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (PEN)	6:41	6:46	6:49	6:56	7:00	7:12	7:18	7:22	7:26	7:32
4TH & TOWNSEND (PEN)		6:50	6:55		7:04		7:22	7:26		7:38
22ND STREET (PEN)		6:54	7:00		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:19					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22ND STREET (PEN)			7:29							
4TH & TOWNSEND (PEN)	7:20		7:33	7:40		7:50		8:02	8:08	
TRANSBAY TRANSIT CENTER (PEN)	7:23	7:32	7:37	7:43	7:46	7:55	8:02	8:05	8:11	8:18

# NAPT-PEN-B

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

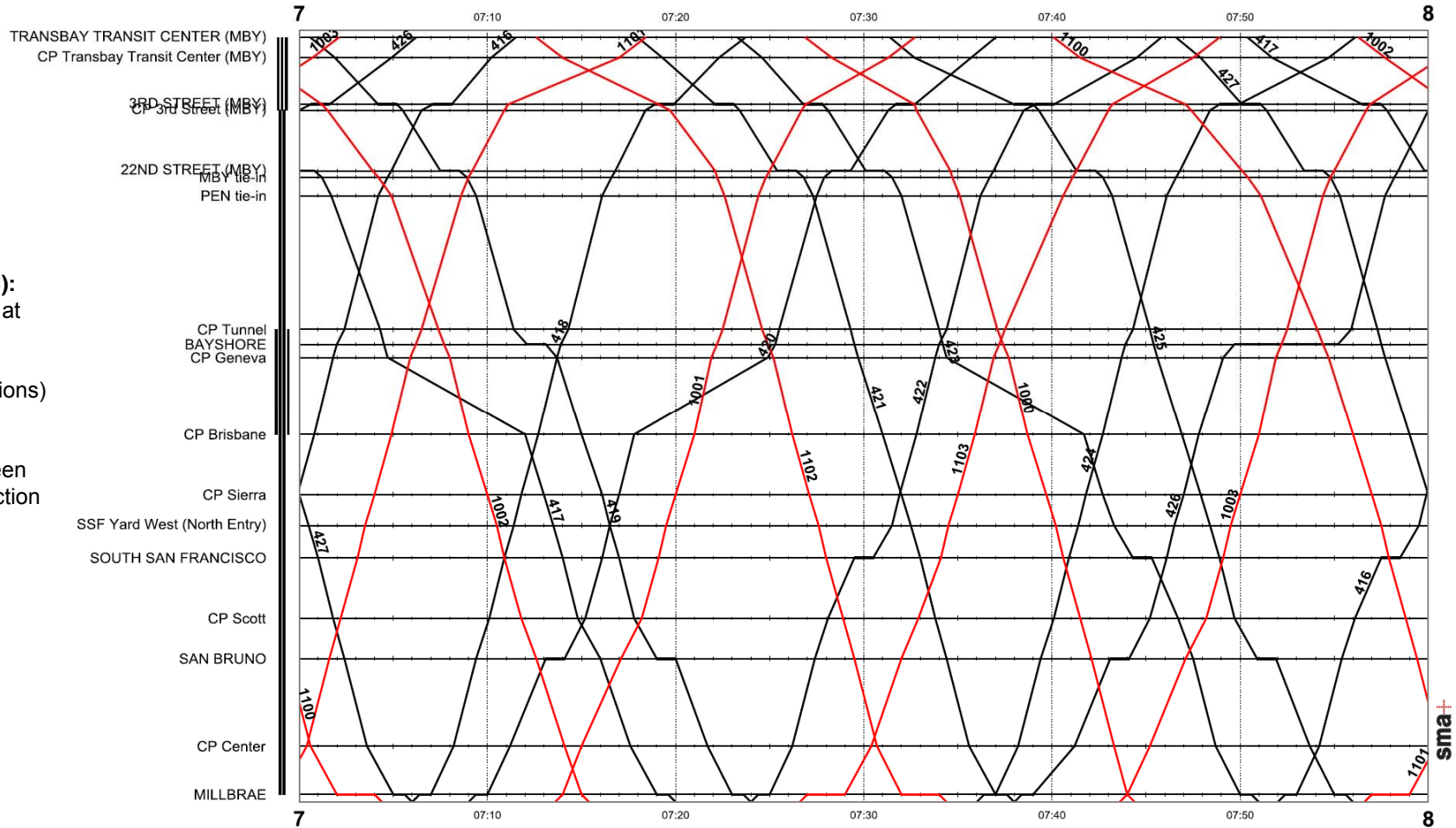
Note: This occupation chart  
 shows platform tracks  
 exclusively being used by  
 either HSR or Caltrain;  
 however, operations are not  
 limited to this pattern and  
 either service could use any  
 platform track.



# NAPT-MBY-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# NAPT-MBY-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (MBY)	6:40	6:46	6:50	6:56	7:00	7:12	7:18	7:23	7:26	7:31
3RD STREET (MBY)		6:51	6:57		7:05		7:23	7:27		7:39
22ND STREET (MBY)		6:54	7:00		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:20					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22ND STREET (MBY)			7:29							
3RD STREET (MBY)	7:19		7:32	7:40		7:49		8:01	8:08	
TRANSBAY TRANSIT CENTER (MBY)	7:23	7:32	7:37	7:45	7:48	7:56	8:02	8:06	8:11	8:18

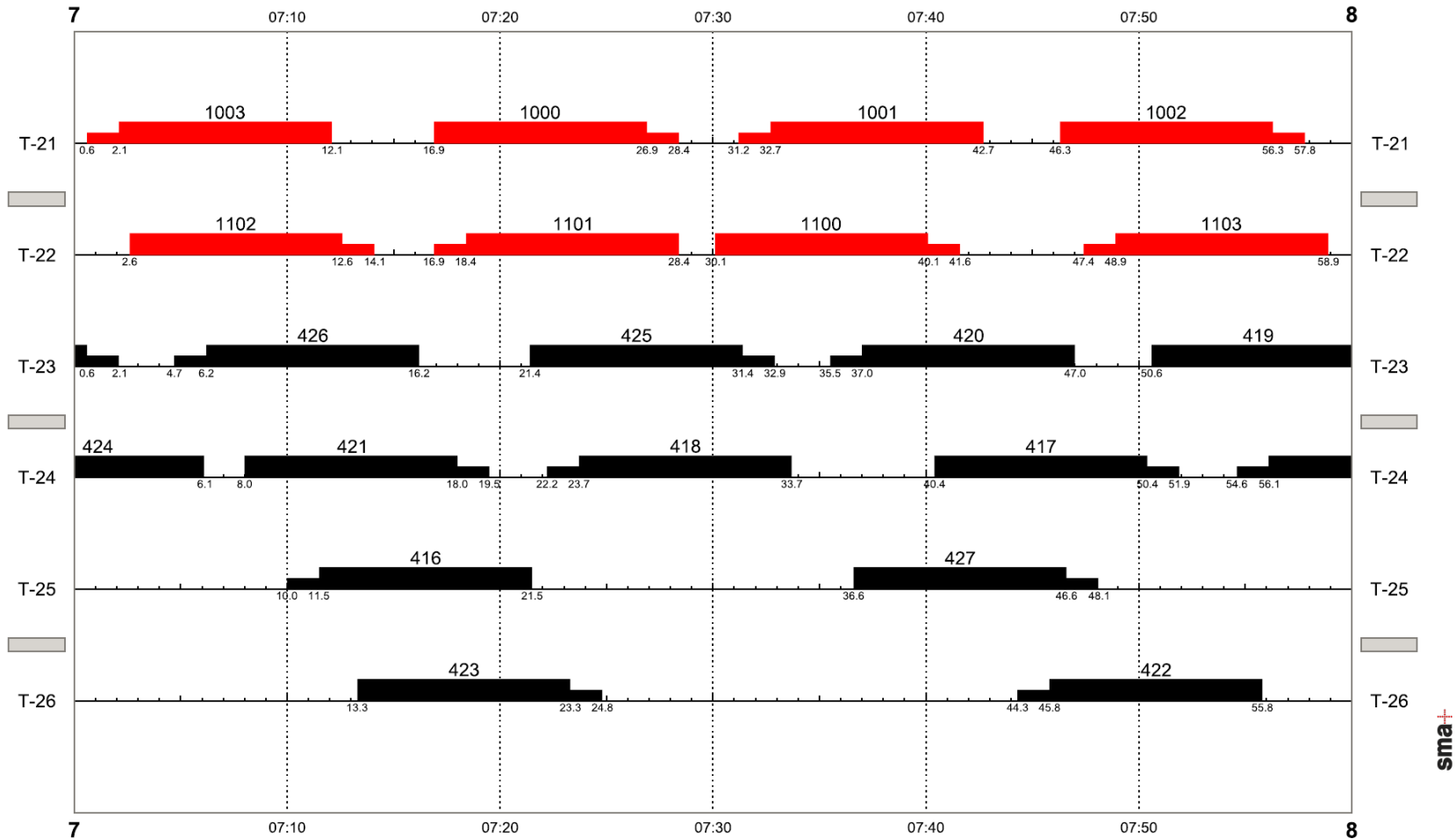
# NAPT-MBY-A

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

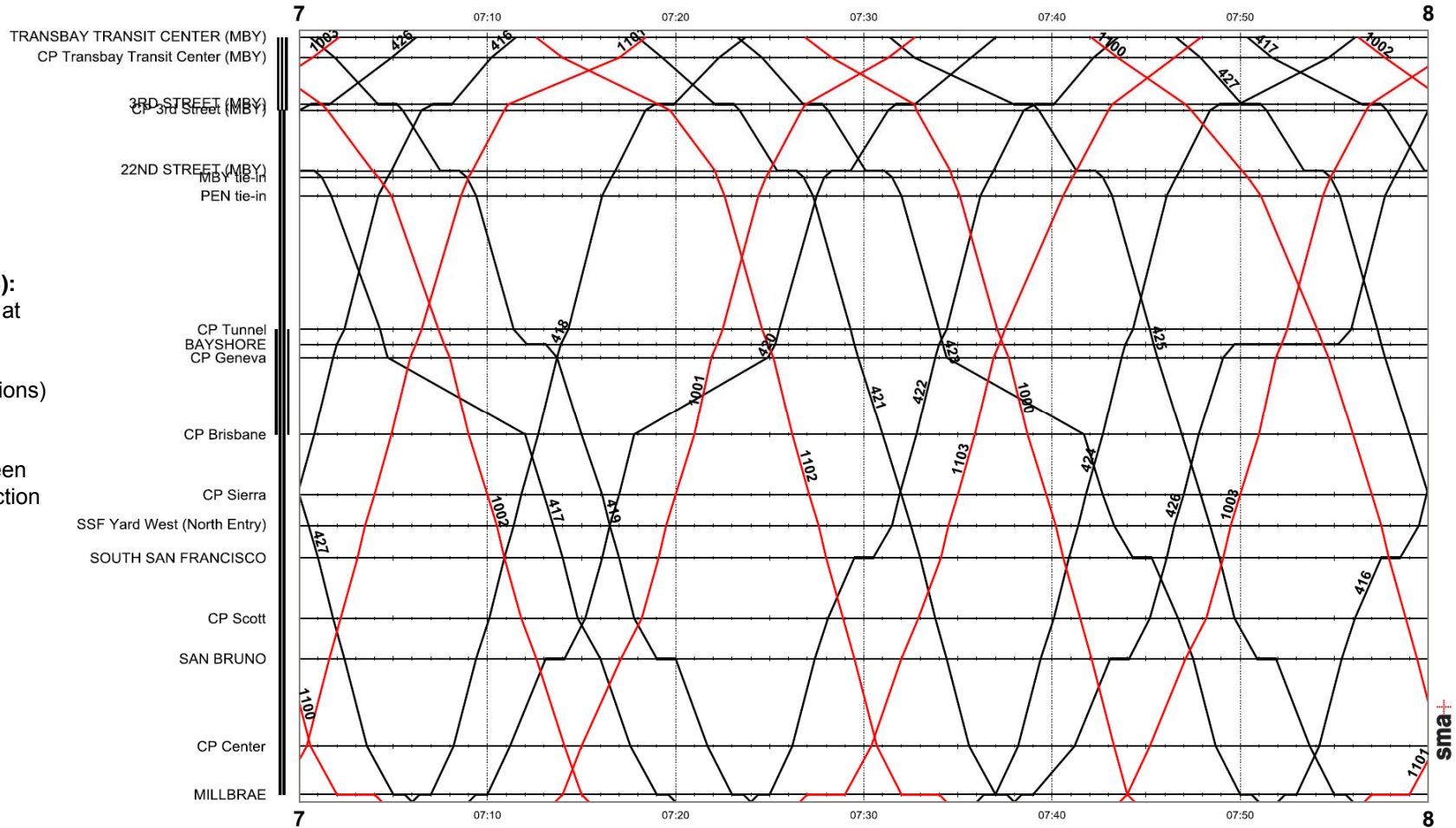
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# NAPT-MBY-B

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# NAPT-MBY-B

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

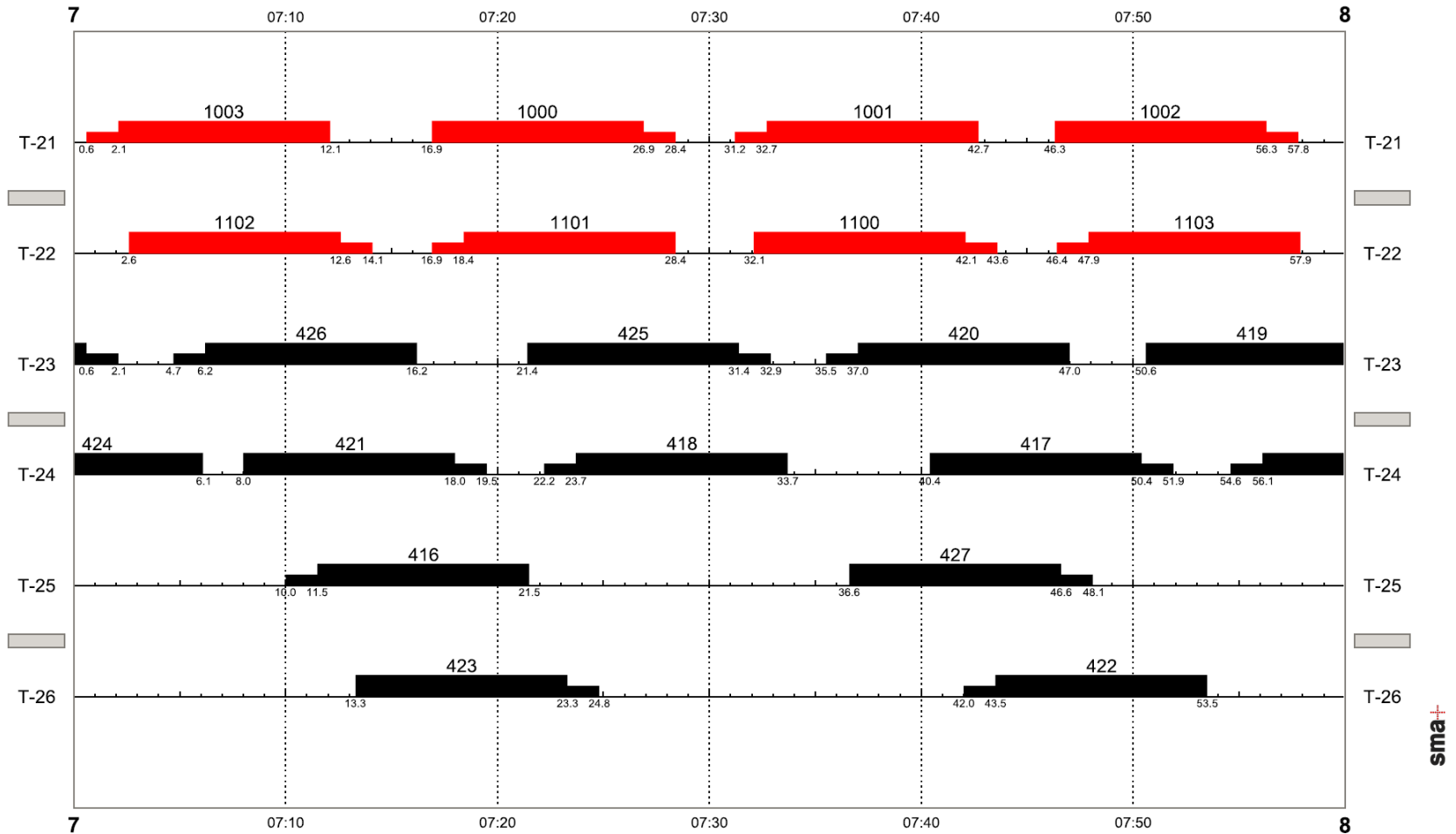
Train type	IC	REG	REG	IC	REG	IC	REG	REG	IC	REG
Train number	1100	427	417	1002	419	1102	421	423	1000	425
TRANSBAY TRANSIT CENTER (MBY)	6:42	6:46	6:50	6:56	7:00	7:12	7:18	7:23	7:26	7:31
3RD STREET (MBY)		6:51	6:57		7:05		7:23	7:27		7:39
22ND STREET (MBY)		6:54	7:00		7:08		7:26	7:31		7:42
BAYSHORE					7:13					
SOUTH SAN FRANCISCO								7:45		
SAN BRUNO					7:20					7:51
MILLBRAE	7:02	7:05	7:19		7:23	7:32	7:37	7:50		7:55
Train type	REG	IC	REG	REG	IC	REG	IC	REG	REG	IC
Train number	418	1001	420	422	1103	424	1003	426	416	1101
MILLBRAE	7:07		7:10	7:25	7:29	7:37		7:39	7:53	7:59
SAN BRUNO			7:14					7:44		
SOUTH SAN FRANCISCO				7:30					7:58	
BAYSHORE								7:55		
22ND STREET (MBY)			7:29							
3RD STREET (MBY)	7:19		7:32	7:40		7:49		8:01	8:08	
TRANSBAY TRANSIT CENTER (MBY)	7:23	7:32	7:37	7:43	7:47	7:56	8:02	8:06	8:11	8:18

# NAPT-MBY-B

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

Note: This occupation chart  
 shows platform tracks  
 exclusively being used by  
 either HSR or Caltrain;  
 however, operations are not  
 limited to this pattern and  
 either service could use any  
 platform track.

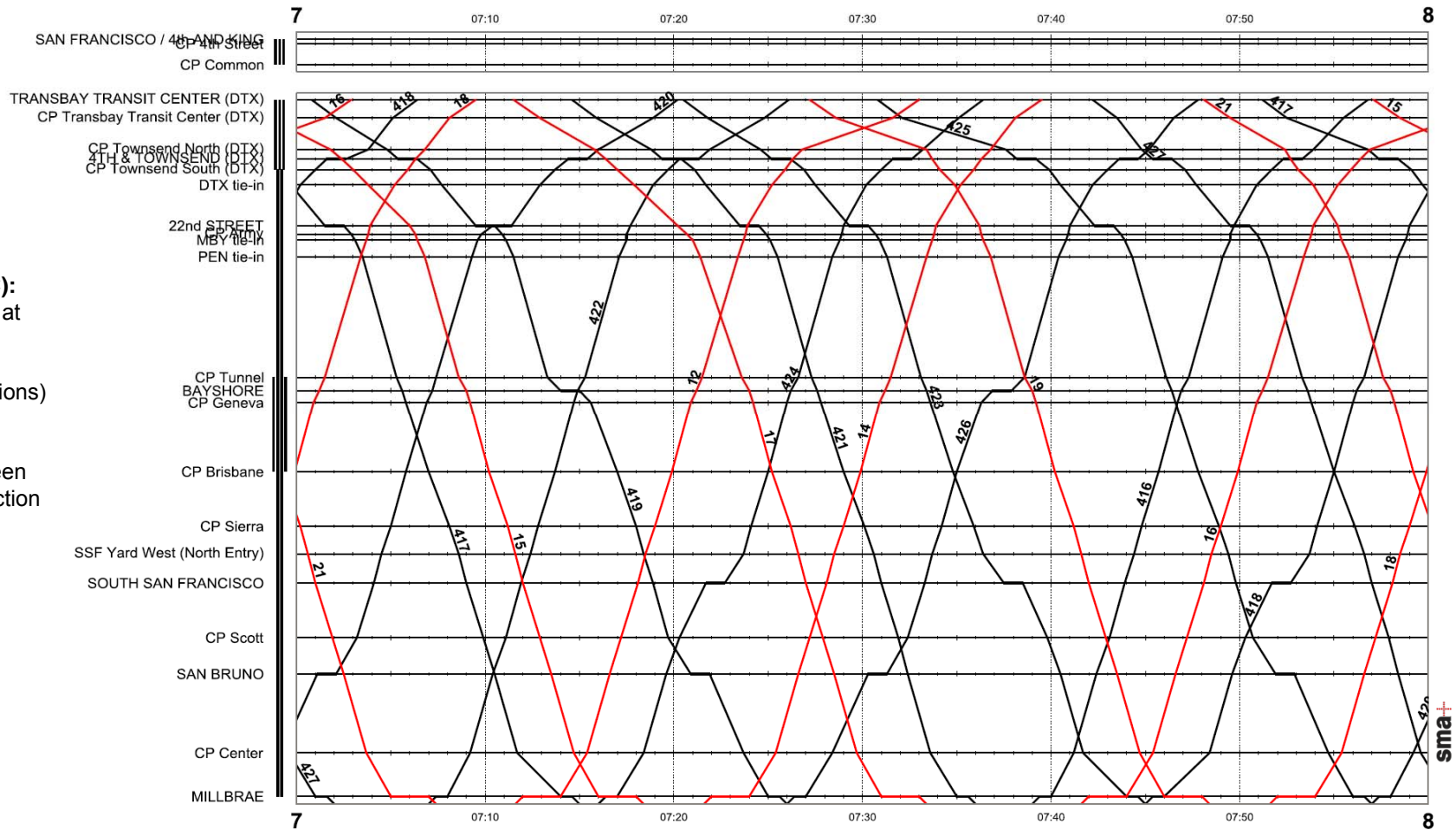




# LTK-DTX-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-DTX-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

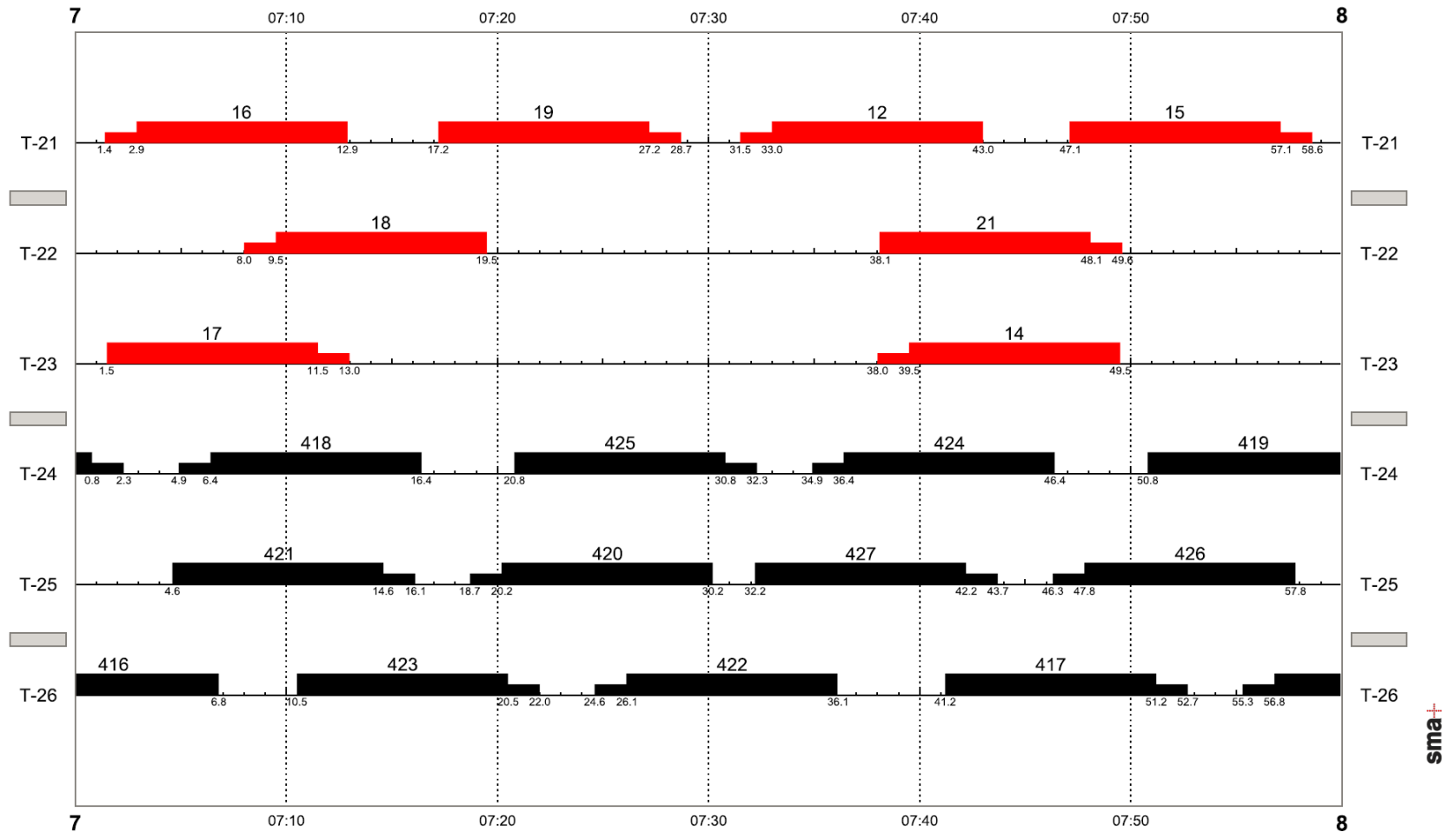
Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (DTX)	6:42	6:48	6:51	6:57	7:00	7:11	7:14	7:20	7:27	7:30
4TH & TOWNSEND (DTX)	6:46		6:58		7:06		7:20	7:26		7:39
22nd STREET	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:38		
SAN BRUNO					7:21					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22nd STREET										8:11
4TH & TOWNSEND (DTX)	7:21		7:32		7:44	7:53		8:02		8:15
TRANSBAY TRANSIT CENTER (DTX)	7:26	7:33	7:36	7:39	7:47	7:56	8:02	8:06	8:09	8:20

# LTK-DTX-A

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

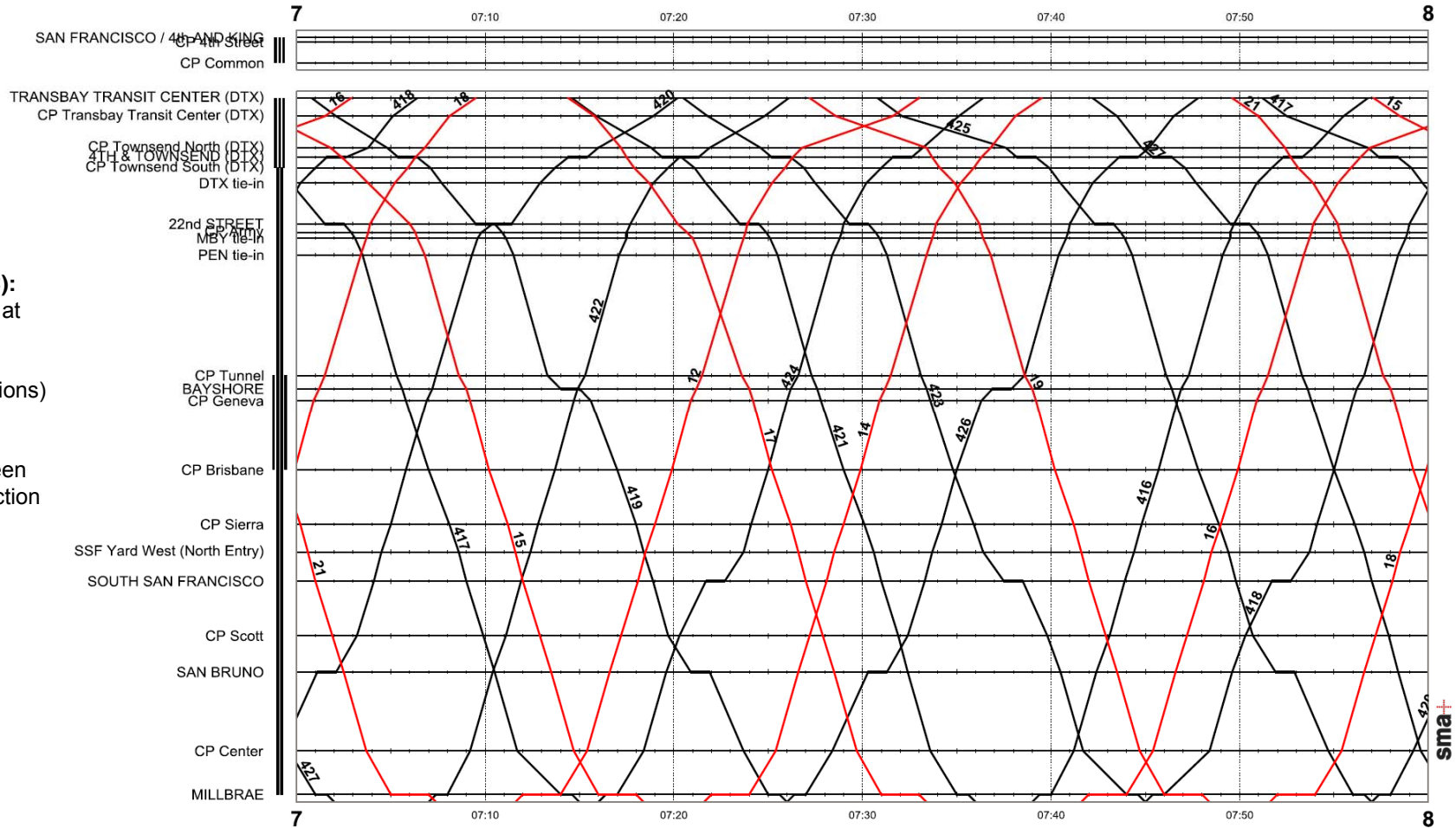
Note: This occupation chart  
 shows platform tracks  
 exclusively being used by  
 either HSR or Caltrain;  
 however, operations are not  
 limited to this pattern and  
 either service could use any  
 platform track.



# LTK-DTX-B

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-DTX-B

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (DTX)	6:42	6:49	6:51	6:57	7:00	7:14	7:14	7:20	7:27	7:30
4TH & TOWNSEND (DTX)	6:46		6:58		7:06		7:20	7:26		7:39
22nd STREET	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:38		
SAN BRUNO					7:21					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22nd STREET										8:11
4TH & TOWNSEND (DTX)	7:21		7:32		7:44	7:53		8:02		8:15
TRANSBAY TRANSIT CENTER (DTX)	7:26	7:33	7:36	7:39	7:47	7:56	8:02	8:06	8:09	8:20

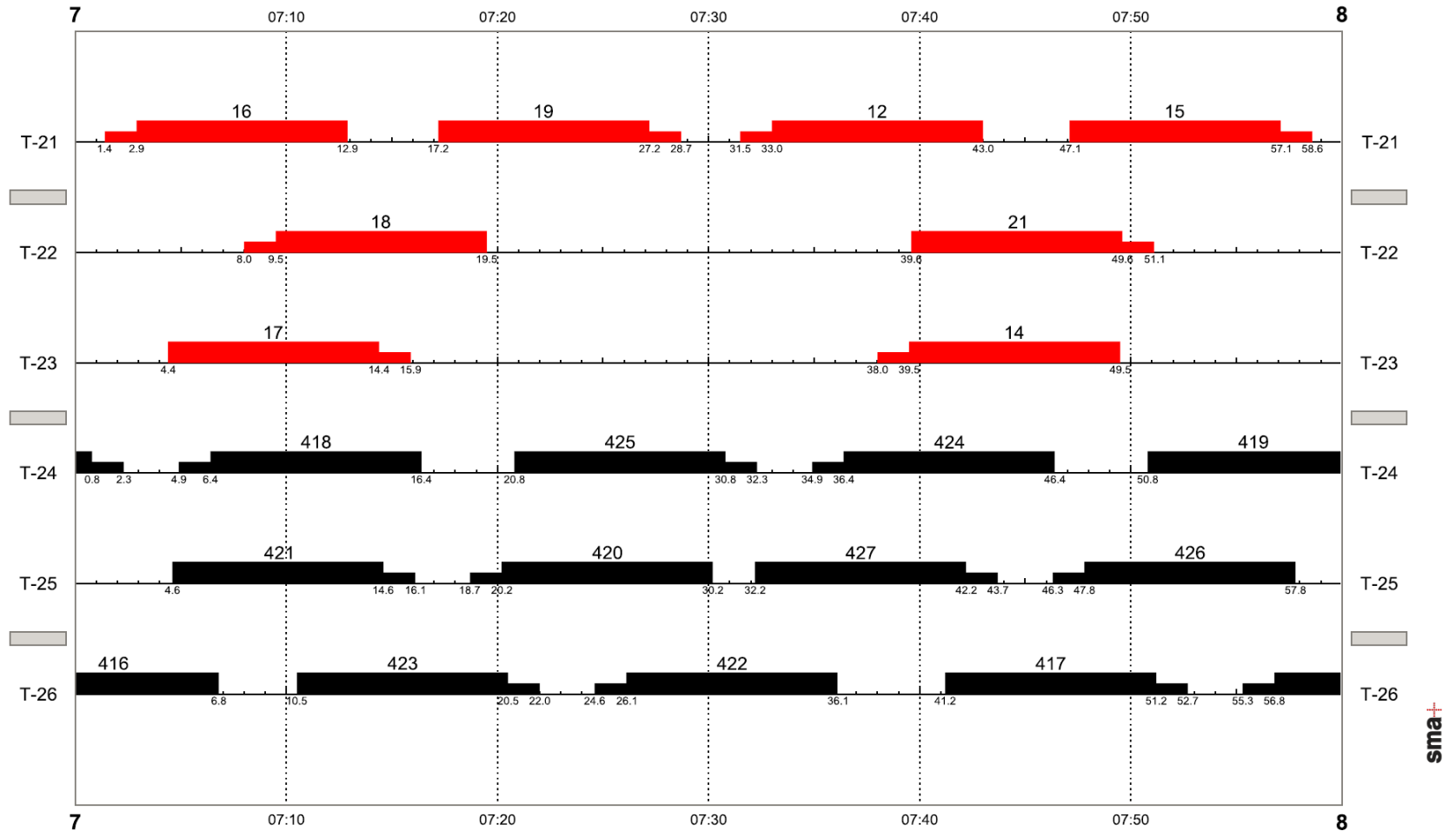
# LTK-DTX-B

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

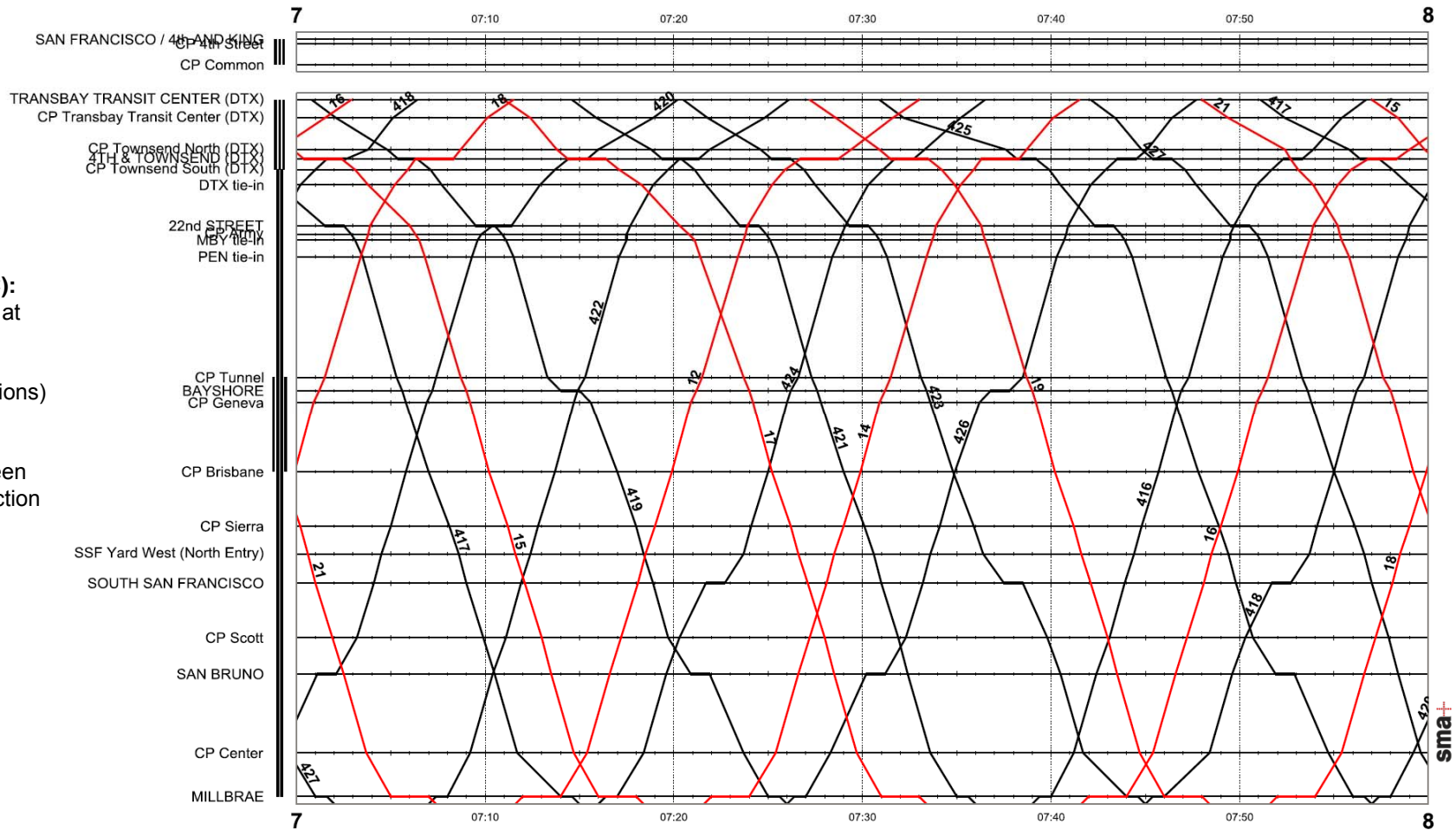
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# LTK-DTX-C

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-DTX-C

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (DTX)	6:42	6:48	6:51	6:57	7:00	7:11	7:14	7:20	7:27	7:30
4TH & TOWNSEND (DTX)	6:46		6:57	7:02	7:06	7:16	7:20	7:26	7:33	7:39
22nd STREET	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:37		
SAN BRUNO					7:21					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22nd STREET										8:11
4TH & TOWNSEND (DTX)	7:21	7:28	7:32	7:38	7:44	7:53	7:58	8:02	8:08	8:15
TRANSBAY TRANSIT CENTER (DTX)	7:26	7:33	7:36	7:41	7:47	7:56	8:02	8:06	8:11	8:20

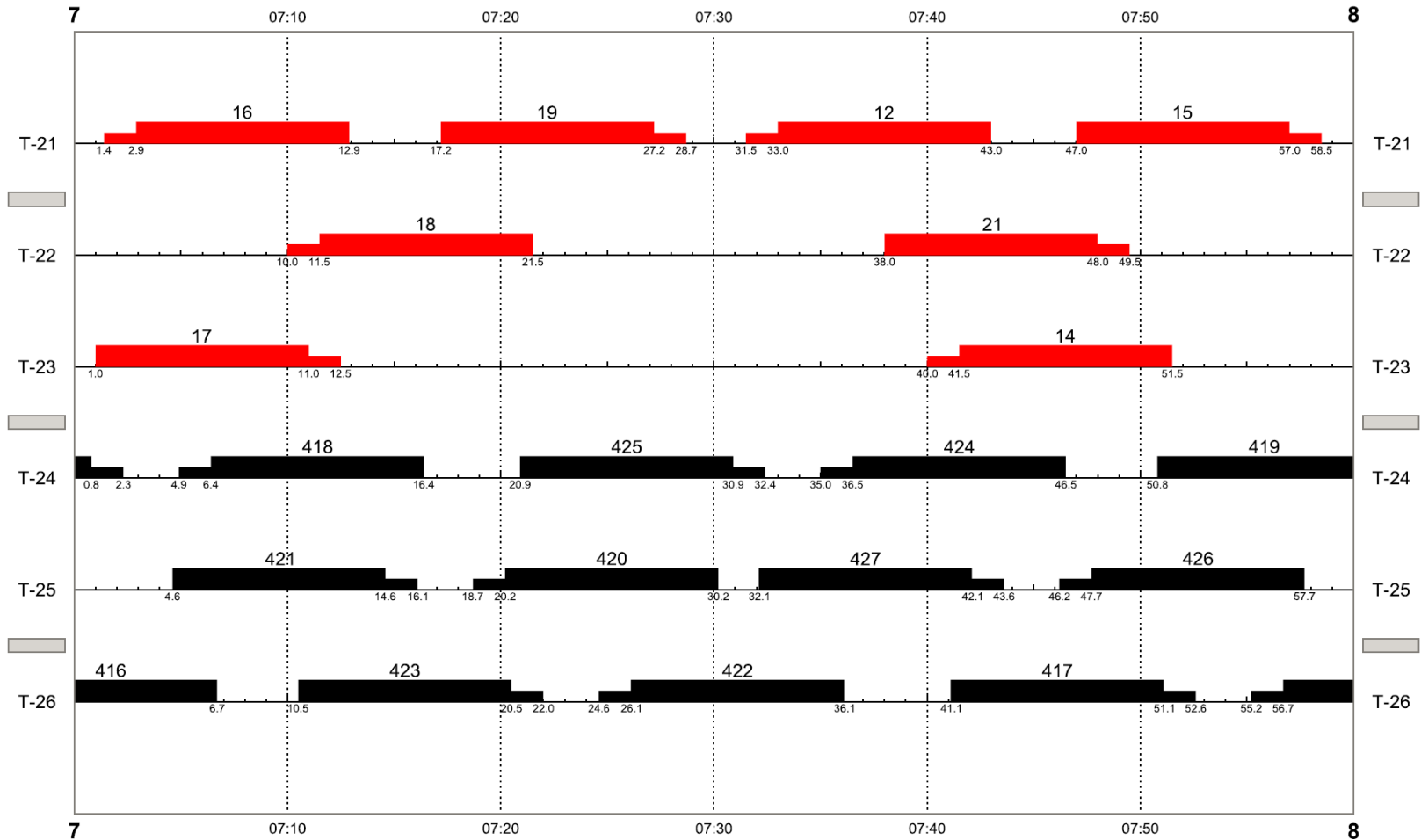


# LTK-DTX-C

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

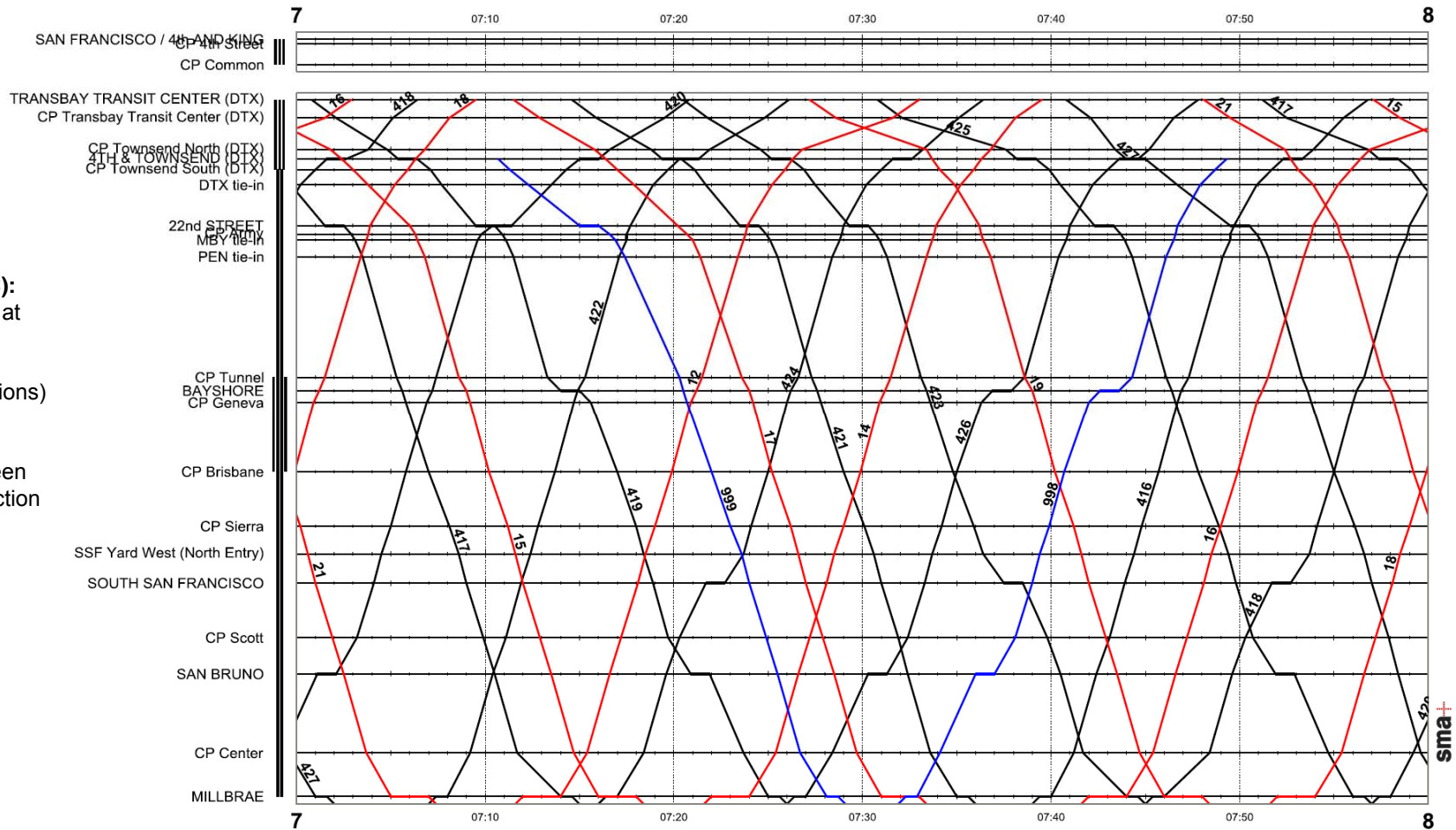
Note: This occupation chart  
 shows platform tracks  
 exclusively being used by  
 either HSR or Caltrain;  
 however, operations are not  
 limited to this pattern and  
 either service could use any  
 platform track.



# LTK-DTX-D

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-DTX-D

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	IC	REG	IC	REG	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	999	17	421	423	19	425
TRANSBAY TRANSIT CENTER (DTX)	6:40	6:48	6:51	6:57	7:00		7:11	7:14	7:20	7:27	7:30
4TH & TOWNSEND (DTX)	6:45		6:58		7:06	7:10		7:20	7:26		7:39
22nd STREET	6:50		7:02		7:10	7:16		7:24	7:30		7:43
BAYSHORE					7:15						
SOUTH SAN FRANCISCO									7:38		
SAN BRUNO					7:21						7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:28	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	998	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:32	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31	7:37					8:02
SOUTH SAN FRANCISCO			7:22						7:52		
BAYSHORE					7:37	7:43					
22nd STREET											8:11
4TH & TOWNSEND (DTX)	7:21		7:32		7:44	7:49	7:53		8:02		8:16
TRANSBAY TRANSIT CENTER (DTX)	7:26	7:33	7:36	7:39	7:47		7:56	8:02	8:06	8:09	8:20

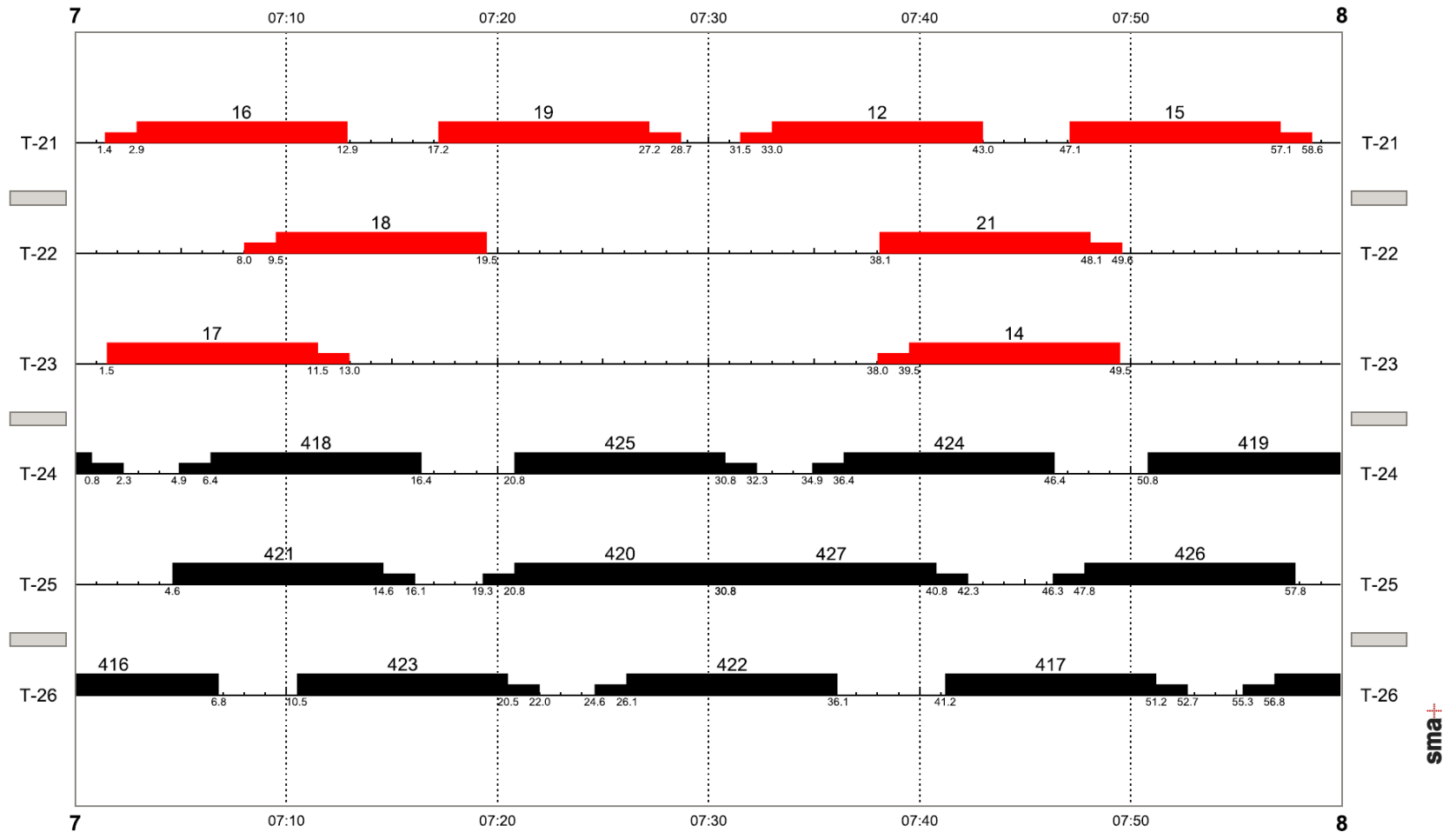
# LTK-DTX-D

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

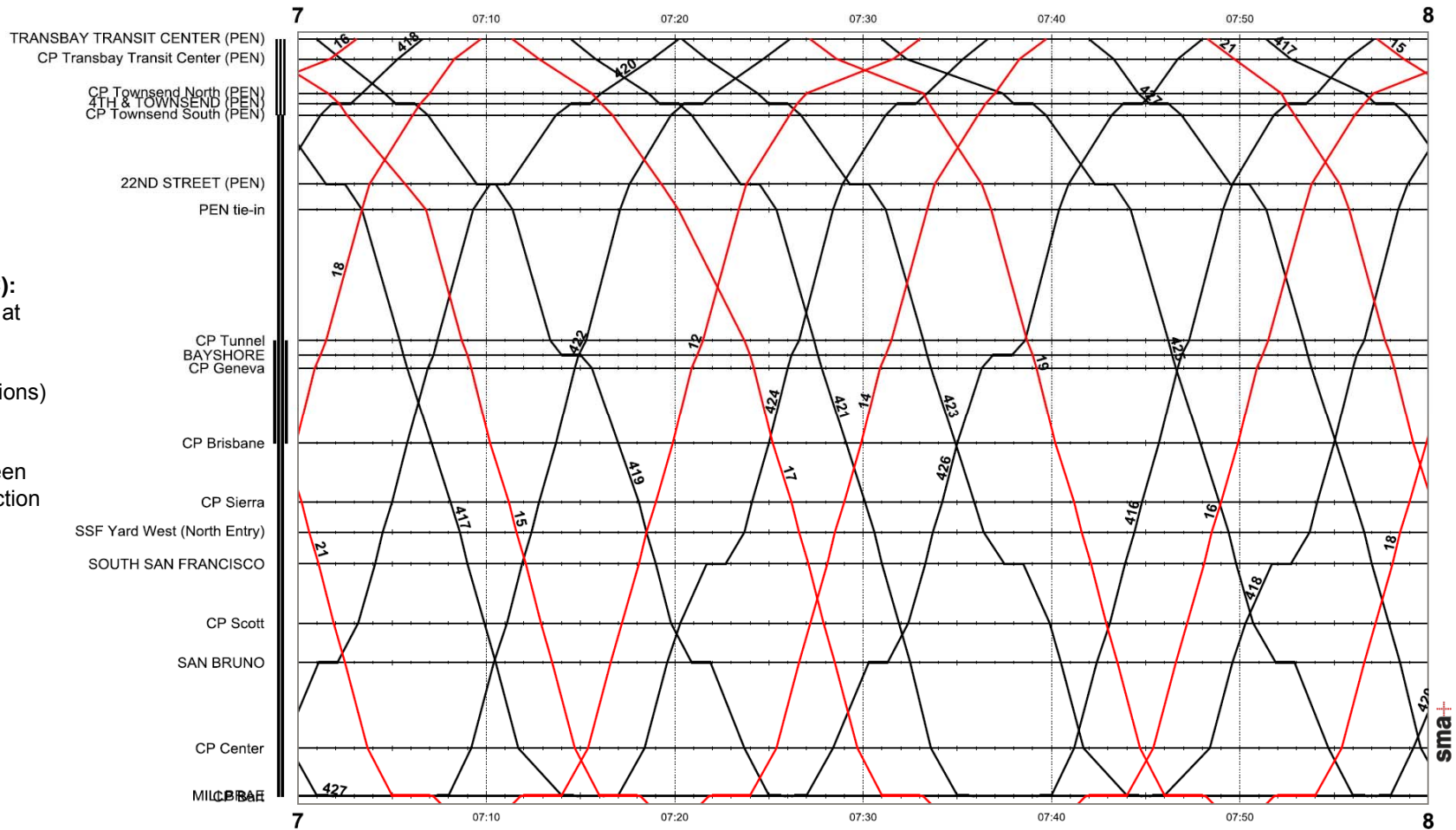
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# LTK-PEN-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-PEN-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

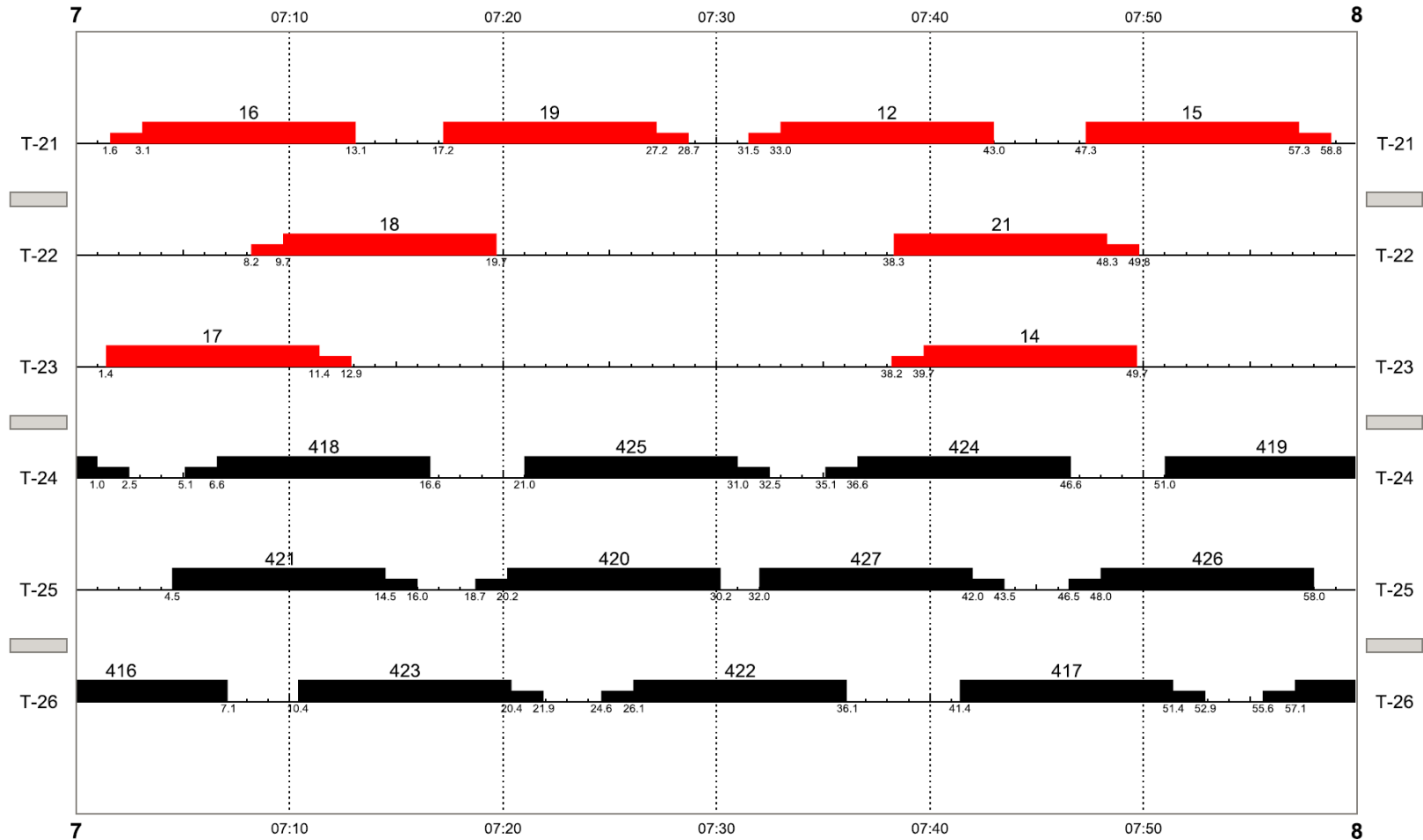
Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (PEN)	6:42	6:48	6:51	6:57	7:01	7:11	7:14	7:20	7:27	7:31
4TH & TOWNSEND (PEN)	6:46		6:58		7:06		7:20	7:26		7:39
22ND STREET (PEN)	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:38		
SAN BRUNO					7:21					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22ND STREET (PEN)										8:11
4TH & TOWNSEND (PEN)	7:21		7:32		7:44	7:53		8:02		8:15
TRANSBAY TRANSIT CENTER (PEN)	7:26	7:33	7:36	7:39	7:48	7:57	8:03	8:06	8:09	8:20

# LTK-PEN-A

**Turn Times:**  
 ≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

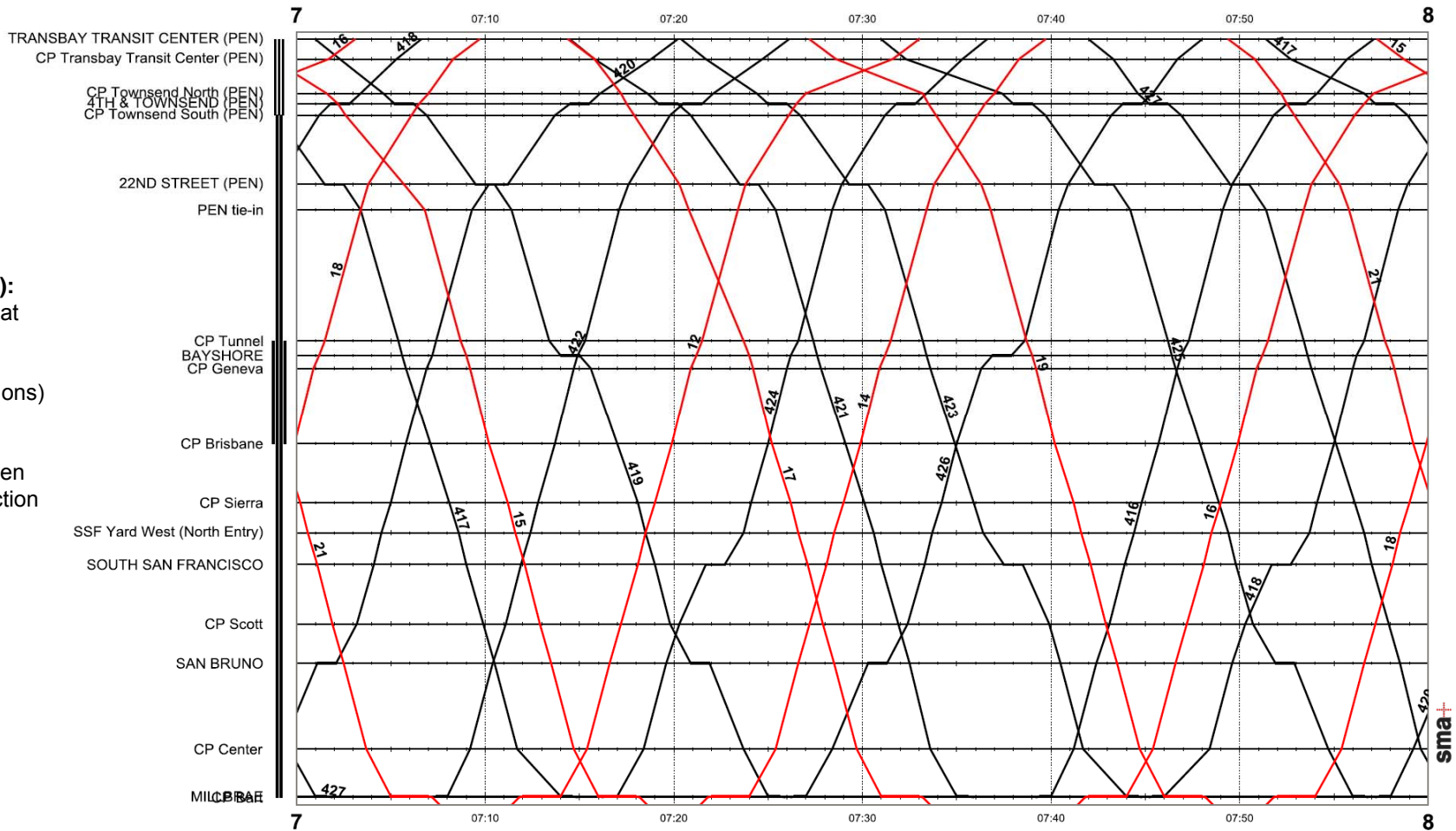
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# LTK-PEN-B

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track





# LTK-PEN-B

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (PEN)	6:42	6:49	6:51	6:57	7:01	7:14	7:14	7:20	7:27	7:31
4TH & TOWNSEND (PEN)	6:46		6:58		7:06		7:20	7:26		7:39
22ND STREET (PEN)	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:38		
SAN BRUNO					7:21					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22ND STREET (PEN)										8:11
4TH & TOWNSEND (PEN)	7:21		7:32		7:44	7:53		8:02		8:15
TRANSBAY TRANSIT CENTER (PEN)	7:26	7:33	7:36	7:39	7:48	7:57	8:03	8:06	8:09	8:20

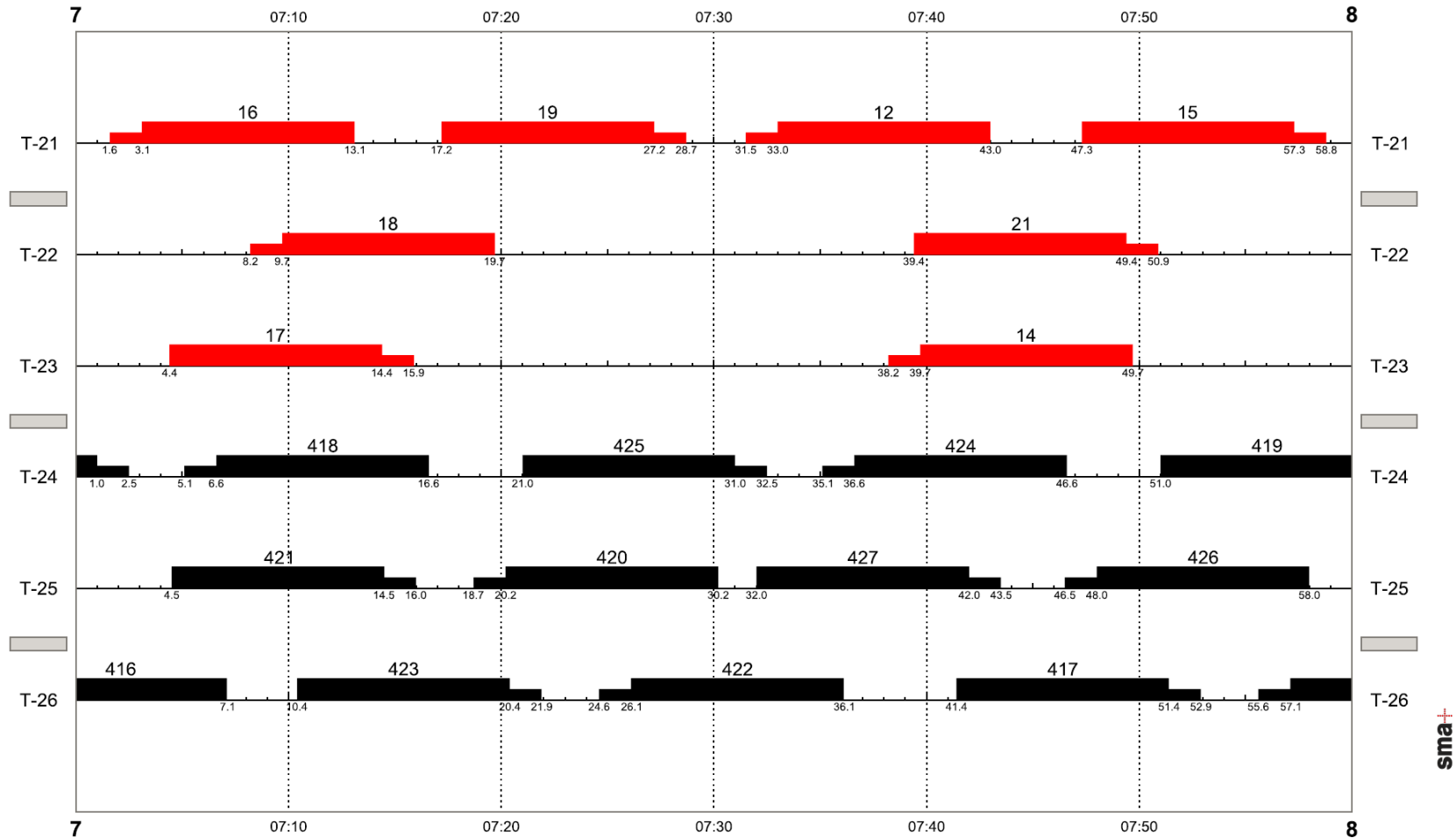
# LTK-PEN-B

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

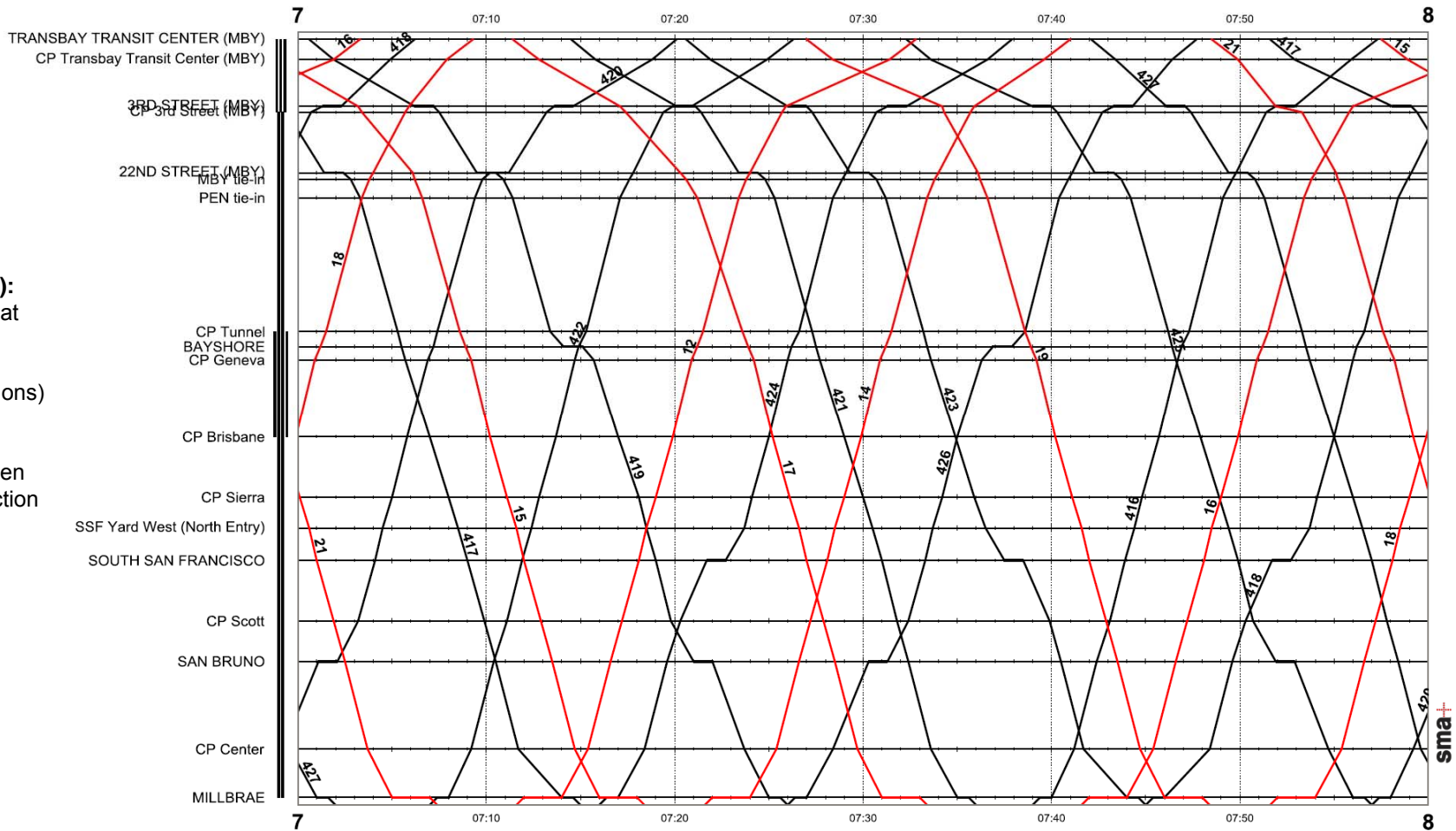
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# LTK-MBY-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-MBY-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (MBY)	6:42	6:48	6:51	6:57	7:00	7:11	7:14	7:20	7:27	7:32
3RD STREET (MBY)	6:47		6:59		7:07		7:21	7:27		7:40
22ND STREET (MBY)	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:38		
SAN BRUNO					7:22					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22ND STREET (MBY)										8:11
3RD STREET (MBY)	7:20		7:32		7:44	7:52		8:02		8:14
TRANSBAY TRANSIT CENTER (MBY)	7:26	7:32	7:37	7:41	7:47	7:57	8:03	8:06	8:09	8:20

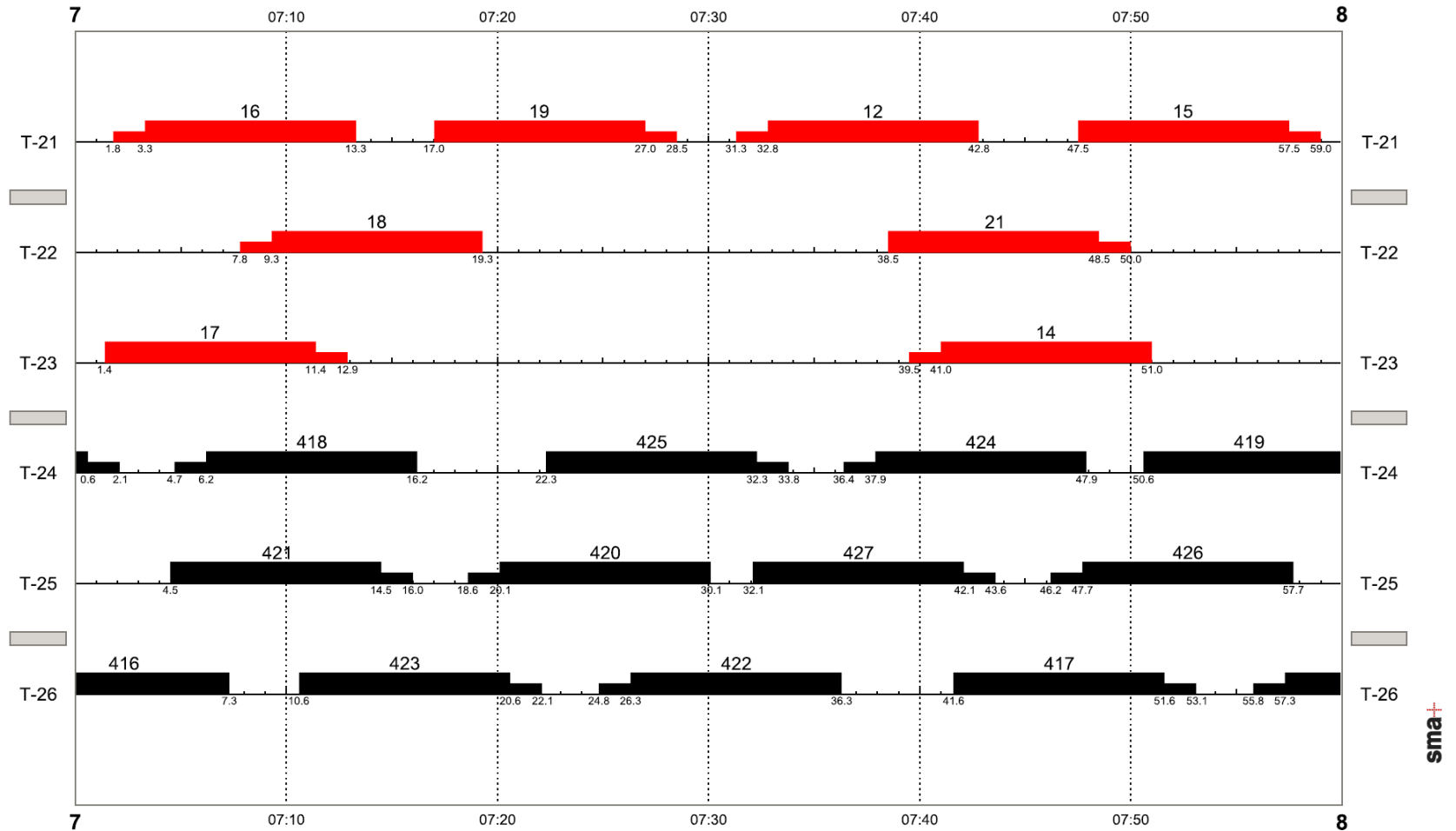
# LTK-MBY-A

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

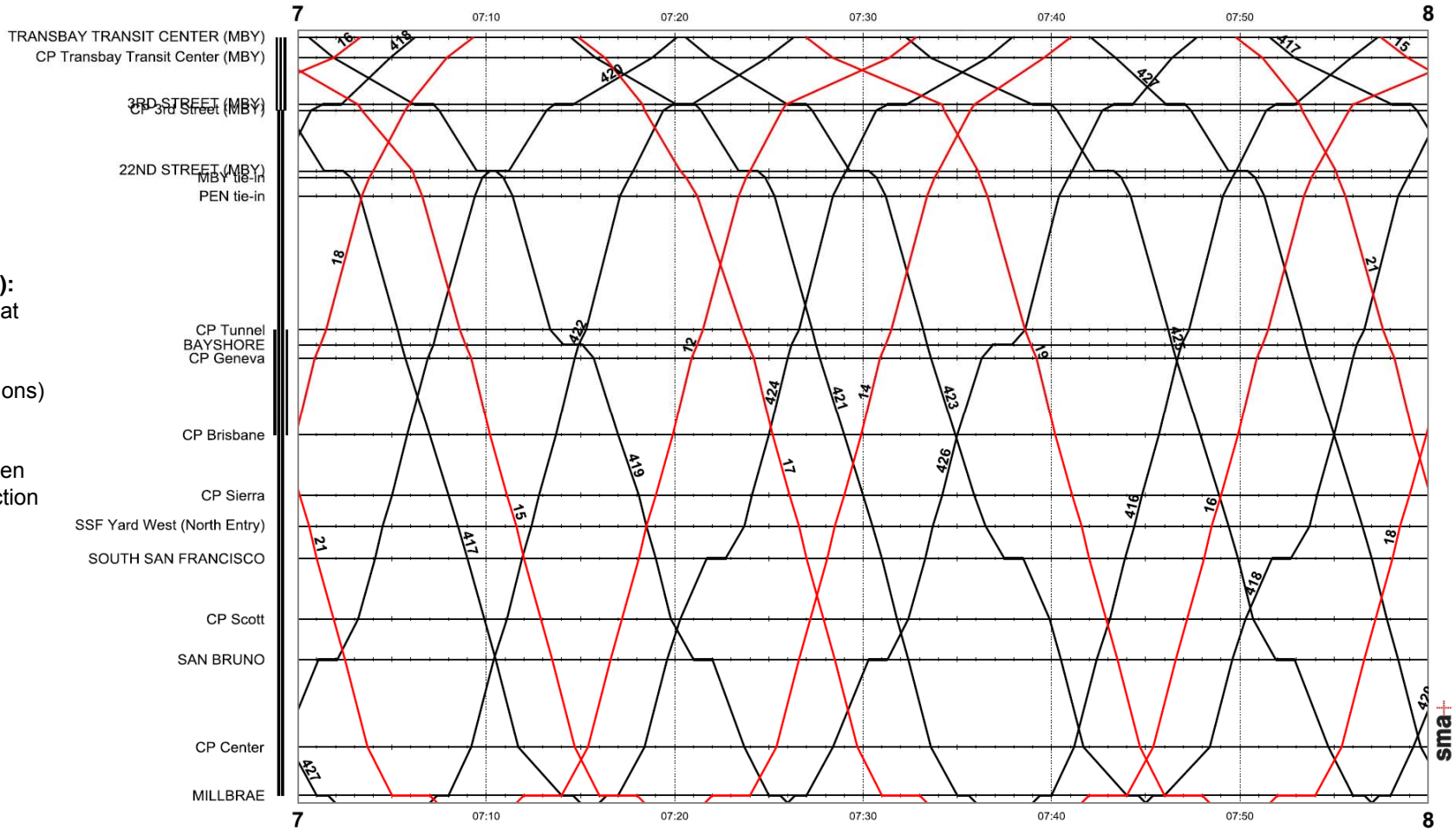
Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.



# LTK-MBY-B

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# LTK-MBY-B

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	IC	REG	IC	REG	IC	REG	REG	IC	REG
Train number	427	21	417	15	419	17	421	423	19	425
TRANSBAY TRANSIT CENTER (MBY)	6:42	6:49	6:51	6:57	7:00	7:14	7:14	7:20	7:27	7:32
3RD STREET (MBY)	6:47		6:59		7:07		7:21	7:27		7:40
22ND STREET (MBY)	6:50		7:02		7:10		7:24	7:30		7:43
BAYSHORE					7:15					
SOUTH SAN FRANCISCO								7:38		
SAN BRUNO					7:22					7:52
MILLBRAE	7:01	7:05	7:14	7:16	7:25	7:31	7:35	7:44	7:46	7:56
Train type	REG	IC	REG	IC	REG	REG	IC	REG	IC	REG
Train number	422	12	424	14	426	416	16	418	18	420
MILLBRAE	7:08	7:14	7:17	7:24	7:27	7:40	7:44	7:46	7:54	7:58
SAN BRUNO					7:31					8:02
SOUTH SAN FRANCISCO			7:22					7:52		
BAYSHORE					7:37					
22ND STREET (MBY)										8:11
3RD STREET (MBY)	7:20		7:32		7:44	7:52		8:02		8:14
TRANSBAY TRANSIT CENTER (MBY)	7:26	7:32	7:37	7:41	7:47	7:57	8:03	8:06	8:09	8:20

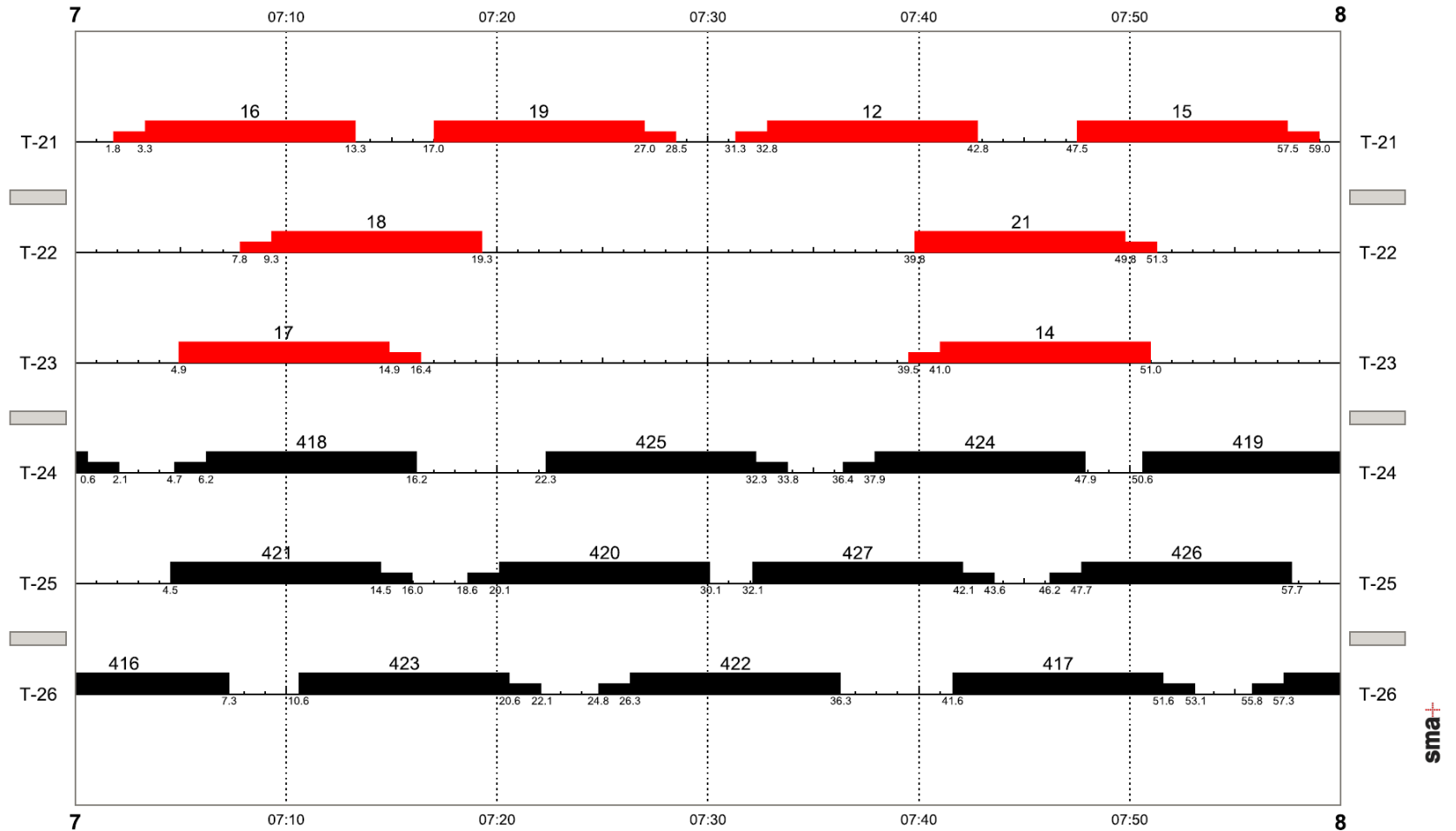
# LTK-MBY-B

## Turn Times:

≥ 20-minute turns for HSR and Caltrain

Each train band represents a 10-minute dwell. 20-minute turns can be visually verified by seeing that the bands forming a train turn pair do not overlap.

Note: This occupation chart shows platform tracks exclusively being used by either HSR or Caltrain; however, operations are not limited to this pattern and either service could use any platform track.

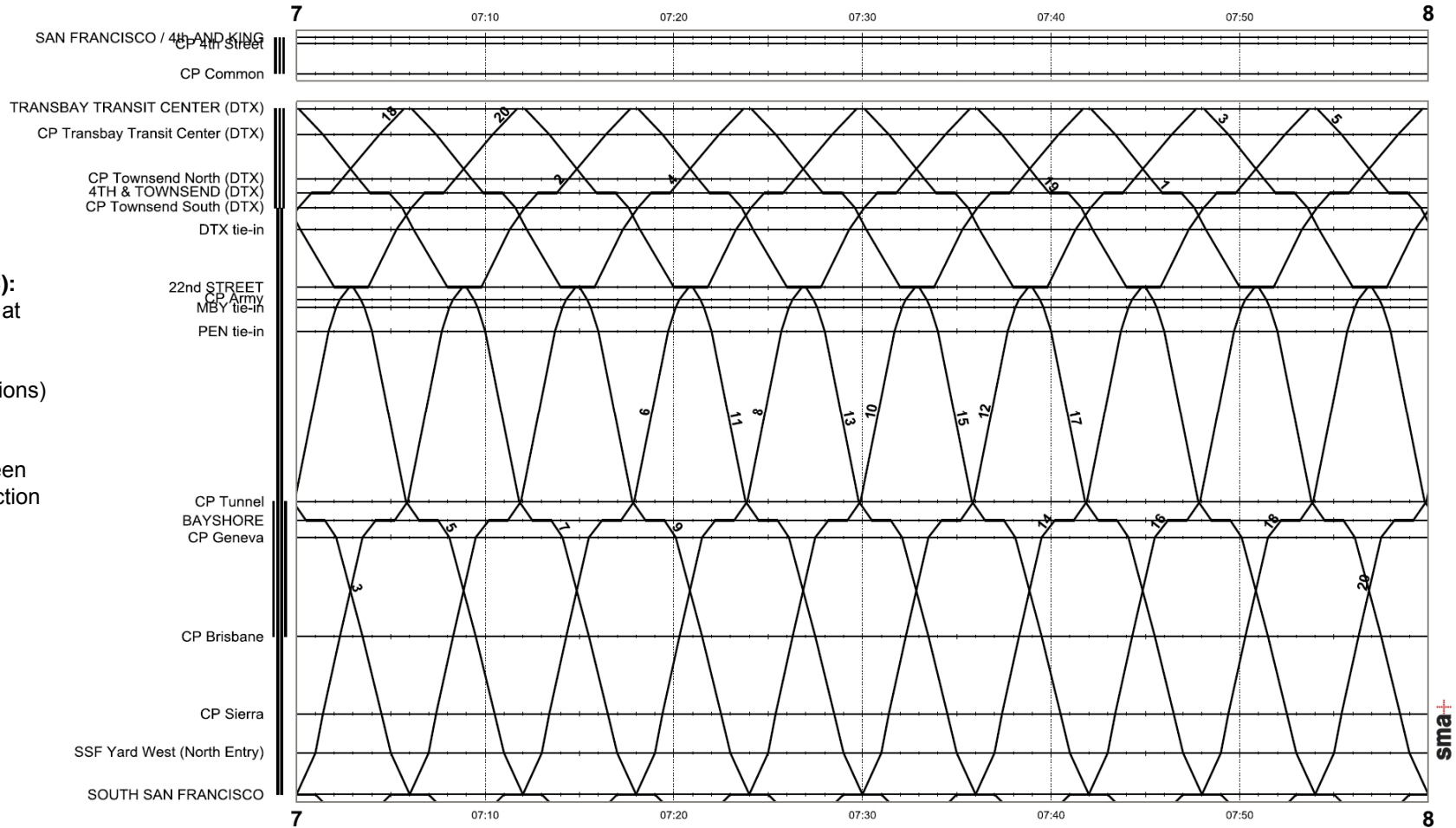




# GEN-DTX-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# GEN-DTX-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	1	3	5	7	9	11	13	15	17	19
TRANSBAY TRANSIT CENTER (DTX)	6:42	6:48	6:54	7:00	7:06	7:12	7:18	7:24	7:30	7:36
4TH & TOWNSEND (DTX)	6:46	6:52	6:58	7:04	7:10	7:16	7:22	7:28	7:34	7:40
22nd STREET	6:51	6:57	7:03	7:09	7:15	7:21	7:27	7:33	7:39	7:45
BAYSHORE	6:55	7:01	7:07	7:13	7:19	7:25	7:31	7:37	7:43	7:49
SOUTH SAN FRANCISCO	7:00	7:06	7:12	7:18	7:24	7:30	7:36	7:42	7:48	7:54

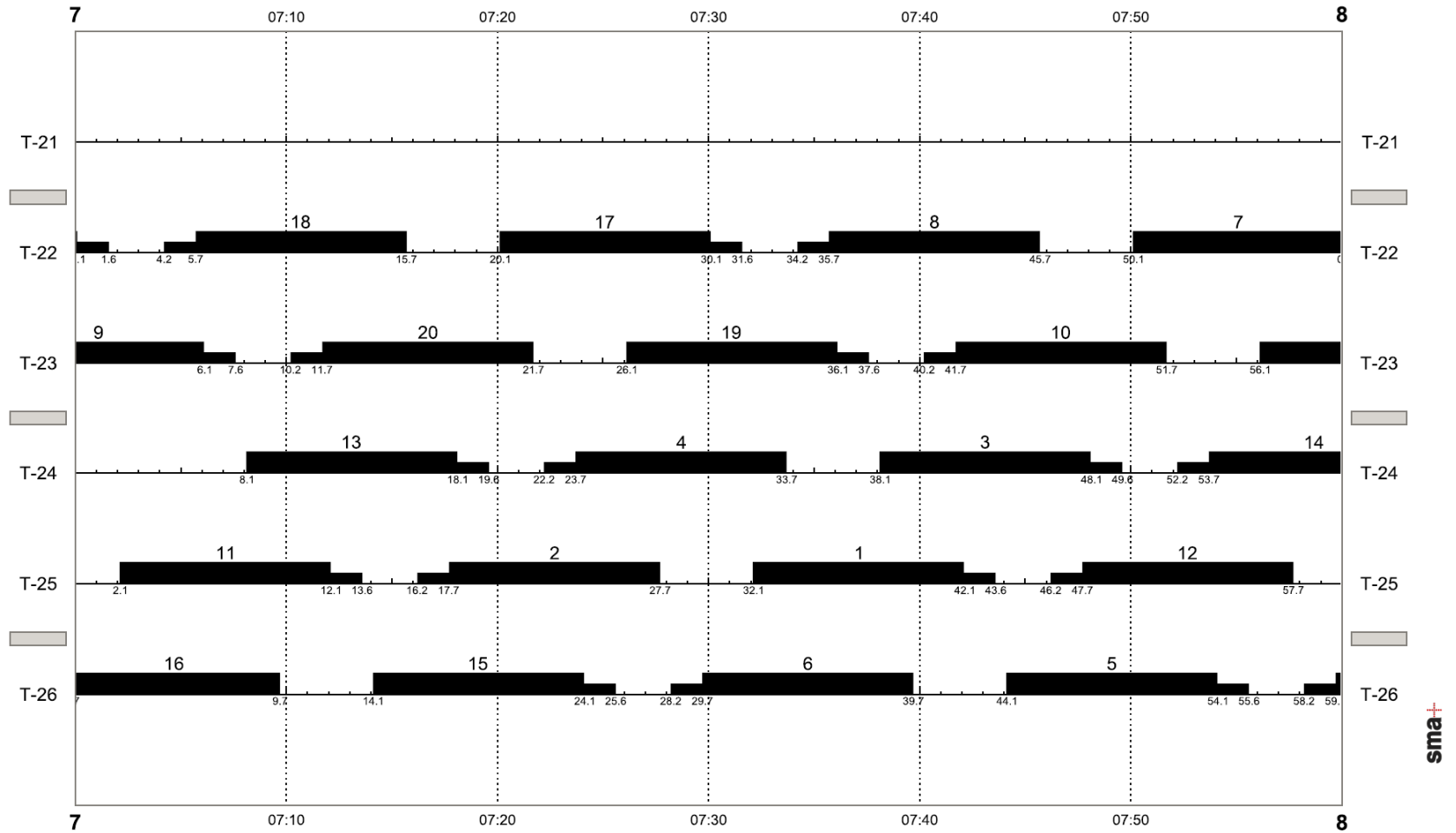
Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	2	4	6	8	10	12	14	16	18	20
SOUTH SAN FRANCISCO	7:00	7:06	7:12	7:18	7:24	7:30	7:36	7:42	7:48	7:54
BAYSHORE	7:05	7:11	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59
22nd STREET	7:09	7:15	7:21	7:27	7:33	7:39	7:45	7:51	7:57	8:03
4TH & TOWNSEND (DTX)	7:13	7:19	7:25	7:31	7:37	7:43	7:49	7:55	8:01	8:07
TRANSBAY TRANSIT CENTER (DTX)	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59	8:05	8:11

# GEN-DTX-A

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

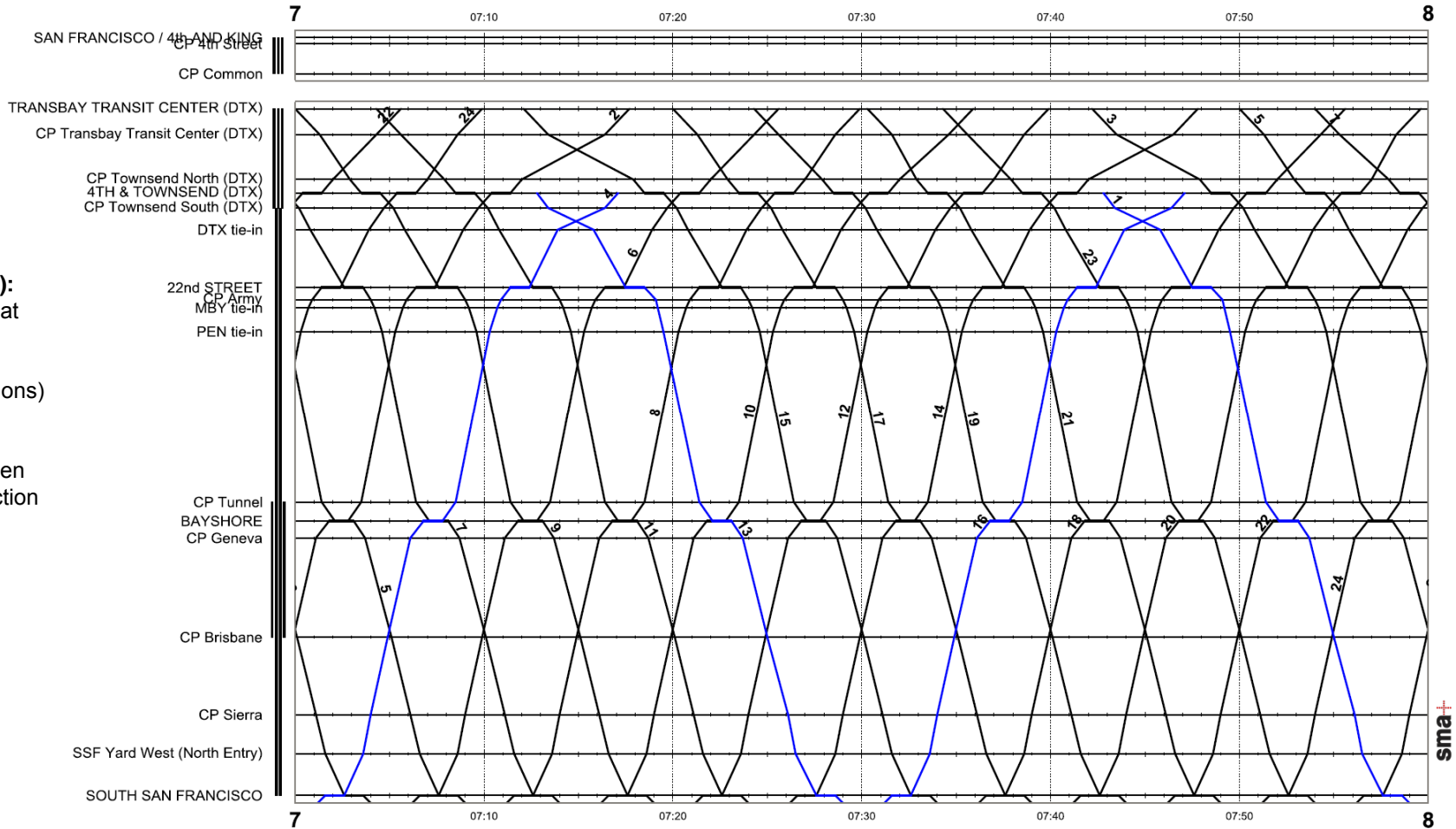
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# GEN-DTX-C

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# GEN-DTX-C

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	3	5	7	9	11	13	15	17	19	21	23	1
TRANSBAY TRANSIT CENTER (DTX)	6:42	6:50	6:54	7:00	7:04		7:12	7:20	7:24	7:30	7:34	
4TH & TOWNSEND (DTX)	6:49	6:54	6:59	7:04	7:09	7:12	7:19	7:24	7:29	7:34	7:39	7:42
22nd STREET	6:53	6:58	7:03	7:08	7:13	7:18	7:23	7:28	7:33	7:38	7:43	7:48
BAYSHORE	6:58	7:03	7:08	7:13	7:18	7:23	7:28	7:33	7:38	7:43	7:48	7:53
SOUTH SAN FRANCISCO	7:02	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57

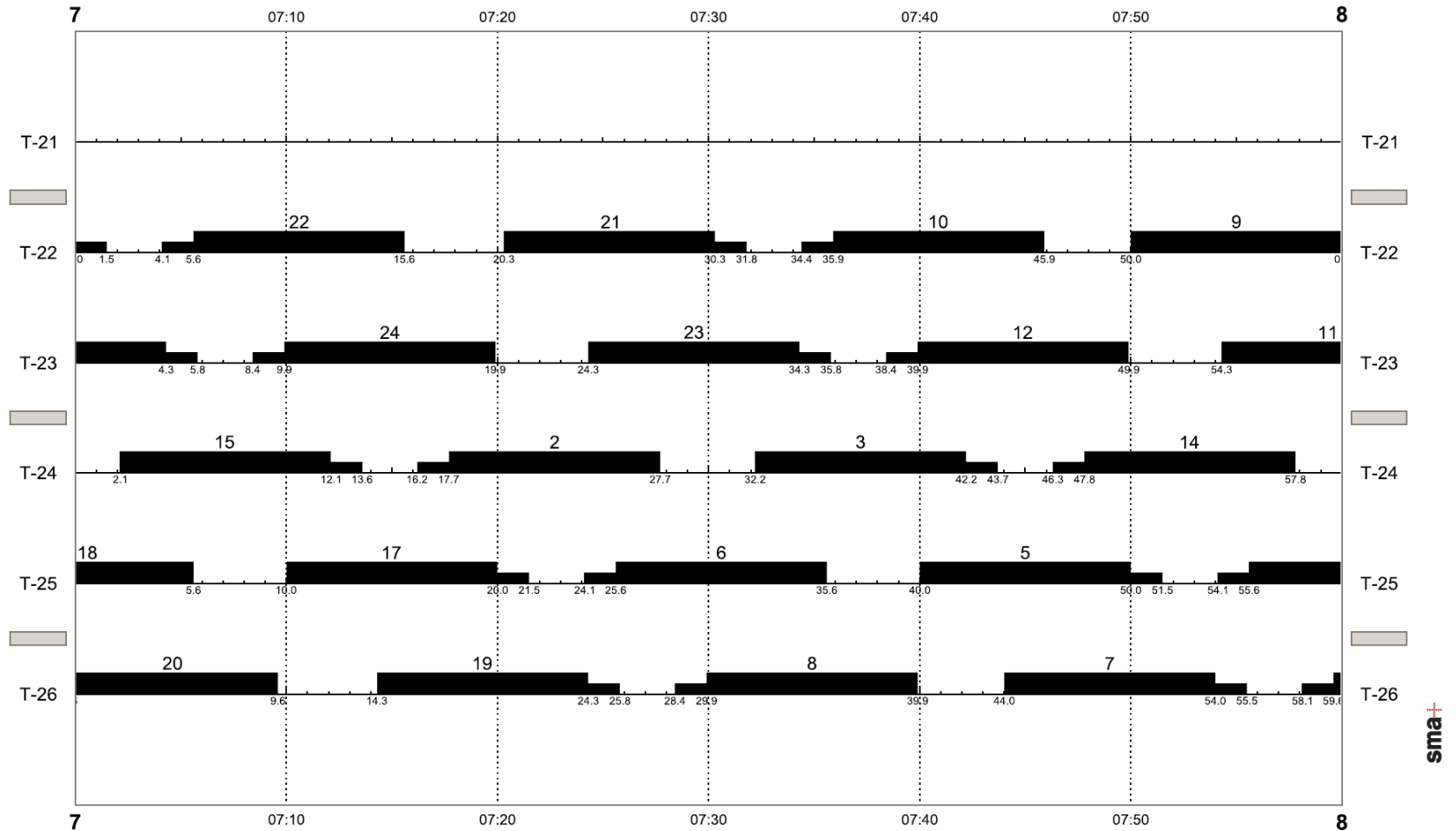
Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	4	6	8	10	12	14	16	18	20	22	24	2
SOUTH SAN FRANCISCO	7:02	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57
BAYSHORE	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57	8:02
22nd STREET	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57	8:02	8:07
4TH & TOWNSEND (DTX)	o 7:17	7:21	7:26	7:31	7:36	7:41	o 7:47	7:51	7:56	8:01	8:06	8:11
TRANSBAY TRANSIT CENTER (DTX)		7:25	7:29	7:35	7:39	7:47		7:55	7:59	8:05	8:09	8:17

# GEN-DTX-C

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

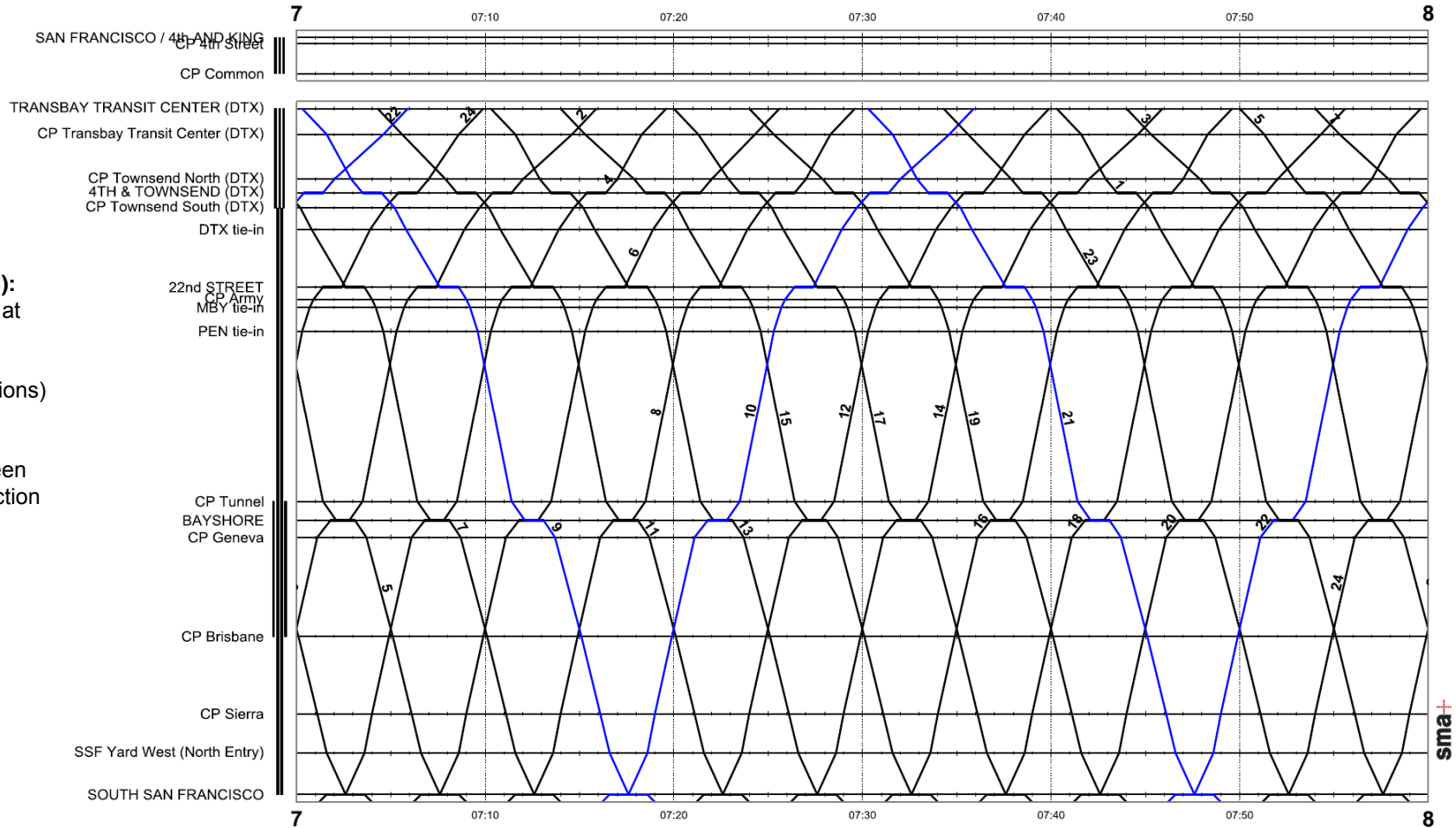
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# GEN-DTX-D

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# GEN-DTX-D

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	3	5	7	9	11	13	15	17	19	21	23	1
TRANSBAY TRANSIT CENTER (DTX)	6:44	6:50	6:54	7:00	7:04	7:10	7:14	7:20	7:24	7:30	7:34	7:40
4TH & TOWNSEND (DTX)	6:49	6:54	6:59	7:04	7:09	7:14	7:19	7:24	7:29	7:34	7:39	7:44
22nd STREET	6:53	6:58	7:03	7:08	7:13	7:18	7:23	7:28	7:33	7:38	7:43	7:48
BAYSHORE	6:58	7:03	7:08	7:13	7:18	7:23	7:28	7:33	7:38	7:43	7:48	7:53
SOUTH SAN FRANCISCO	7:02	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

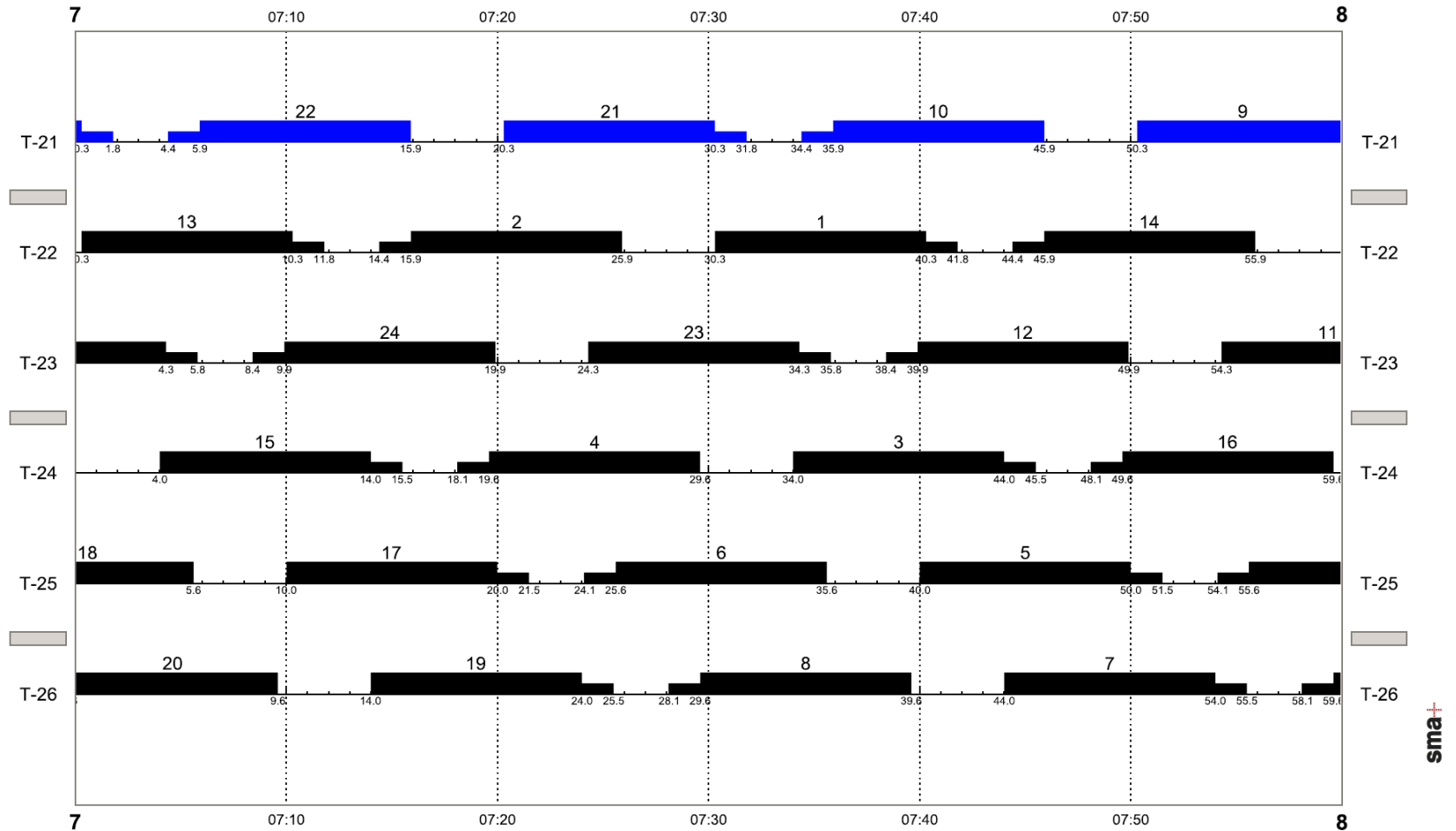
Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	4	6	8	10	12	14	16	18	20	22	24	2
SOUTH SAN FRANCISCO	7:02	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57
BAYSHORE	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57	8:02
22nd STREET	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57	8:02	8:07
4TH & TOWNSEND (DTX)	7:16	7:21	7:26	7:31	7:36	7:41	7:46	7:51	7:56	8:01	8:06	8:11
TRANSBAY TRANSIT CENTER (DTX)	7:19	7:25	7:29	7:35	7:39	7:45	7:49	7:55	7:59	8:05	8:09	8:15



# GEN-DTX-D

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

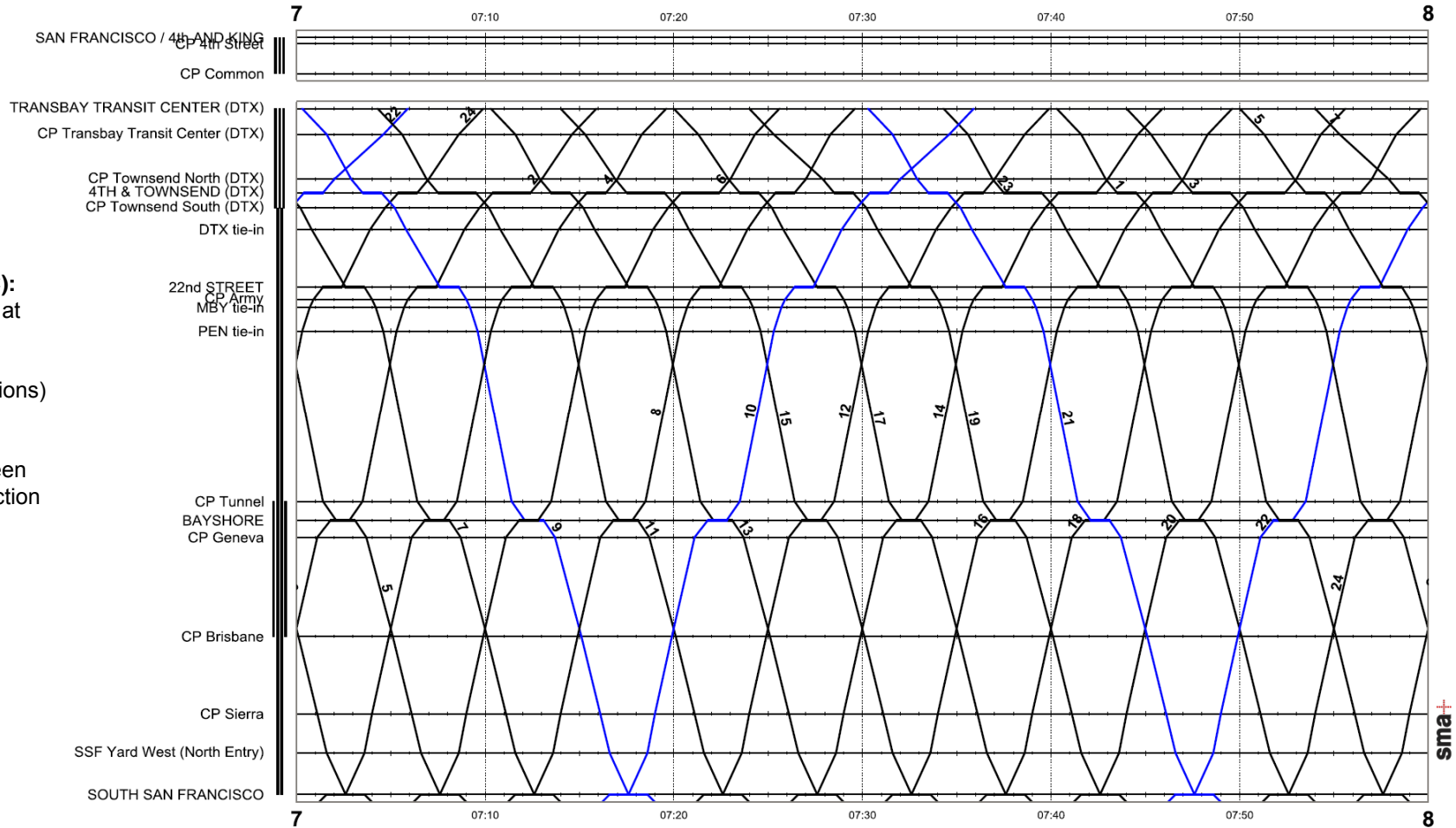
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# GEN-DTX-E

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# GEN-DTX-E

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	3	5	7	9	11	13	15	17	19	21	23	1
TRANSBAY TRANSIT CENTER (DTX)	6:44	6:50	6:54	7:00	7:04	7:10	7:14	7:20	7:24	7:30	7:34	7:40
4TH & TOWNSEND (DTX)	6:49	6:54	6:59	7:04	7:09	7:14	7:19	7:24	7:29	7:34	7:39	7:44
22nd STREET	6:53	6:58	7:03	7:08	7:13	7:18	7:23	7:28	7:33	7:38	7:43	7:48
BAYSHORE	6:58	7:03	7:08	7:13	7:18	7:23	7:28	7:33	7:38	7:43	7:48	7:53
SOUTH SAN FRANCISCO	7:02	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57

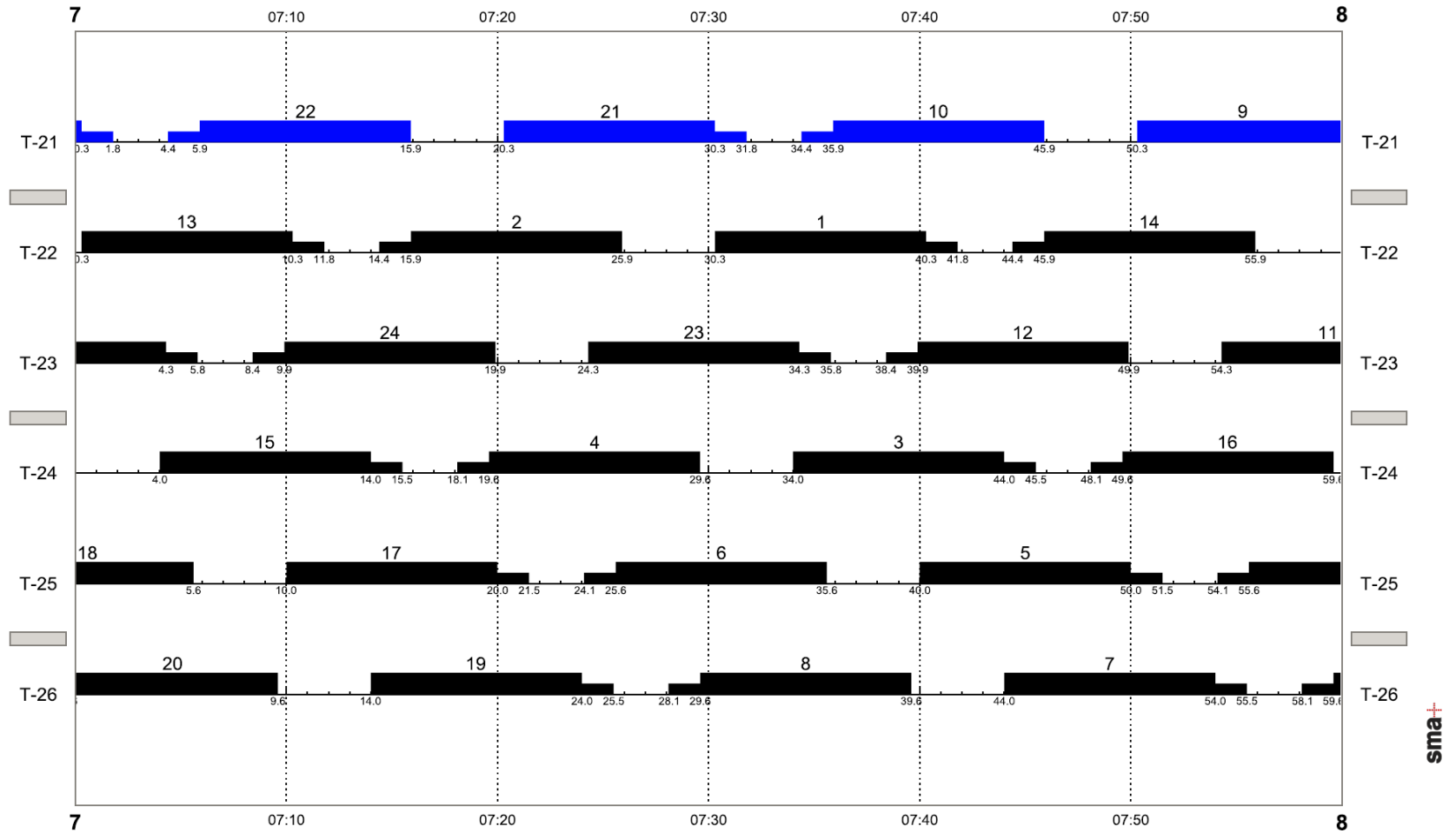
Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	4	6	8	10	12	14	16	18	20	22	24	2
SOUTH SAN FRANCISCO	7:02	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57
BAYSHORE	7:07	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57	8:02
22nd STREET	7:12	7:17	7:22	7:27	7:32	7:37	7:42	7:47	7:52	7:57	8:02	8:07
4TH & TOWNSEND (DTX)	7:16	7:22	7:26	7:31	7:36	7:42	7:46	7:52	7:56	8:01	8:06	8:12
TRANSBAY TRANSIT CENTER (DTX)	7:19	7:25	7:29	7:35	7:39	7:45	7:49	7:55	7:59	8:05	8:09	8:15

# GEN-DTX-E

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

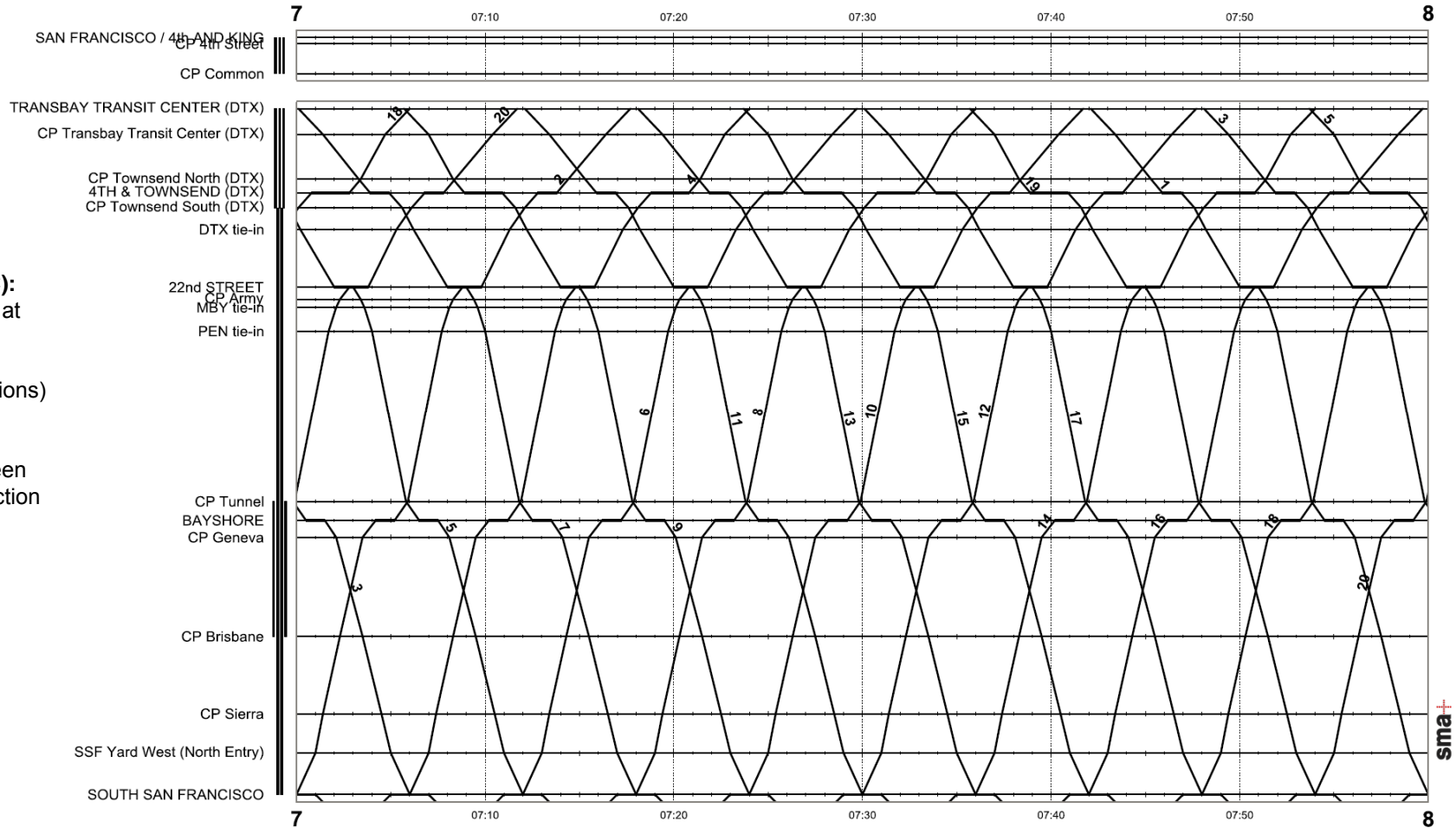
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# GEN-DTX-F

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# GEN-DTX-F

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	1	3	5	7	9	11	13	15	17	19
TRANSBAY TRANSIT CENTER (DTX)	6:42	6:48	6:53	7:00	7:05	7:12	7:18	7:23	7:30	7:35
4TH & TOWNSEND (DTX)	6:46	6:52	6:58	7:04	7:10	7:16	7:22	7:28	7:34	7:40
22nd STREET	6:51	6:57	7:03	7:09	7:15	7:21	7:27	7:33	7:39	7:45
BAYSHORE	6:55	7:01	7:07	7:13	7:19	7:25	7:31	7:37	7:43	7:49
SOUTH SAN FRANCISCO	7:00	7:06	7:12	7:18	7:24	7:30	7:36	7:42	7:48	7:54

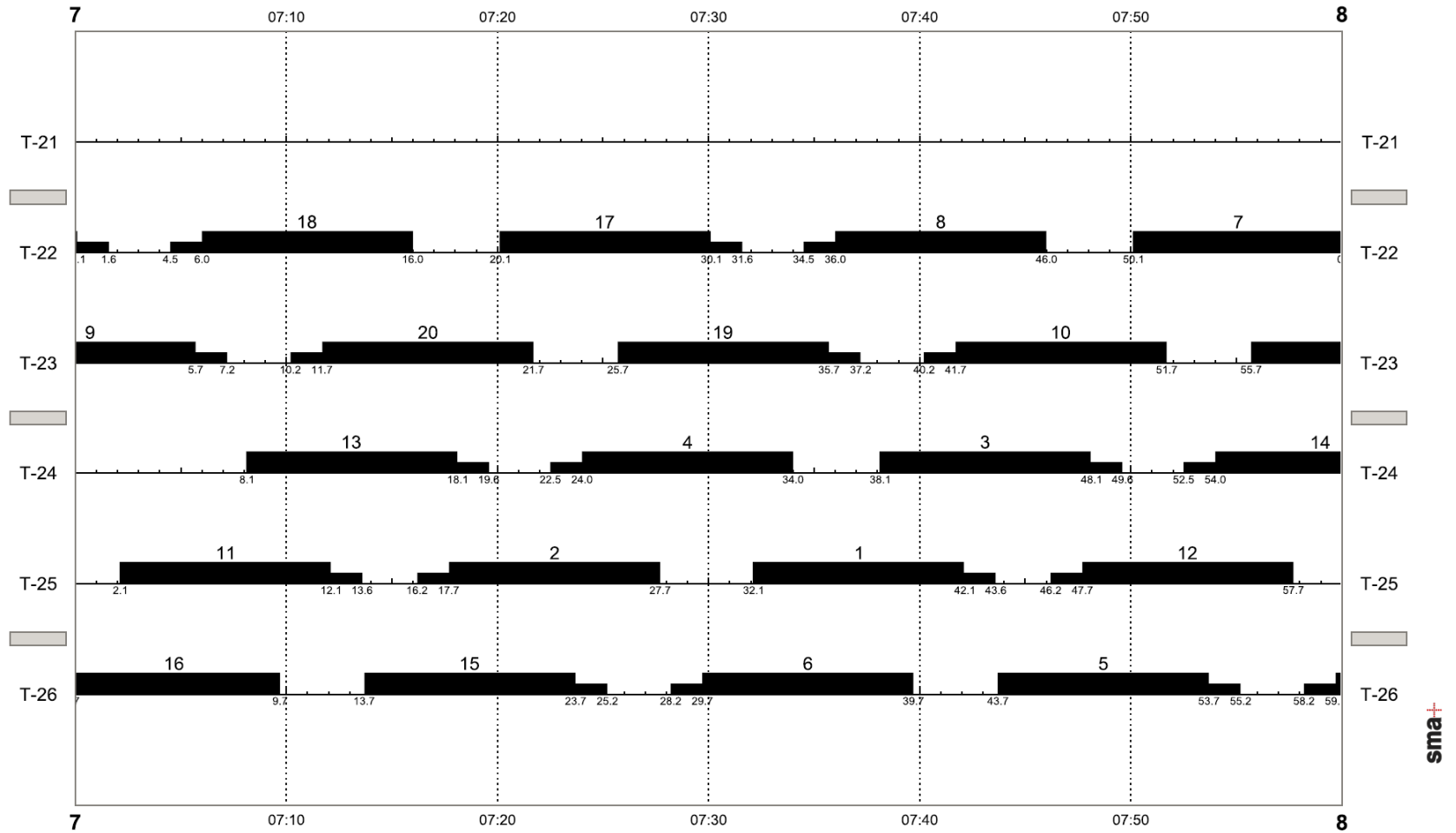
Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	2	4	6	8	10	12	14	16	18	20
SOUTH SAN FRANCISCO	7:00	7:06	7:12	7:18	7:24	7:30	7:36	7:42	7:48	7:54
BAYSHORE	7:05	7:11	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59
22nd STREET	7:09	7:15	7:21	7:27	7:33	7:39	7:45	7:51	7:57	8:03
4TH & TOWNSEND (DTX)	7:13	7:20	7:25	7:32	7:37	7:43	7:50	7:55	8:02	8:07
TRANSBAY TRANSIT CENTER (DTX)	7:17	7:24	7:29	7:36	7:41	7:47	7:54	7:59	8:06	8:11

# GEN-DTX-F

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

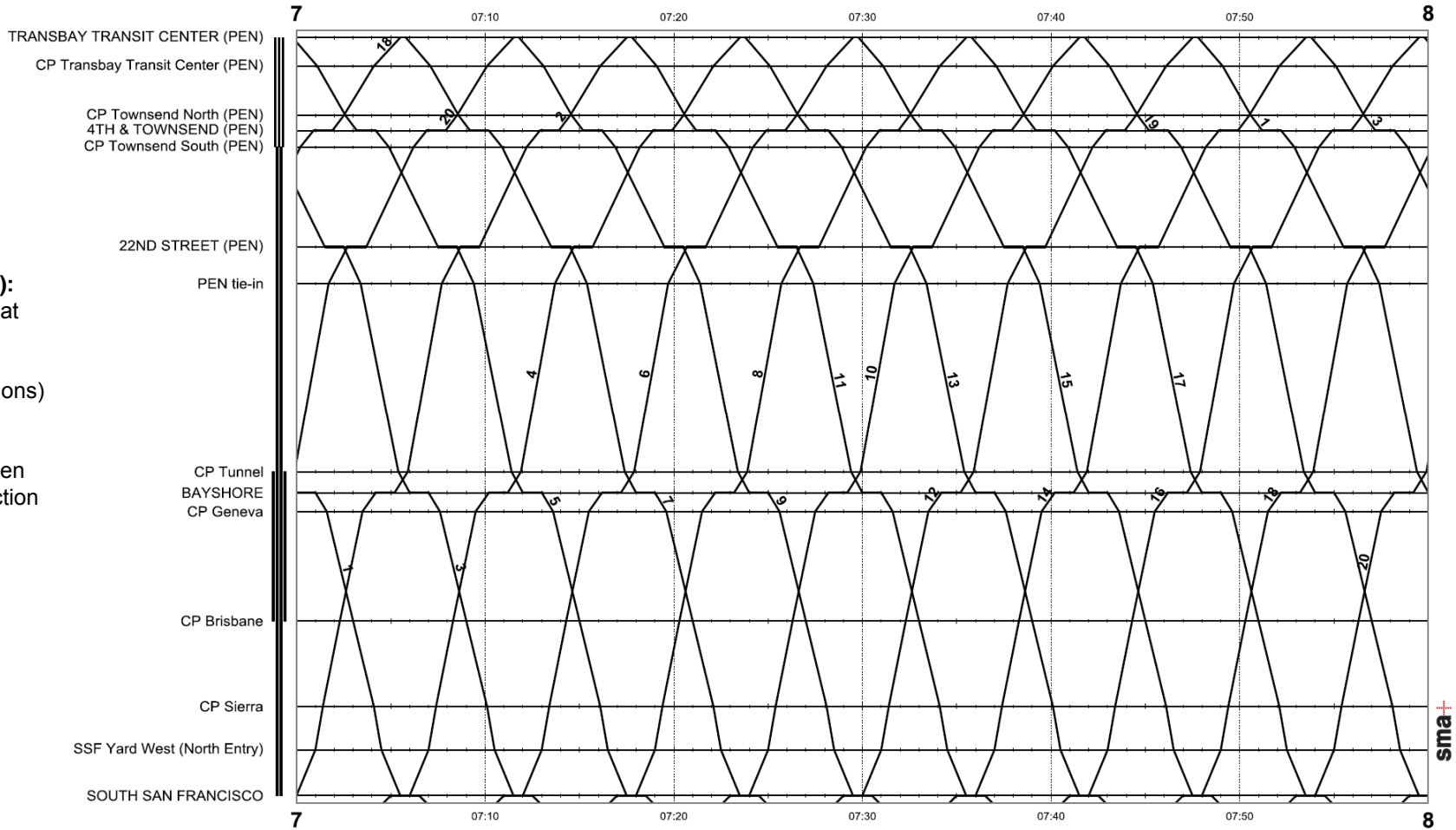
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# GEN-PEN-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track





# GEN-PEN-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	1	3	5	7	9	11	13	15	17	19
TRANSBAY TRANSIT CENTER (PEN)	6:47	6:53	6:59	7:05	7:11	7:17	7:23	7:29	7:35	7:41
4TH & TOWNSEND (PEN)	6:52	6:58	7:04	7:10	7:16	7:22	7:28	7:34	7:40	7:46
22ND STREET (PEN)	6:56	7:02	7:08	7:14	7:20	7:26	7:32	7:38	7:44	7:50
BAYSHORE	7:01	7:07	7:13	7:19	7:25	7:31	7:37	7:43	7:49	7:55
SOUTH SAN FRANCISCO	7:05	7:11	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59

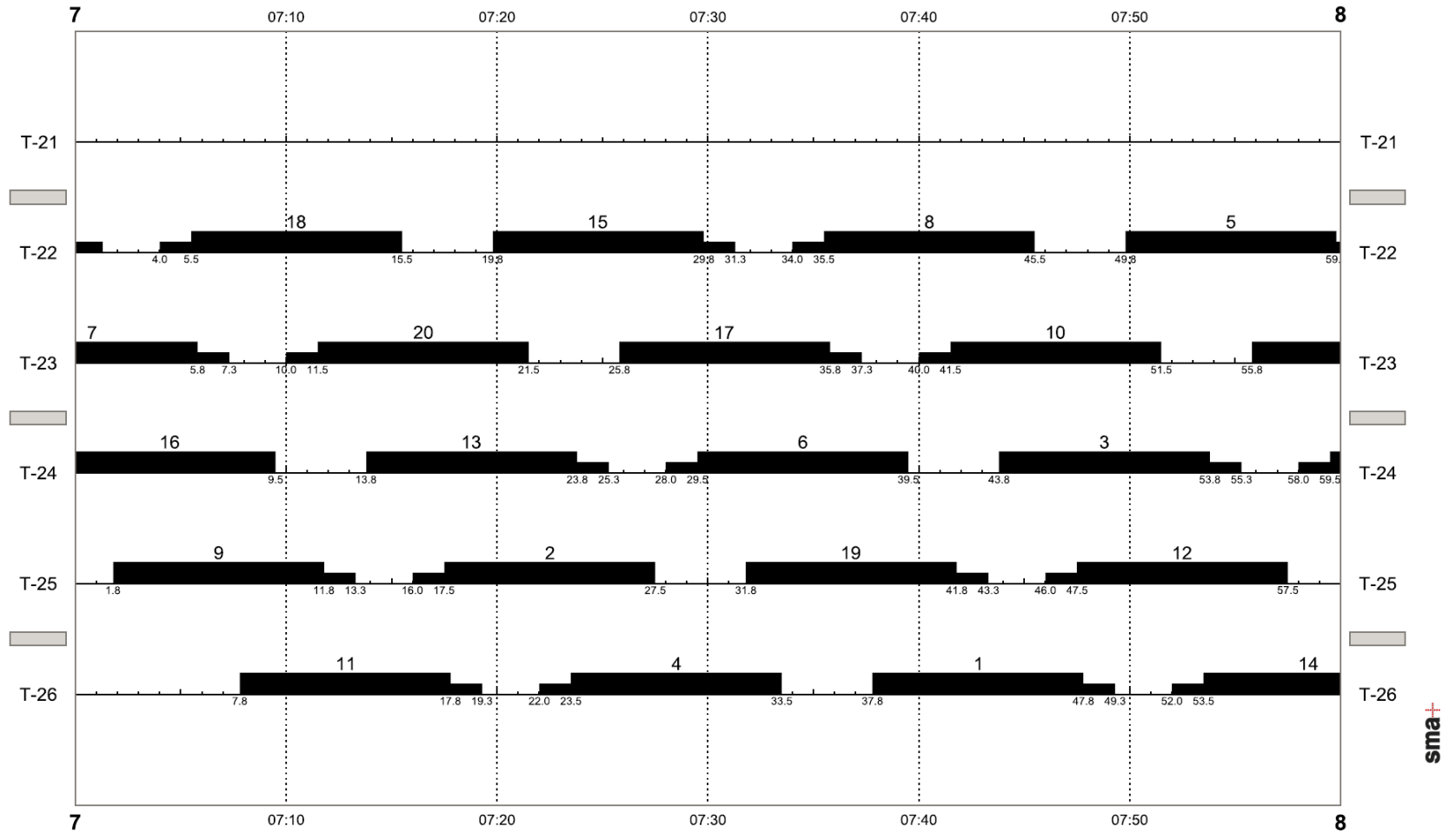
Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	2	4	6	8	10	12	14	16	18	20
SOUTH SAN FRANCISCO	7:00	7:06	7:12	7:18	7:24	7:30	7:36	7:42	7:48	7:54
BAYSHORE	7:05	7:11	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59
22ND STREET (PEN)	7:09	7:15	7:21	7:27	7:33	7:39	7:45	7:51	7:57	8:03
4TH & TOWNSEND (PEN)	7:13	7:19	7:25	7:31	7:37	7:43	7:49	7:55	8:01	8:07
TRANSBAY TRANSIT CENTER (PEN)	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59	8:05	8:11

# GEN-PEN-A

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

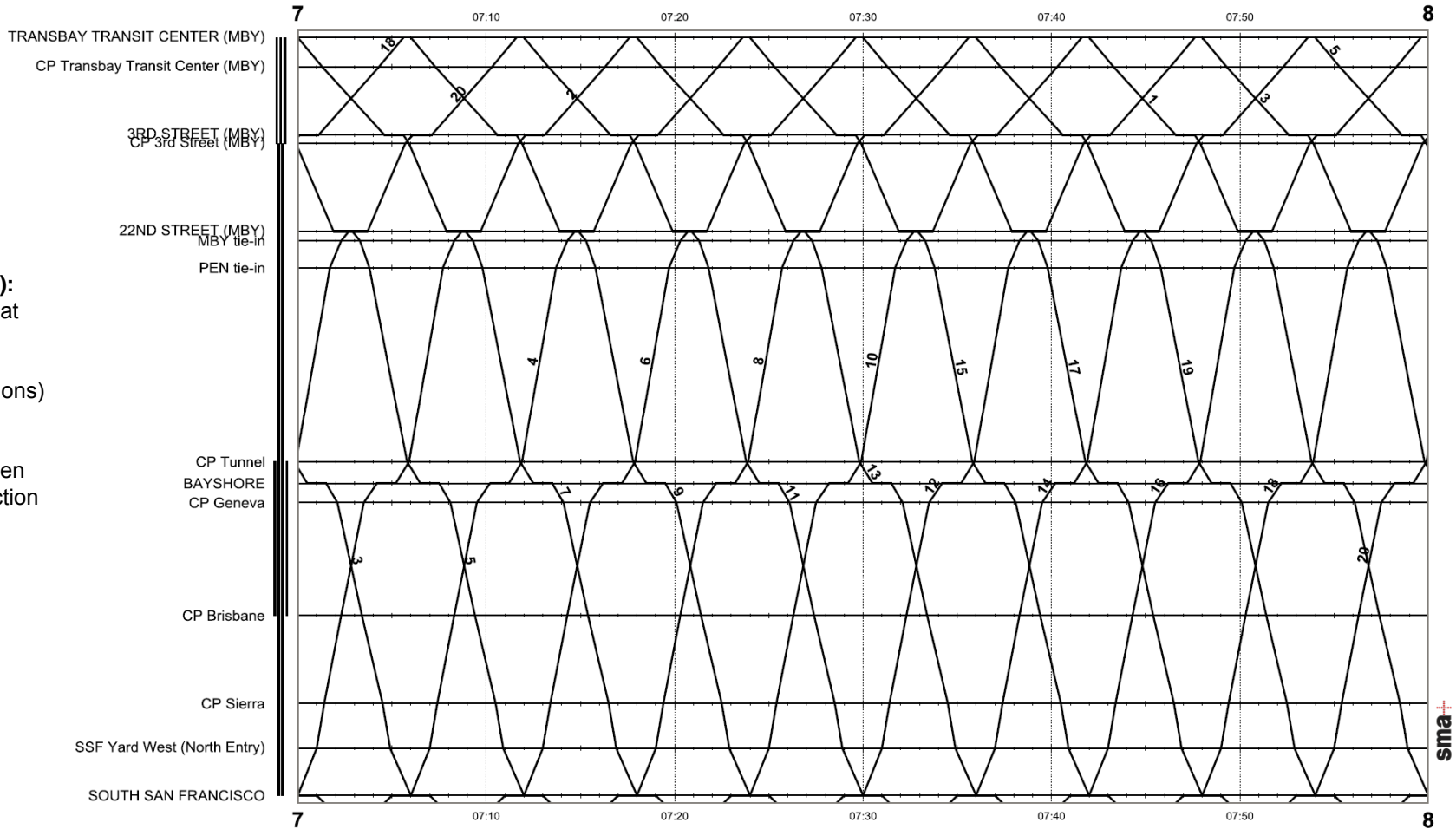
Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.



# GEN-MBY-A

**Separation Times (CP TTC):**  
 3.0-minute separation times at junctions for opposing train movements (e.g. crossing conflicts, platform reoccupations)

**Headways:**  
 3.0-minute separation between trains traveling in same direction on same track



# GEN-MBY-A

Millbrae arrival and departure times specified in original LTK and NAPT service patterns were held constant.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	1	3	5	7	9	11	13	15	17	19
TRANSBAY TRANSIT CENTER (MBY)	6:42	6:48	6:54	7:00	7:06	7:12	7:18	7:24	7:30	7:36
3RD STREET (MBY)	6:47	6:53	6:59	7:05	7:11	7:17	7:23	7:29	7:35	7:41
22ND STREET (MBY)	6:50	6:56	7:02	7:08	7:14	7:20	7:26	7:32	7:38	7:44
BAYSHORE	6:55	7:01	7:07	7:13	7:19	7:25	7:31	7:37	7:43	7:49
SOUTH SAN FRANCISCO	7:01	7:07	7:13	7:19	7:25	7:31	7:37	7:43	7:49	7:55

Note: Concepts with the Generic service pattern begin/end at South San Francisco. The South San Francisco arrival and departure times were not held constant, as they do not affect the Generic service pattern.

Train type	REG	REG	REG	REG	REG	REG	REG	REG	REG	REG
Train number	2	4	6	8	10	12	14	16	18	20
SOUTH SAN FRANCISCO	7:00	7:06	7:12	7:18	7:24	7:30	7:36	7:42	7:48	7:54
BAYSHORE	7:05	7:11	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59
22ND STREET (MBY)	7:09	7:15	7:21	7:27	7:33	7:39	7:45	7:51	7:57	8:03
3RD STREET (MBY)	7:13	7:19	7:25	7:31	7:37	7:43	7:49	7:55	8:01	8:07
TRANSBAY TRANSIT CENTER (MBY)	7:17	7:23	7:29	7:35	7:41	7:47	7:53	7:59	8:05	8:11

# GEN-MBY-A

**Turn Times:**  
 ≥ 20-minute turns for HSR  
 and Caltrain

Each train band represents a  
 10-minute dwell. 20-minute  
 turns can be visually verified  
 by seeing that the bands  
 forming a train turn pair do  
 not overlap.

