Appendix C: Operations Analysis Phase I Report and Phase II Supplementary Presentation

San Francisco Railyards Relocation and I-280 Boulevard Feasibility Study (RAB)

RAB Operations Sketch Planning Analysis

Presented April 17, 2015
Revised November 4, 2015

optimising railways

sma

Agenda

Input Documents

Alignments

Operations

Scenario Analysis

Conclusions

Input Documents

- Current DTX Progress drawings (2012) were used for the TTC track and signal layout.
- 2011 Blended Study
- The *RAB Draft Conceptual Alternatives* document was used to estimate how the tunnel variants would connect to the network.
- The *RAB Draft Conceptual Alternatives* document and associated alignment breakdown information was used for the track horizontal and vertical alignment information.
- Proposed station locations were estimated from the *RAB Draft Conceptual Alternatives* document by taking the midpoint of the proposed station location areas.

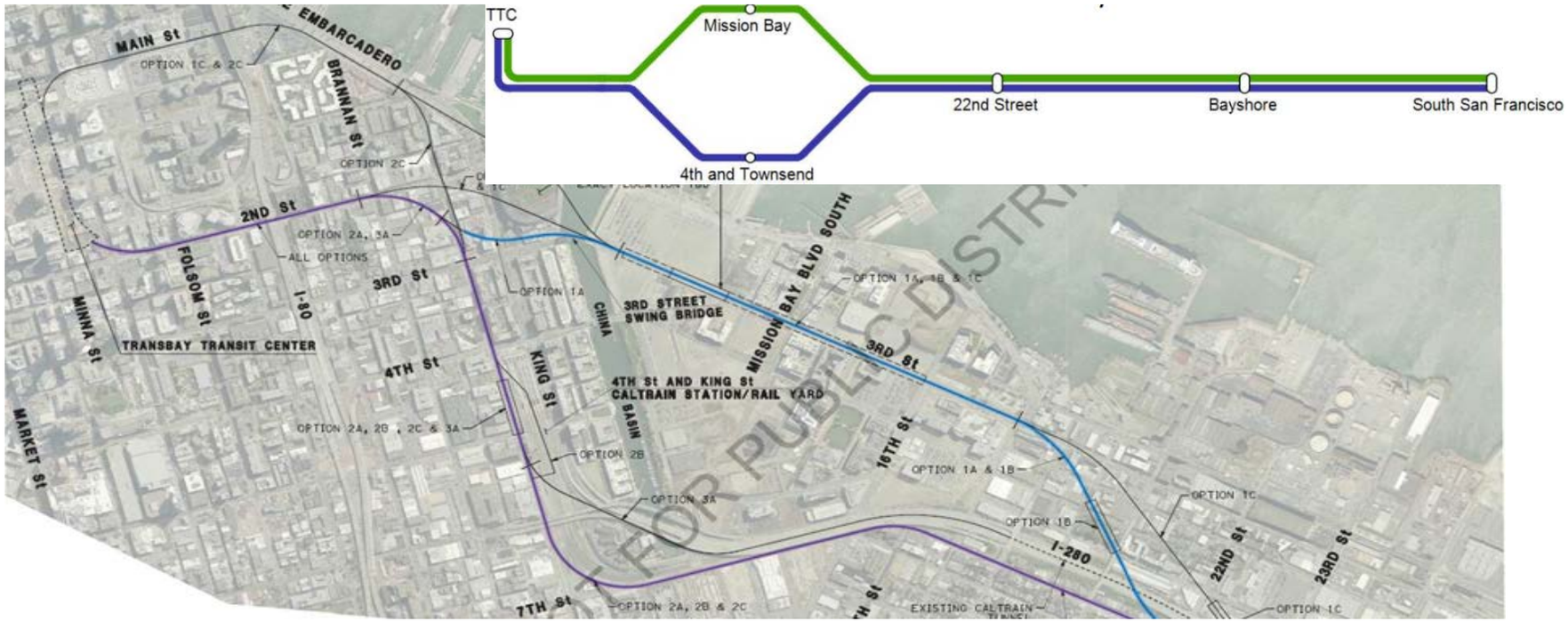
Alignment Options

RAB is studying three alignment options:

- The current Caltrain alignment and approved DTX (the RAB no-build option)
- The Pennsylvania Alignment option
- The Mission Bay Alignment option

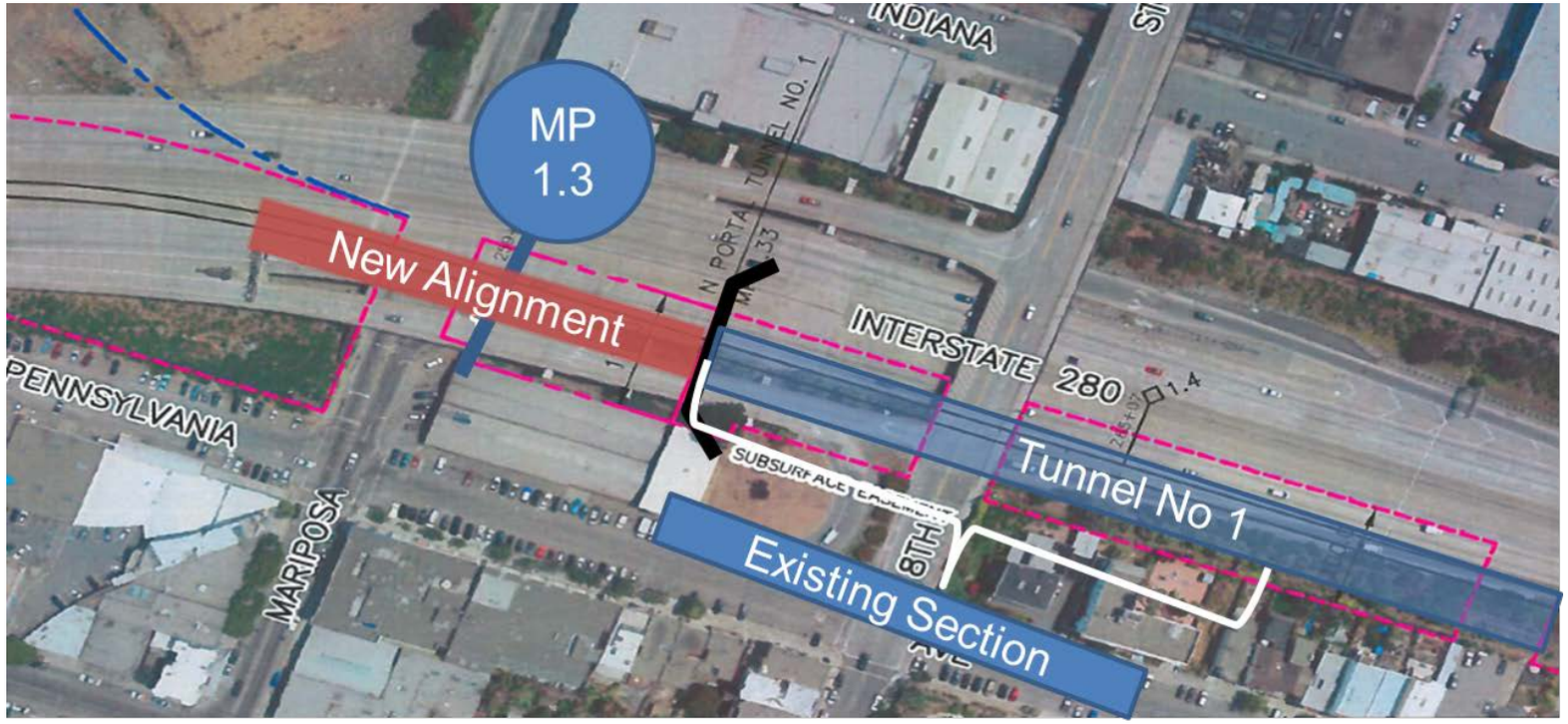
Alignment Options

- RAB Study area is TTC to South San Francisco, only.
- Review of the alignment options, train sets, and speed profiles reveals that all three alignments operate similarly (within 1.8 minute runtime variation).



– Pennsylvania and Mission Bay alignments would connect to the existing network at CP Army. (25th and Pennsylvania Avenue)

Alignment Options



Train Sets Used

Caltrain

– EMU double decker (Stadler KISS)

HSR

– Siemens Velaro

Speed Profiles

E_a Assumptions

- Two speed profiles were calculated using superelevations of:
  - 2 inches
  - 3 inches

- Speed profiles were simplified to multiples of 10 mph

  (Conclusion: In the tunnel 30 & 40 mph were permissable)

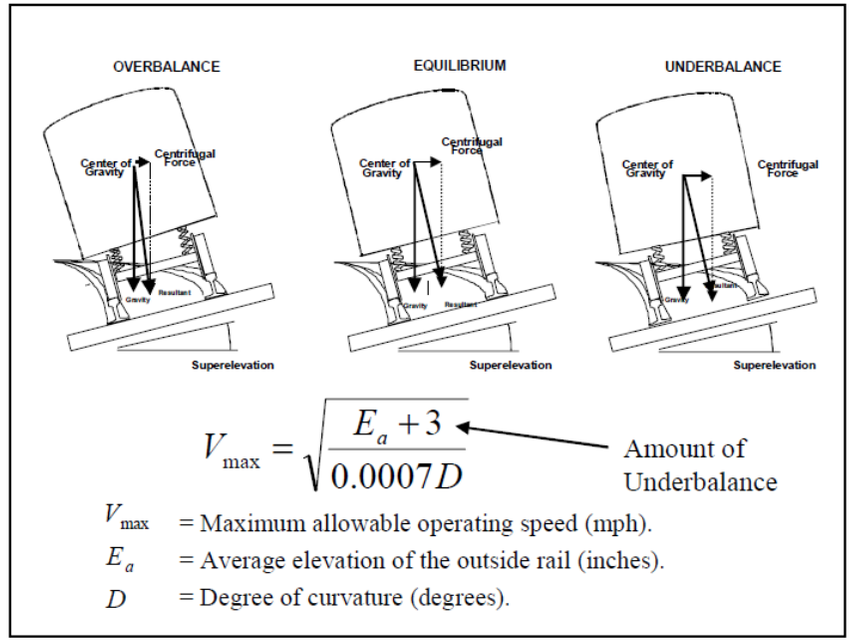


Figure 6-7 Overbalance, Equilibrium and Underbalanced

*from Caltrain's "Engineering Standards" – Chapter 2 – Track Design

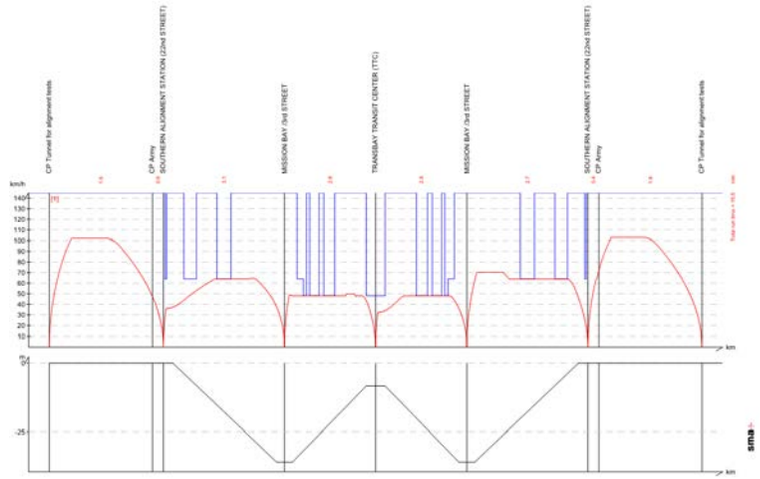
Speed Profiles

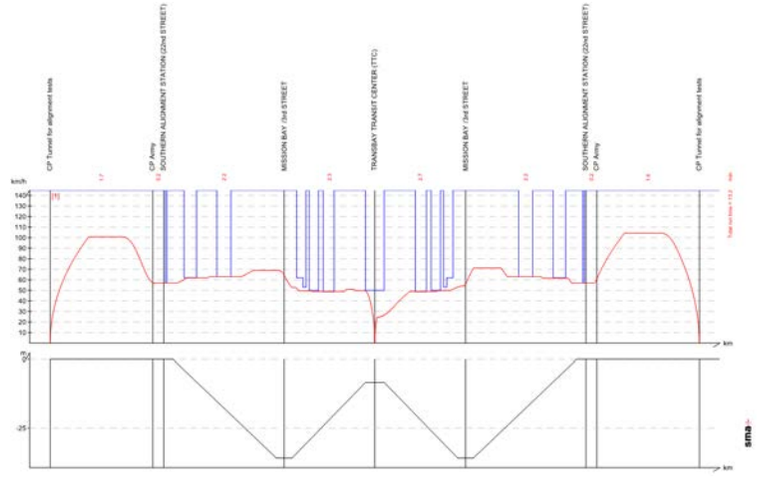
Entering and Exiting System

Caltrain

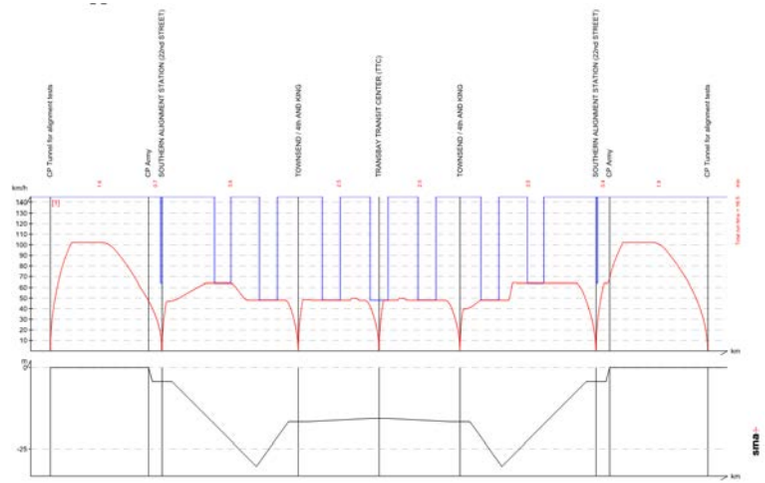
HSR

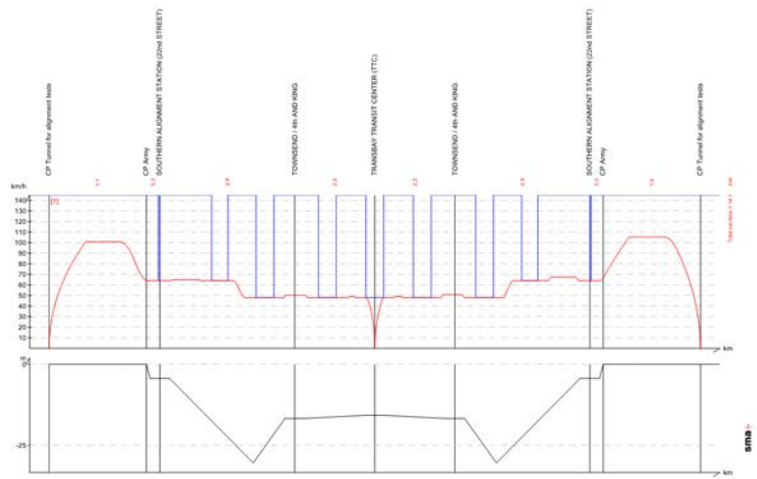
Mission Bay Alignment





Pennsylvania and Current Approved (no-build) Alignments





Pre-Screening Results

Alignment	Running Times CP Army - TTC - CP Army CALTRAIN	HSR
Mission Bay	11.7	9
Pennsylvania	13.3	10.8
Current+DTX	12.7	10

Calculated Runtimes

Stations	Technical Running Times HSR	Caltrain Express	Caltrain Local	Max Run time	Runtime + 10% Reserve Max Run time	Most Conservative Case	
South San Francisco							**South San Francisco**
SSF	1.0	0.8	0.8	1.0	1.1	1.3	SSF
CP Sierra	0.4	0.4	0.4	0.4	0.4	0.4	CP Sierra
CP Brisbane	1.0	0.9	0.9	1.0	1.1	1.1	CP Brisbane
CP Geneva	1.0	1.2	1.2	1.2	1.3	1.3	CP Geneva
Bayshore	0.3	0.4	1.0	1.0	1.1	1.1	**Bayshore**
CP Tunnel	0.3	0.2	0.5	0.5	0.6	0.9	CP Tunnel
CP Army	2.3	2.4	2.5	2.5	2.8	2.8	CP Army
CP 22nd South	0.0	0.0	0.0	0.0	0.0	0.1	CP 22nd South
Southern Street	0.3	0.3	0.6	0.6	0.7	0.7	**Southern Street**
CP 22nd North	0.2	0.2	0.4	0.4	0.4	0.7	CP 22nd North
CP Townsend South	2.4	2.4	2.6	2.6	2.9	2.9	CP Townsend South
Townsend	0.3	0.6	0.6	0.6	0.7	0.7	**Townsend**
CP Townsend North	0.3	0.4	0.4	0.4	0.4	0.7	CP Townsend North
CP Transit Center	1.6	1.6	1.6	1.6	1.8	1.8	CP Transit Center
Transbay Transit Center	0.5	0.6	0.6	0.6	0.7	0.7	**Transbay Transit Center**
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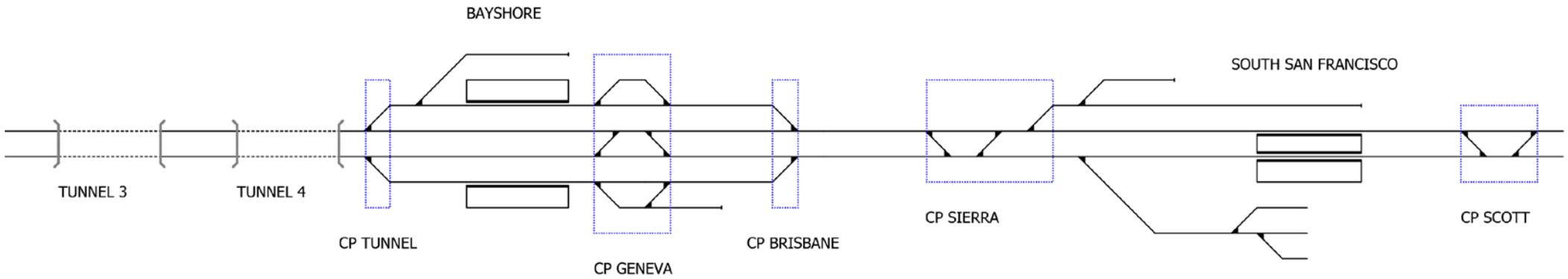
CP Brisbane	1.0	1.2	1.2	1.2	1.3	1.3	CP Brisbane
CP Sierra	1.0	1.0	0.9	1.0	1.1	1.1	CP Sierra
SSF	0.4	0.4	0.4	0.4	0.4	0.4	SSF
South San Francisco	0.9	1.1	1.2	1.2	1.3	1.3	**South San Francisco**

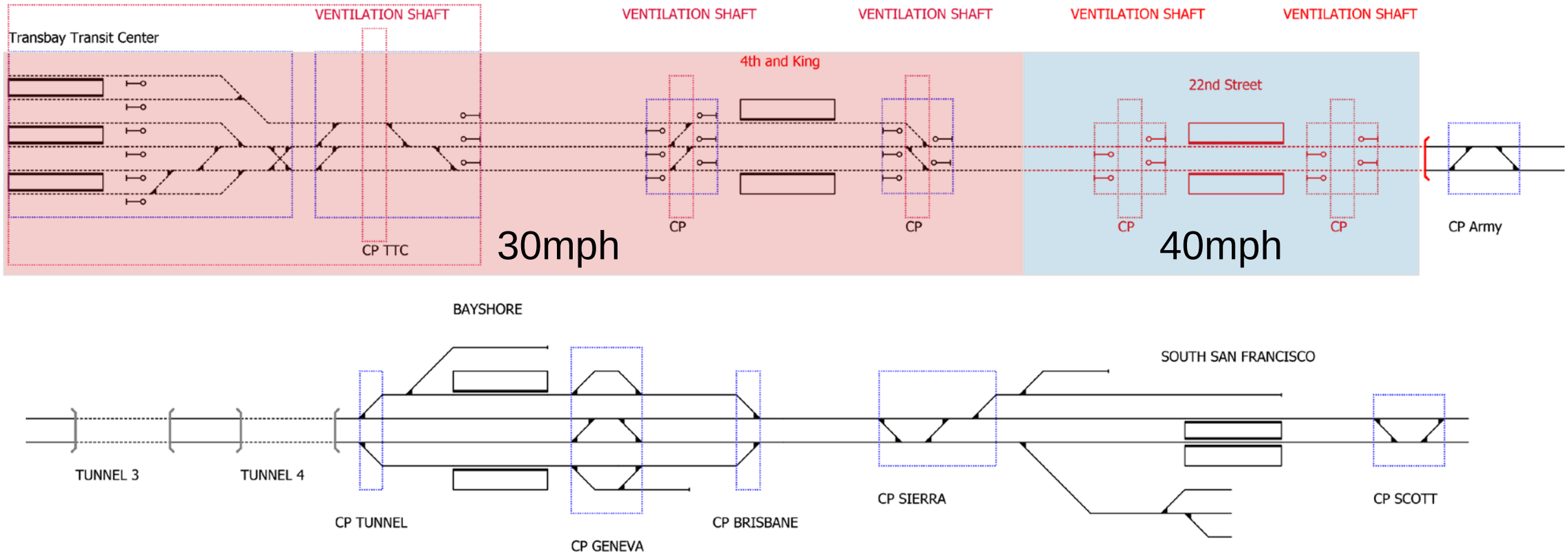
RAB study considered how key operations planning parameters could be managed to best achieve planning goals:

- Track Layout
- Tunnel Headways
- Separation Times
- Schedule (Service Concepts)
- Stop Pattern
- Platform Occupation Times



Current track layout was accepted as the starting point for initial analysis.

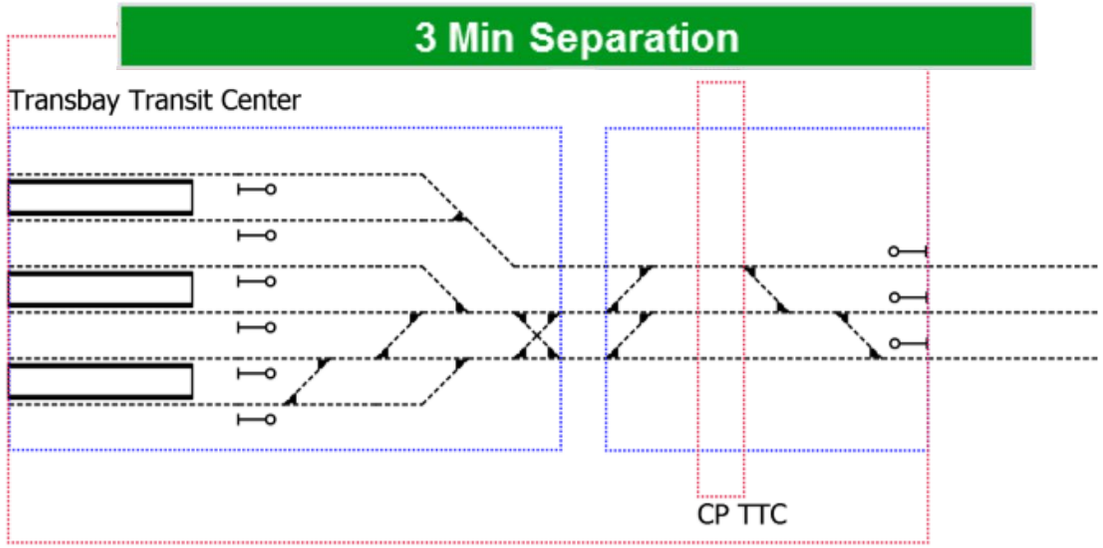
ALTERNATIVE 2A



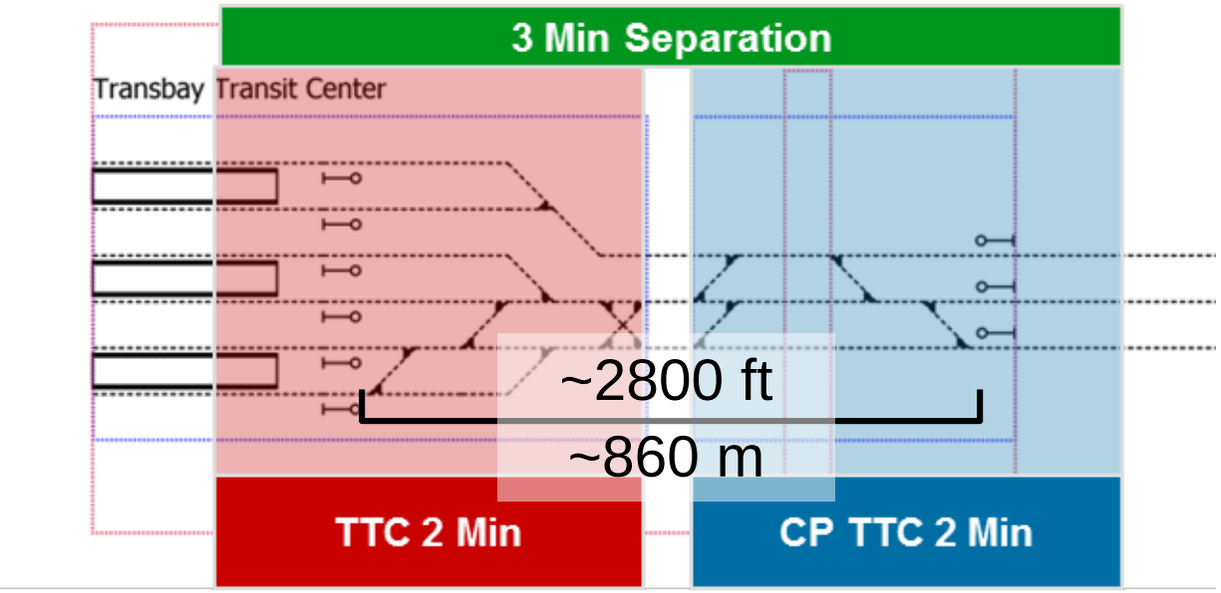
Headways in the Tunnel

- Based on the LTK Conceptual Signal layout drawings, it was assumed that ventilation shafts would be located over CP points
- Headways were estimated using the technical running times for trains between CPs
- It was assumed that 1 train can travel per section per track between ventilation shafts
- Headway estimates indicated that the segment between 4th & King and 22nd Street is the most constraining with at least 4 minutes required between following trains.

Separation Times

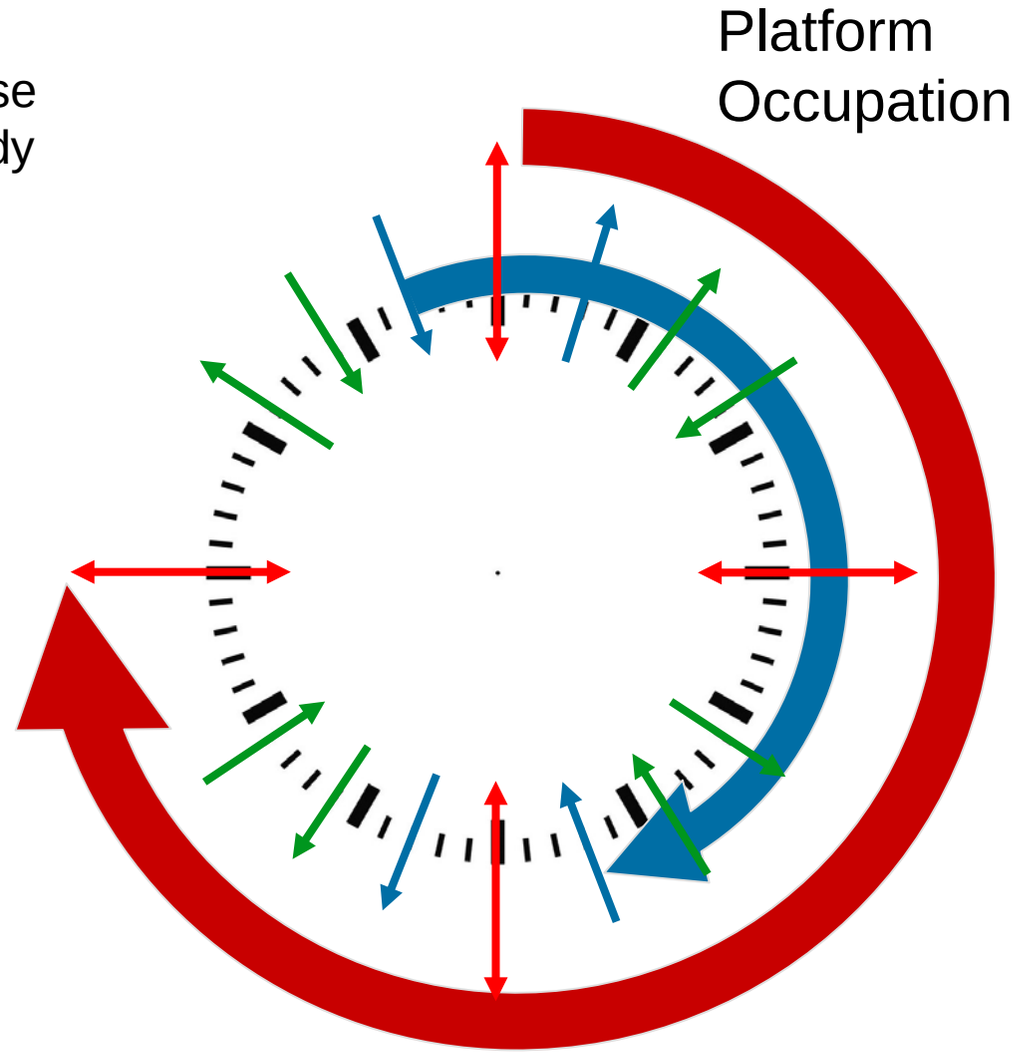


Separation Times



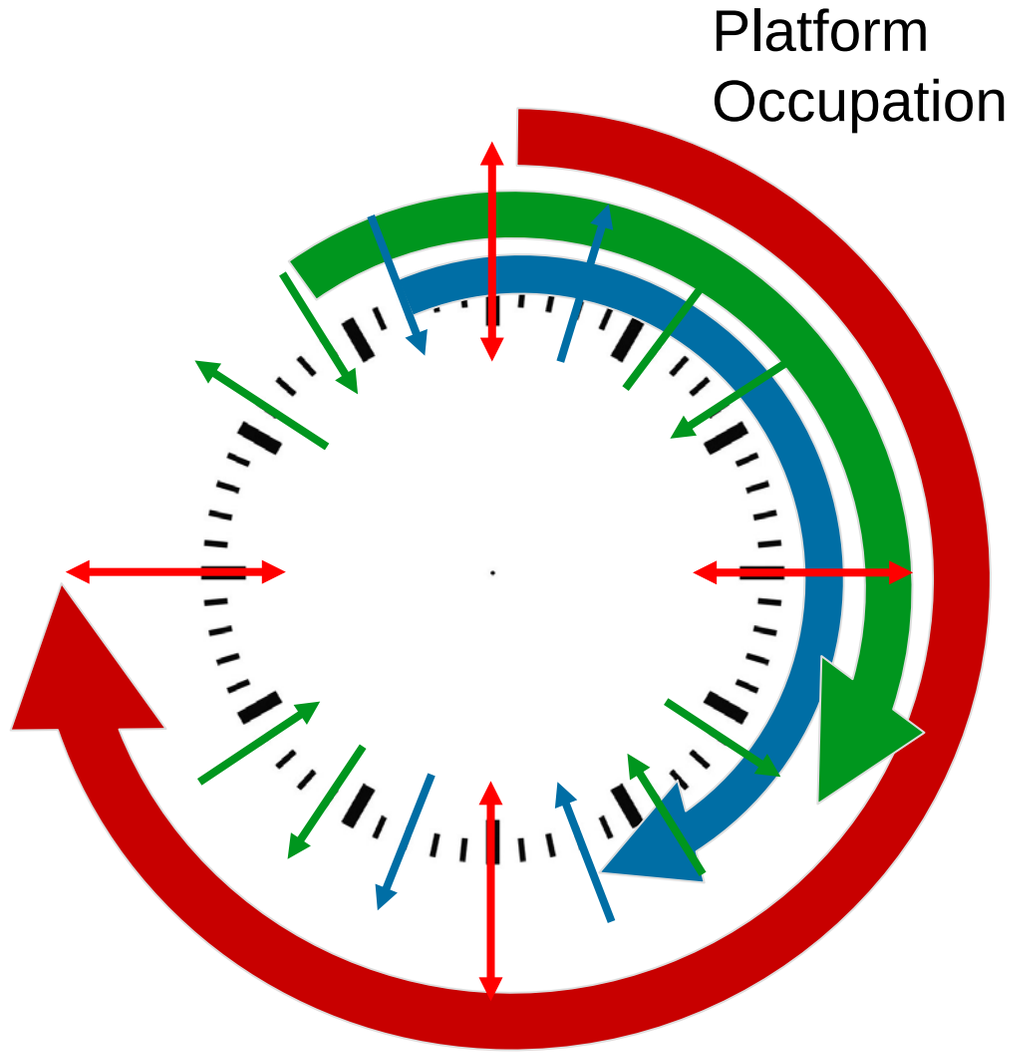
Schedule

Given the planning goal to increase capacity of the TTC, the RAB study considered how to optimize the schedule.



Schedule

Structured Service Pattern



Stop Pattern

- Adjusting the stop pattern of service is another way to manage conflicts to achieve a planning goal.
- Caltrain *Local Service* makes all stops (TTC, 4th/Townsend, 22nd Street, Bayshore, and SSF)
- Caltrain *Express Service* was identified in this analysis for potential adjustment.

Normal Express Service

- Caltrain *Express Service* skips 22nd Street stop

Express Alternatives

- Add 22nd Street – Express makes all SF stops including 22nd Street
- No 4th/Townsend stop – Express skips both 4th/Townsend and 22nd Street

	Technical Running Times				Runtime + 10% Reserve		
Stations	HSR	Caltrain Express	Caltrain Local	Max Run time	Max Run time	Most Conservative Case	
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SSF	0.4	0.4	0.4	0.4	0.4	0.4	SSF
South San Francisco	0.9	1.1	1.2	1.2	1.3	1.3	**South San Francisco**

Platform Occupation Times

Base Assumption

– Platform track 6 to serve Caltrain only

Resulting Constraint

– Under these assumptions, theoretically HSR trains would need to utilize 4 platform tracks requiring a minimum of 196 occupation minutes per hour.

– HSR trains could fit onto 3 platform tracks but only if turnaround times included reoccupation times, or if the requested track occupation (turn time) could be reduced to 41 minutes.

With X numbers of Platform Edges . . .	. . . the theoretically available platform occupation minutes per hour are:
6	360
5	300
4	240
3	180
2	120

	HSR	Caltrain
With the requested Track Occupation time of …	45	20
and a track reoccupation time between trains of (2 mins out and 2 mins in)	4	4
and X trains per hour	4	6
the theoretically required occupation minutes per hour are:	196	144

Scenarios

- Developed platform track scenarios based on the number of tracks used by HSR in the TTC.
- Started with assumption of fully blended operation (HSR using 5 platform tracks, platform track 6 available to Caltrain only due to infrastructure constraints).
- Alternative platform scenarios looked at HSR using only 4, then 3 platform edges.
- An additional “Max Line Capacity” scenario was also considered.

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Requires Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5									
4									
3									
Max Capacity (5)									

Scenarios

Operations Sketch Planning Methodology

For each platform track scenario, operations sketch planning proceeded through two separate approaches:

1. Theoretical operation plans were developed to optimize TTC platform occupation first, and then impact on the line was observed and analyzed.
2. Theoretical operation plans were developed to optimize line throughput first, and then impact on the TTC was observed and analyzed.

Assumptions:

- Currently proposed DTX track and signal layout (used as initial starting point for infrastructure)
- Station at 4th/Townsend with side platforms
- 4th/Townsend Station the tracks should be right-hand running for trains stopping – dedicated direction platforms.

5 Track Scenario

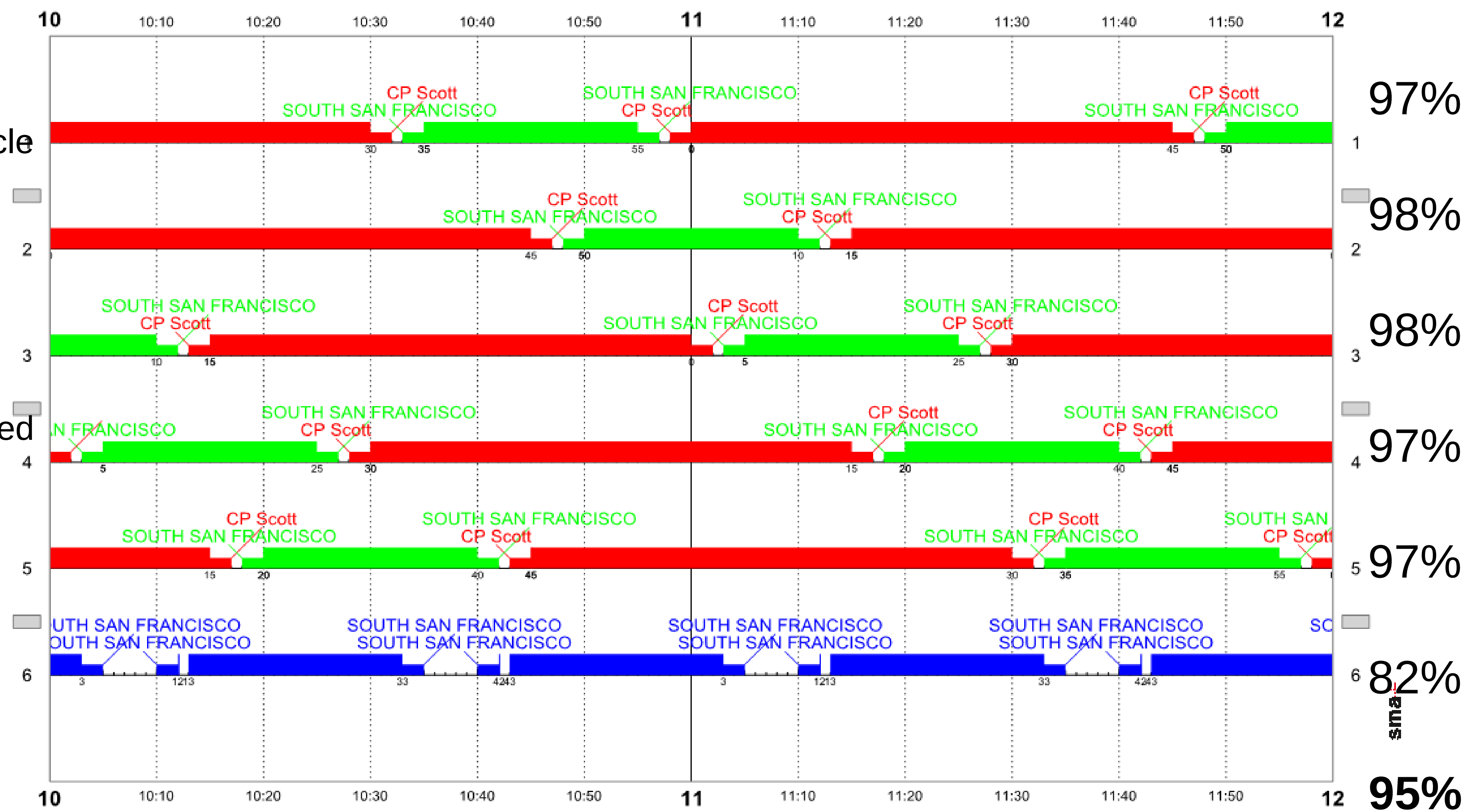
- 5 non-dedicated HSR platform tracks
- 15 minute schedule interval
- 45 and 20 minute turn times – Maintain target turnaround times

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Requires Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min		45	20					
4									
3									
Max Capacity (5)									

5 Track Scenario

Optimizing Platform Track Occupation

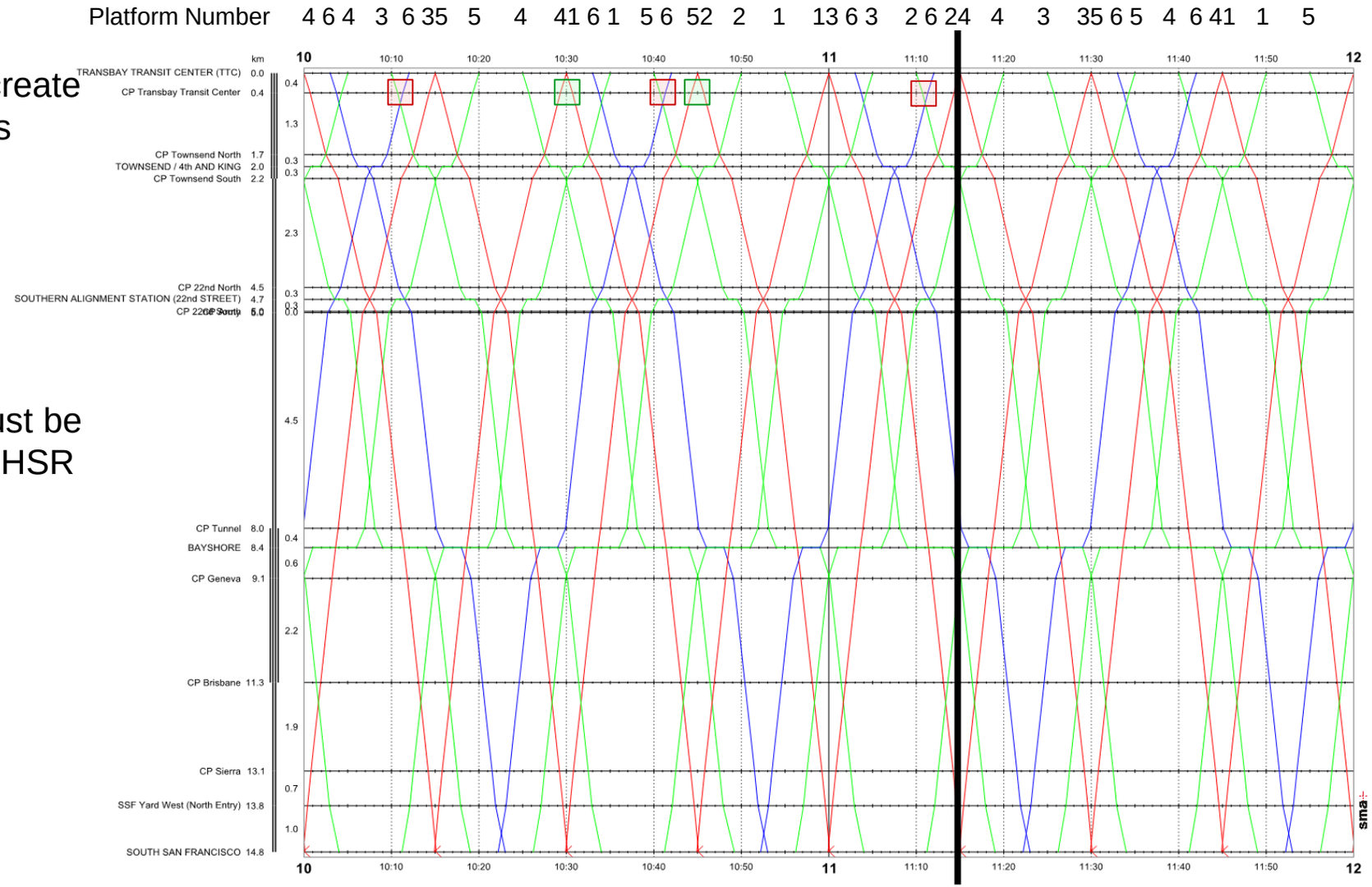
- Platform assumption creates a waterfall/staircase cycle (5 hour cycle)
- Allows 45/20 min turnaround times
- Caltrain Express turnarounds lengthened by 1 min to manage headways



5 Track Scenario

Resulting Operations on the Line

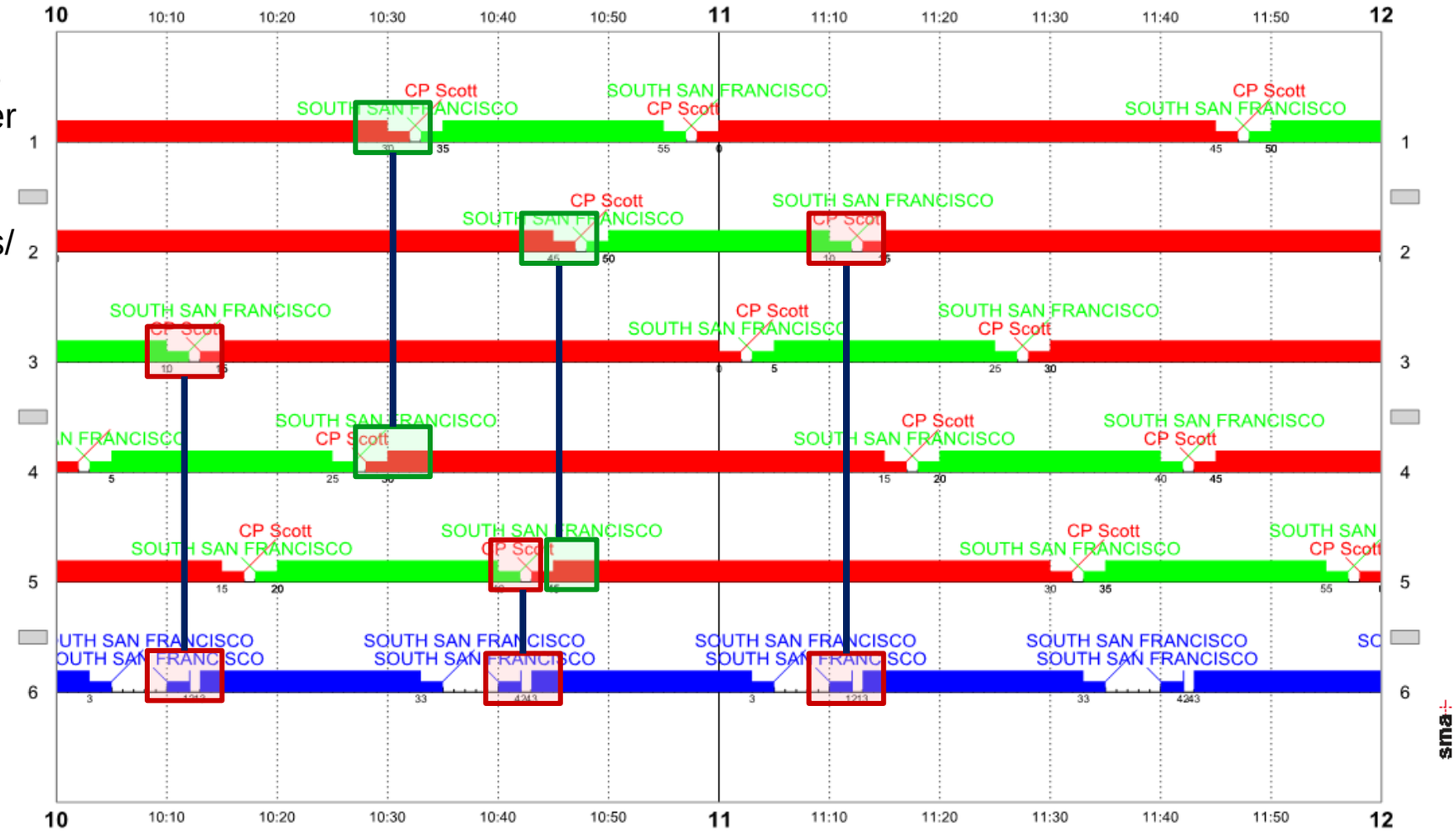
- Platform assumptions create opposing move conflicts (highlighted in boxes)
- Exit/Entry at CP TTC requires shorter headway (2 minute)
- Caltrain's dwell time must be ~5 min at Bayshore for HSR overtake



5 Track Scenario

Conflicts at TTC Platforms Identified

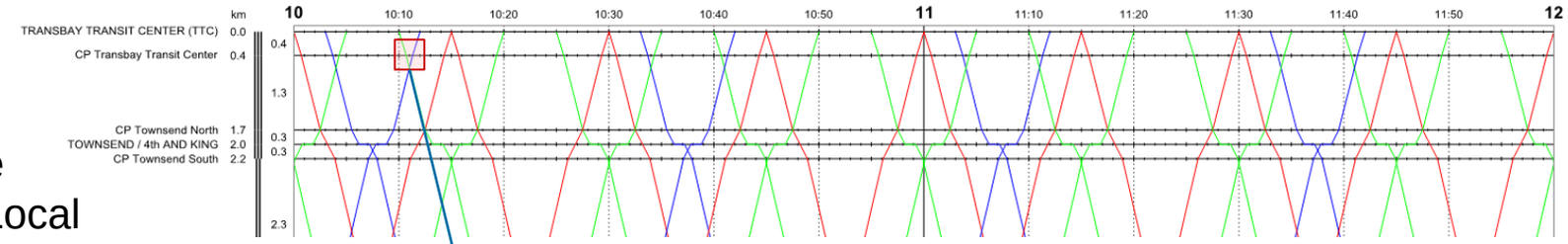
- Caltrain Express service (blue) causes conflicts with the other services
- Simultaneous arrivals/ departures on other platforms are not problematic

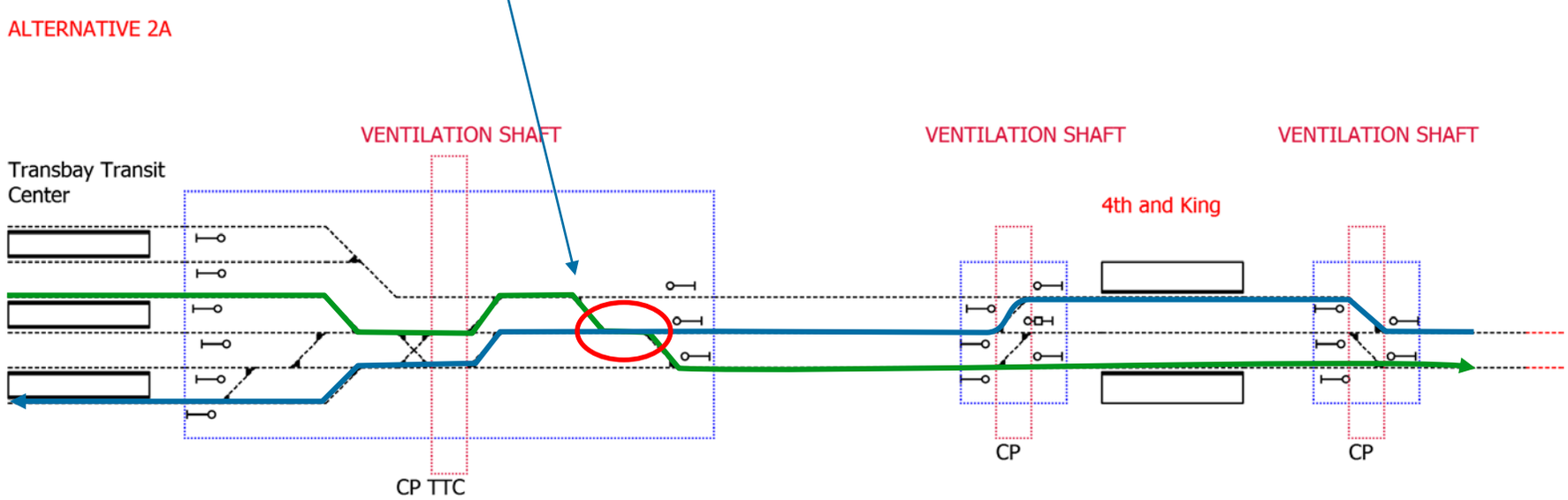


5 Track Scenario

Conflicts at CP TTC Identified

– Inbound Express service conflicts with outbound Local

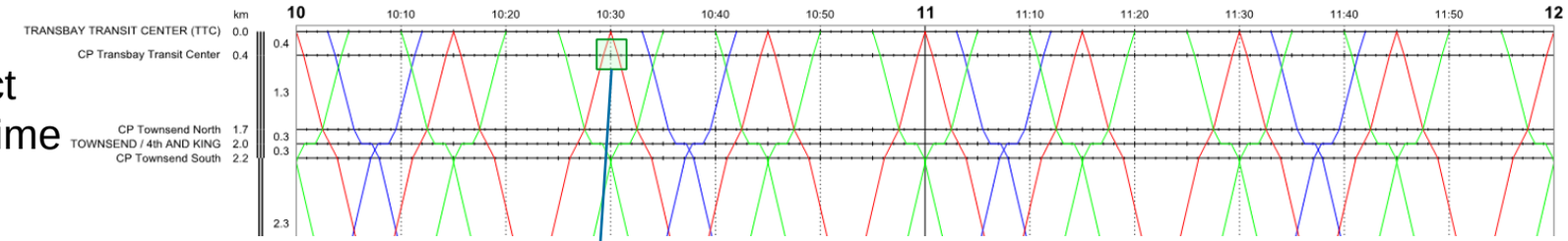




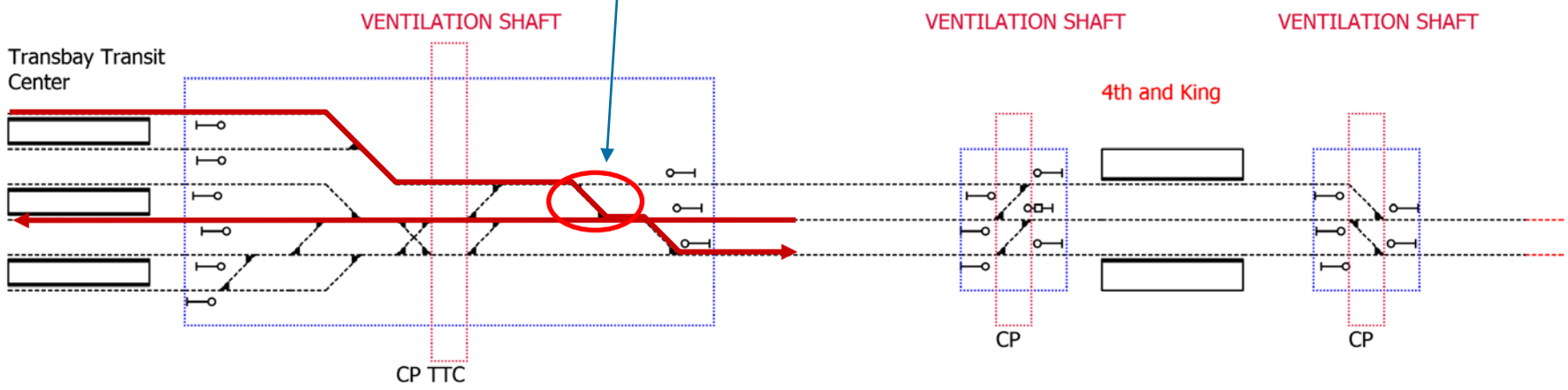
5 Track Scenario

Conflicts at CP TTC Identified

- Train paths are in conflict using 3 min separation time
- Conflict avoided using 2 minute separation time



ALTERNATIVE 2A



5 Track Scenario

Initial Observations

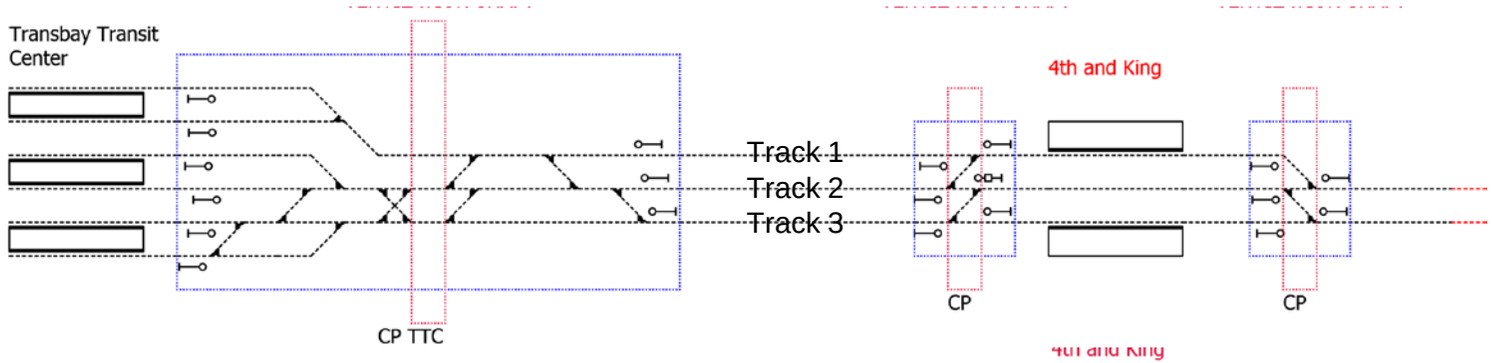
- Platform capacity is not primary constraint of the network.
- Existing track and signal layout (conflicting paths at CP TTC) causes conflicts to occur.
- Separation times are critical for TTC entry and exit slots; a higher capacity CP TTC is required.

5 Track Scenario

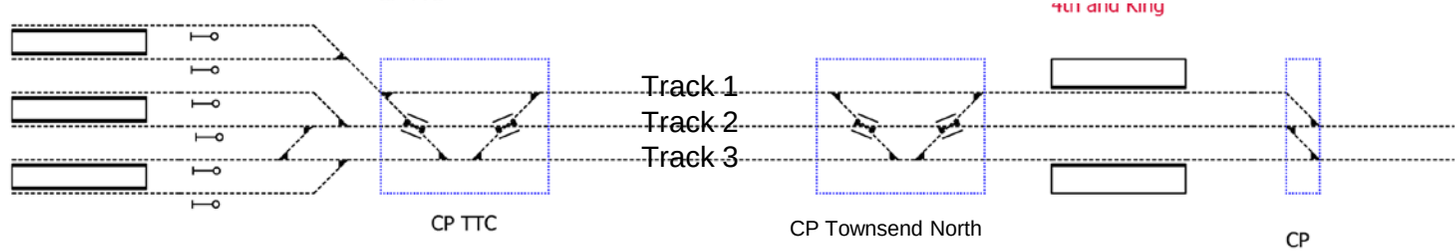
Consider a Revised Track and Signal Layout

- Current layout: tracks 1 and 3 are unidirectional.
- Suggested layout allows bidirectional use of all 3 tracks and allows trains to switch to any track at each CP
- 2 fewer switches are required

Base Layout



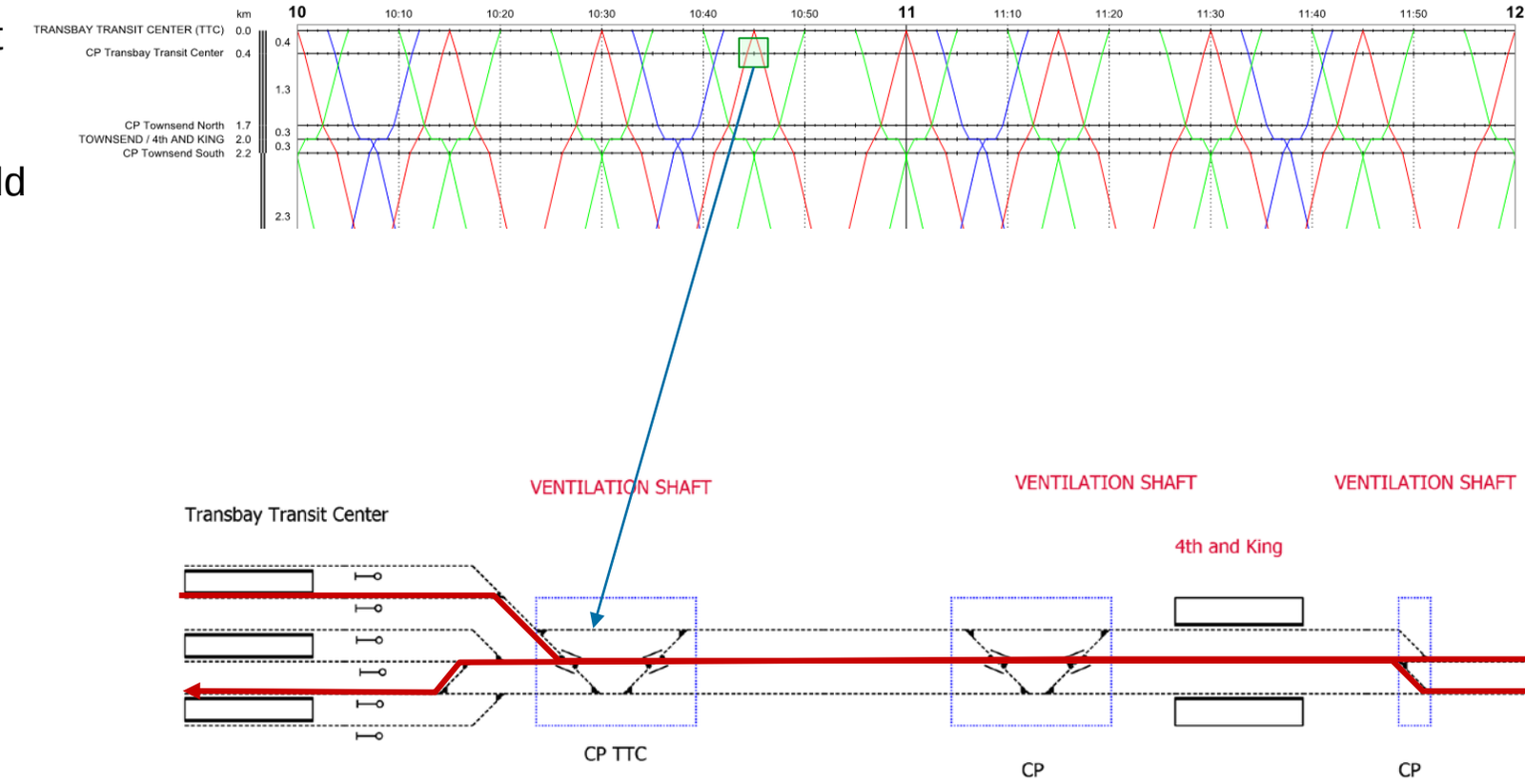
Suggested Layout



5 Track Scenario

Revised Layout Simplifies Track Usage

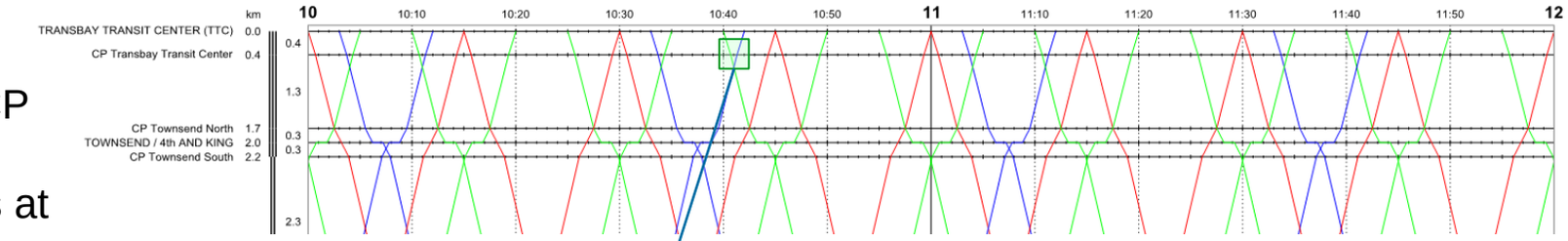
- Regular operations fit on two tracks
- The middle track could be dedicated HSR
- Non-stopping trains would bypass platforms at 4th and Townsend

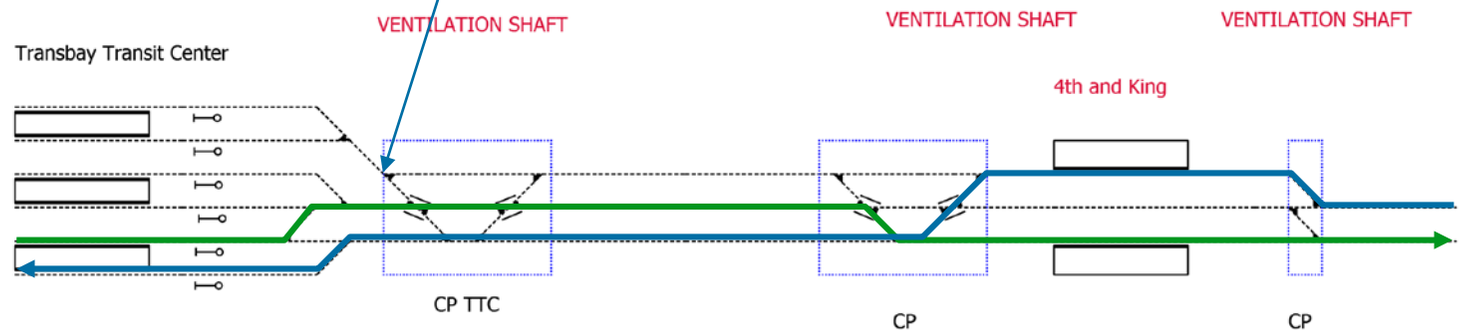


5 Track Scenario

Revised Layout Simplifies Track Usage

– Possible conflicts at CP TTC are avoided by trains switching tracks at CP Townsend North



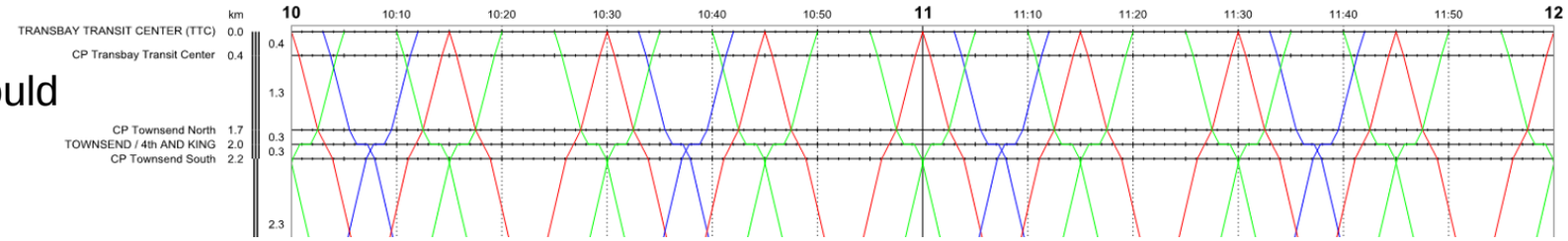


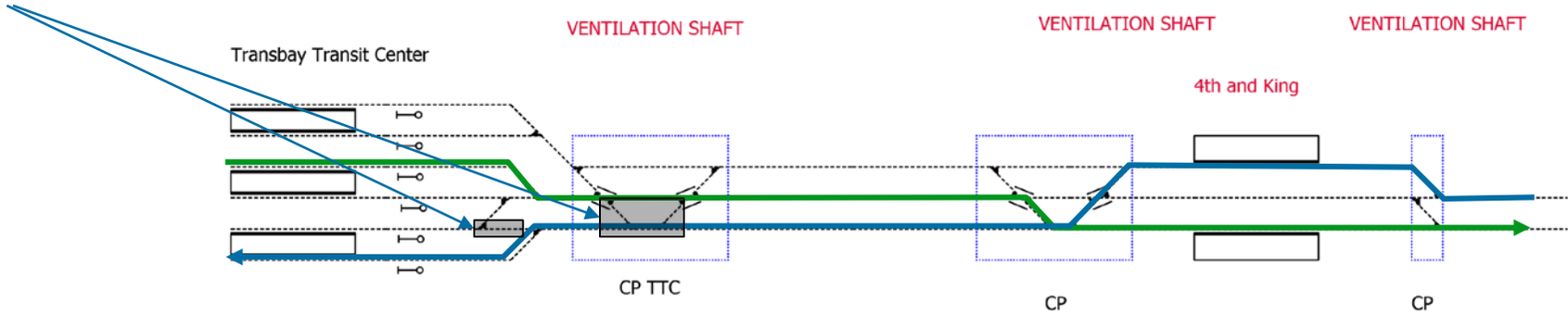
5 Track Scenario

Revised Layout Simplifies Track Usage

- Theoretically the 3rd track could be used as a dedicated entry/exit to platform 6 for Caltrain Express services.

- 6 switches could be removed. Though some may be useful for operational flexibility.





5 Track Scenario
Conclusions

- Increased throughput to 10 trains or more to the TTC may be possible with higher capacity CP TTC and other modifications.
- All scenarios would require a higher capacity CP TTC to achieve planning goal of 10 trains or more to the TTC.
- Scenario requires revised track and signal layout to maintain assumed turn times.
- Revised layout and optimized schedule could simplify track usage and potentially support a dedicated track, either for HSR services or for Caltrain Express services to platform 6.

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
							Yes		
4							Yes		
							Yes		
3							Yes		
Max Capacity (5)							Yes		

5 Track Scenario, alternative

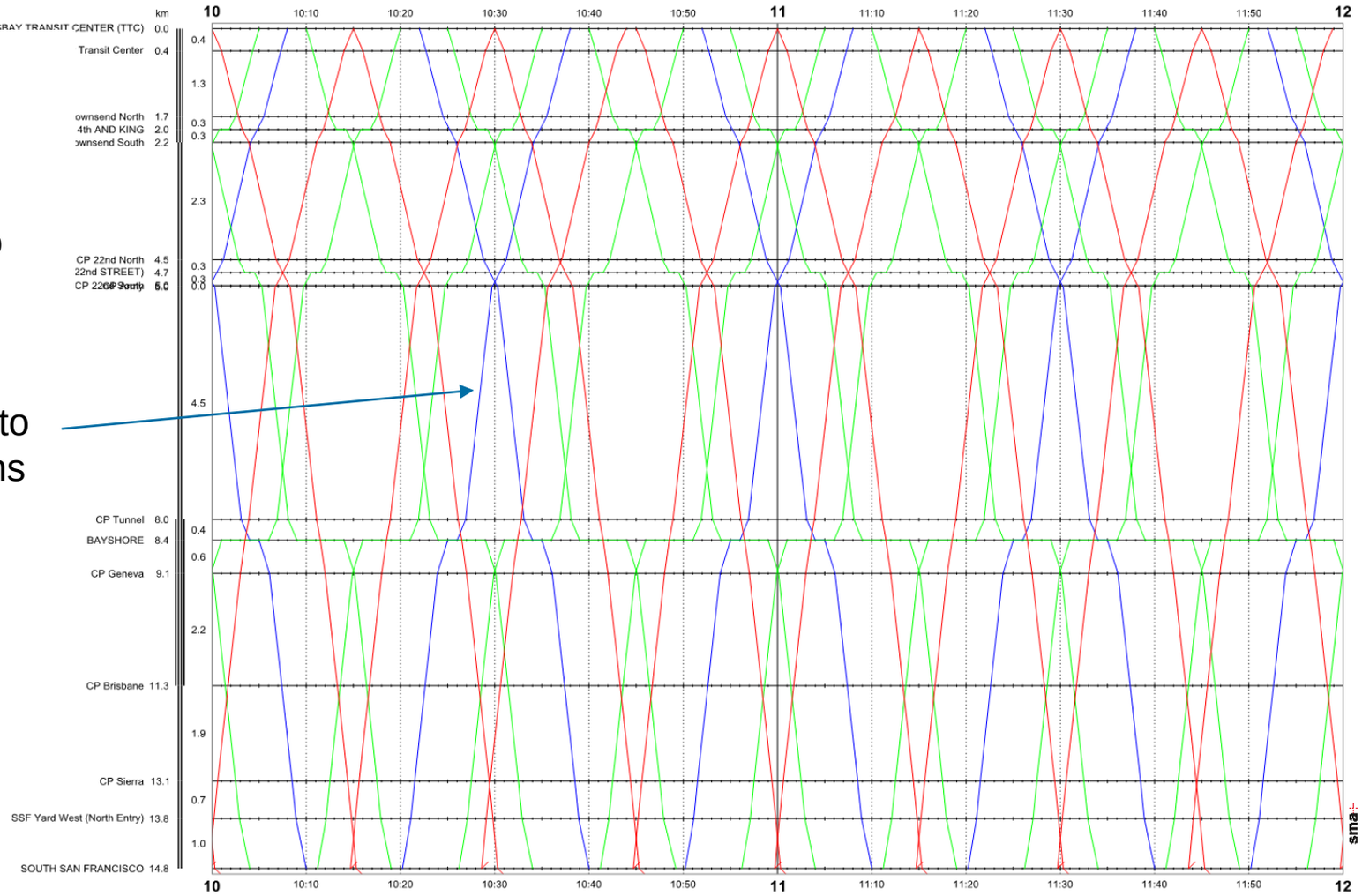
- 5 non-dedicated HSR platform tracks
- Higher capacity CP TTC
- 15 minute schedule interval
- No new track and signal layout – Require trains to operate in current infrastructure

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min						Yes	No	
4							Yes		
							Yes		
3							Yes		
Max Capacity (5)							Yes		

5 Track Scenario, alternative

Optimizing Line Throughput

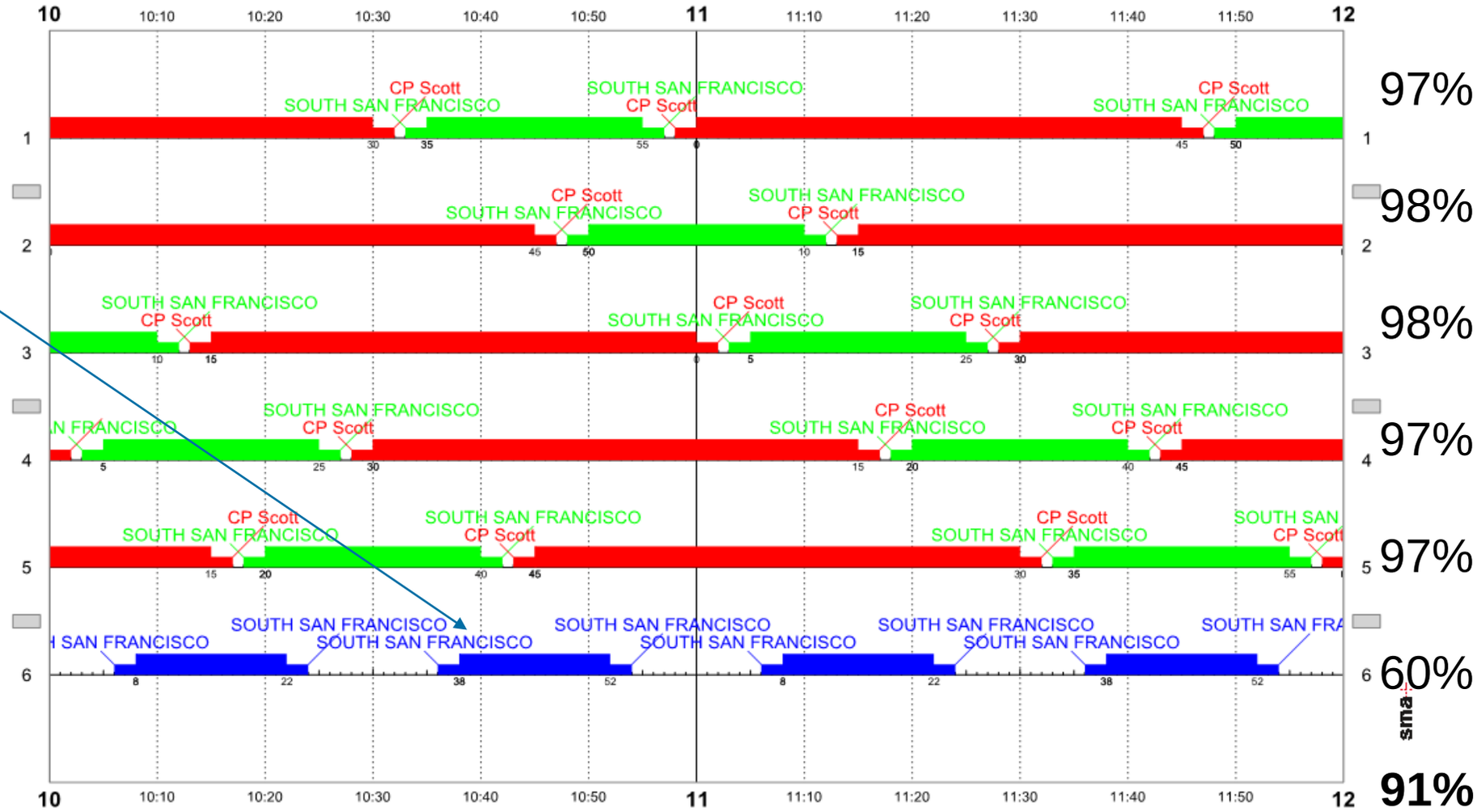
- Trains arranged to create conflict free entry and exit slots at the TTC
- Express services shifted to avoid conflicts at CP TTC
- Caltrain Express 4th and Townsend stop eliminated to mitigate headway limitations



5 Track Scenario, alternative

Impact of Line Optimization on Platform Occupation

- Caltrain Express turnaround times shortened to 14 mins



5 Track Scenario, alternative

Conclusions

- Increased throughput to 10 trains or more to the TTC may be possible with higher capacity CP TTC and other modifications.
- Scenario requires significantly reduced turnaround times:
  45 minutes for HSR, 14/21 minutes for Caltrain Local/Express.
- Scenario requires change in Caltrain Express stop pattern – No stop at 4th/Townsend.

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4							Yes		
							Yes		
3							Yes		
Max Capacity (5)							Yes		

4 Track Scenario

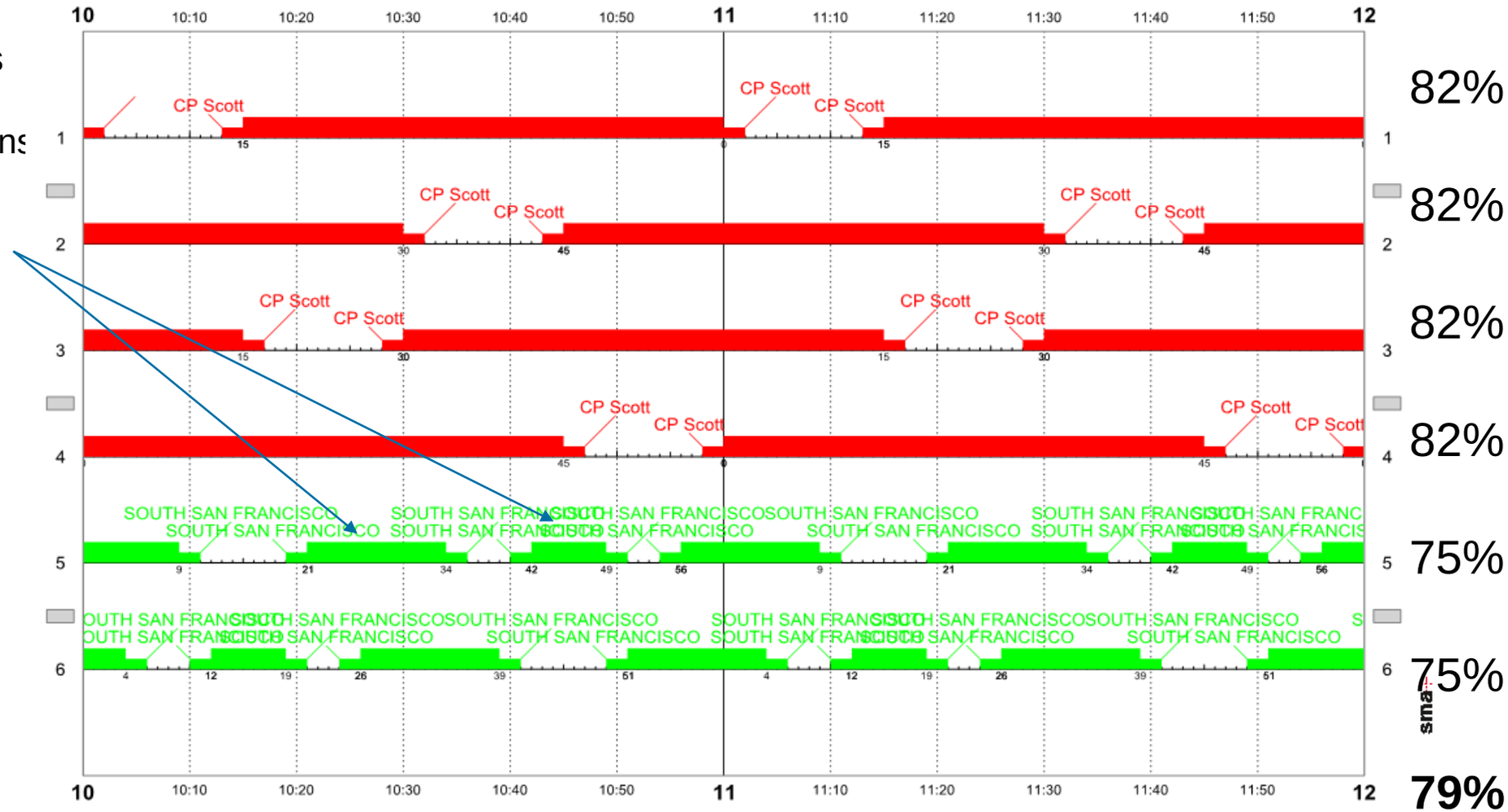
- 4 non-dedicated HSR platform tracks
- Higher capacity CP TTC
- 15 minute schedule interval

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min						Yes		
							Yes		
3							Yes		
Max Capacity (5)							Yes		

4 Track Scenario

Optimizing Platform Track Occupation

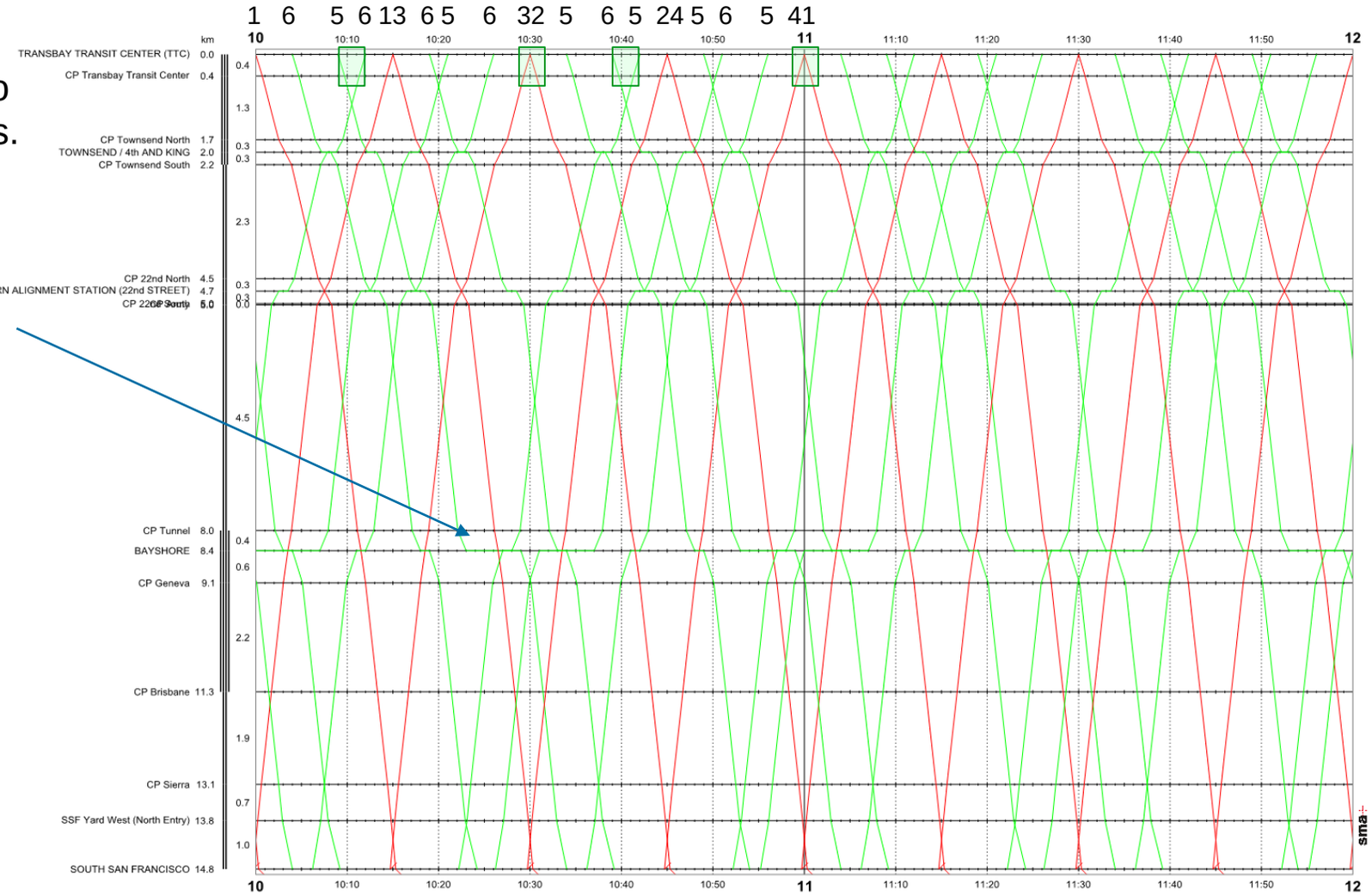
- 7/13 min turnaround times are required for Caltrain operations
- Caltrain local services run uniformly



4 Track Scenario

Resulting Operations on the Line

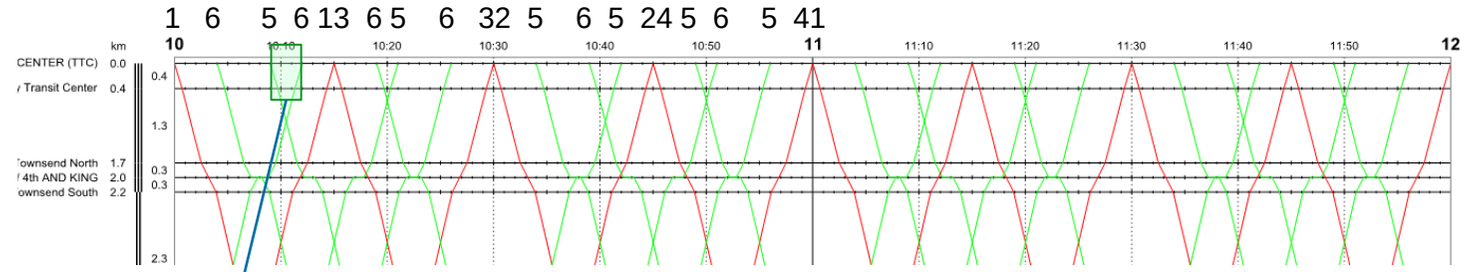
- Relies on the third track to alleviate potential conflicts.
- Due to service pattern variations between HSR and Caltrain, some Caltrain services require longer stops at Bayshore

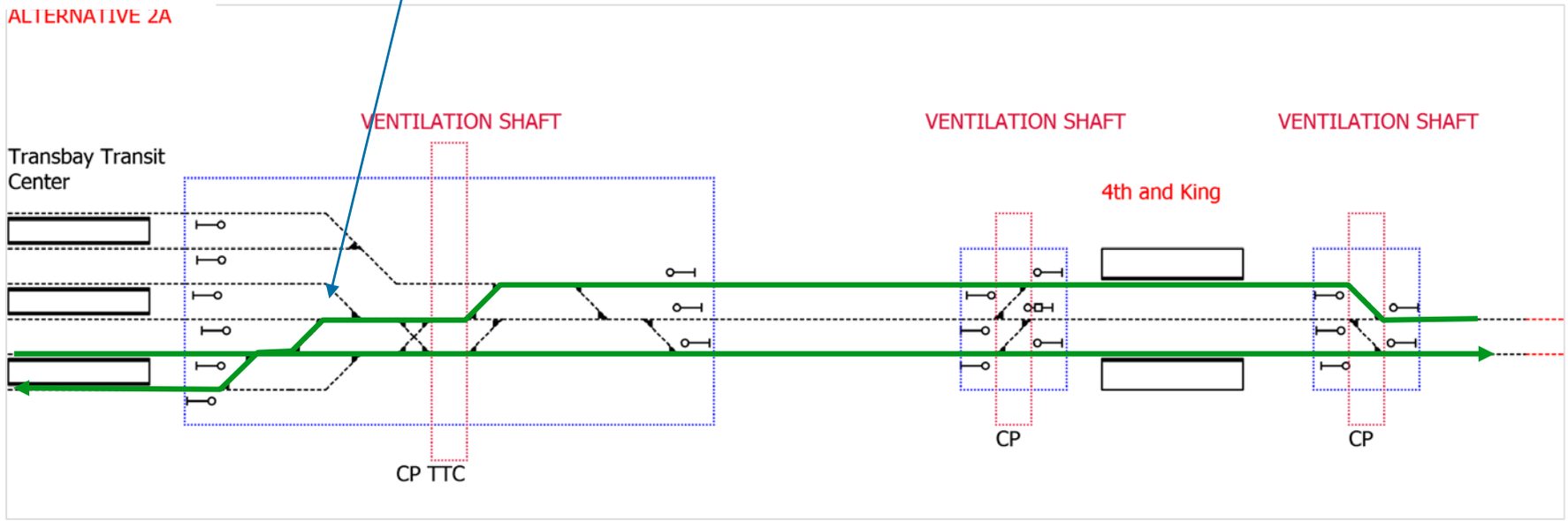


4 Track Scenario

Resulting Operations on the Line

- Conflict avoided with 2 minute separation time
- Separating the CP TTC into two sections allows trains to have non-conflicting paths.





4 Track Scenario
Conclusions

- Increased throughput to 10 trains or more to the TTC may be possible with higher capacity CP TTC and other modifications.
- Scenario requires Caltrain turn times of 7/13 minutes, likely too tight for Caltrain.
- Scenario requires change in Caltrain Express stop pattern – schedule requires ALL stops between TTC and South SF, including 22nd Street.

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
							Yes		
3							Yes		
Max Capacity (5)							Yes		

4 Track Scenario, alternative

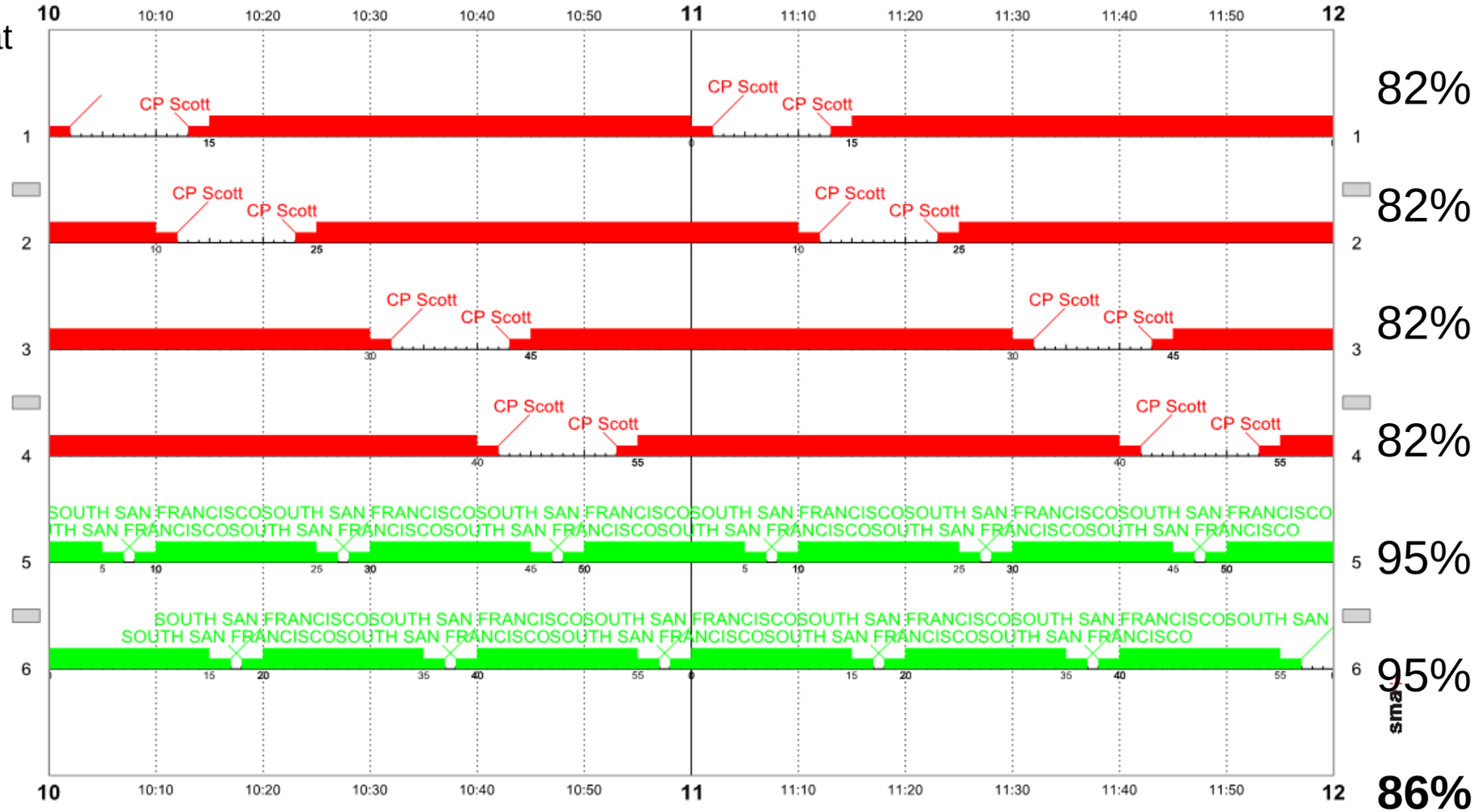
- 4 non-dedicated HSR platform tracks
- Higher capacity CP TTC
- 10 minute schedule interval – Can we push the schedule to increase turn times?

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min						Yes		
3							Yes		
Max Capacity (5)							Yes		

4 Track Scenario, alternative

Optimizing Platform Occupation

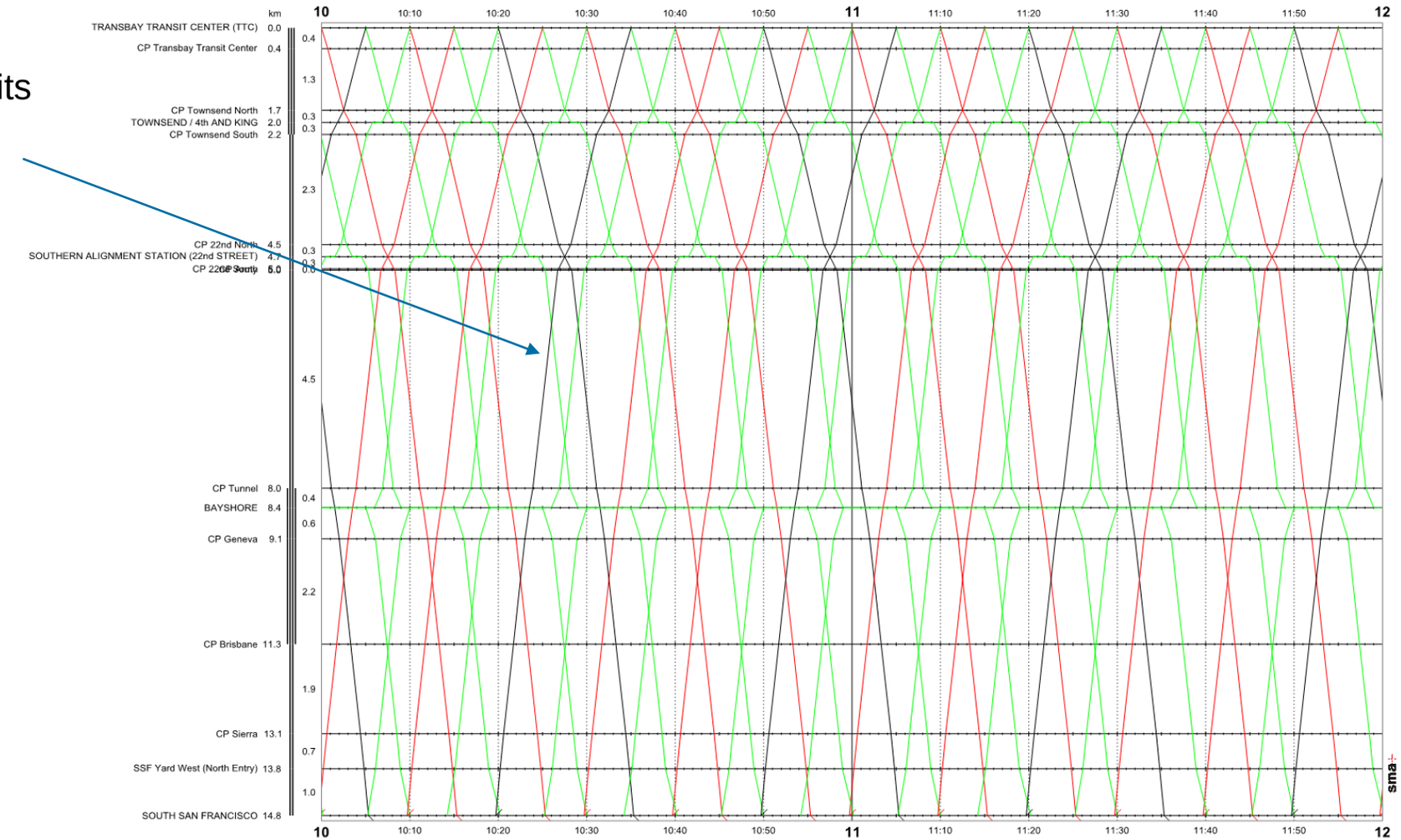
- Trains depart TTC at 10 minute intervals
- Caltrain Local and Express make all stops between TTC and South SF
- Longer turnaround times are achieved



4 Track Scenario, alternative

Resulting Operations on the Line

– Conflict free entry/exits at TTC



4 Track Scenario, alternative
Conclusions

- Increased throughput to 10 trains or more to the TTC may be possible with higher capacity CP TTC and other modifications.
- Scenario requires turnaround times of 15 minutes for Caltrain.
- Scenario requires change in Caltrain Express stop pattern – schedule requires ALL stops between TTC and South SF, including 22nd Street

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3							Yes		
Max Capacity (5)							Yes		

3 Track Scenario

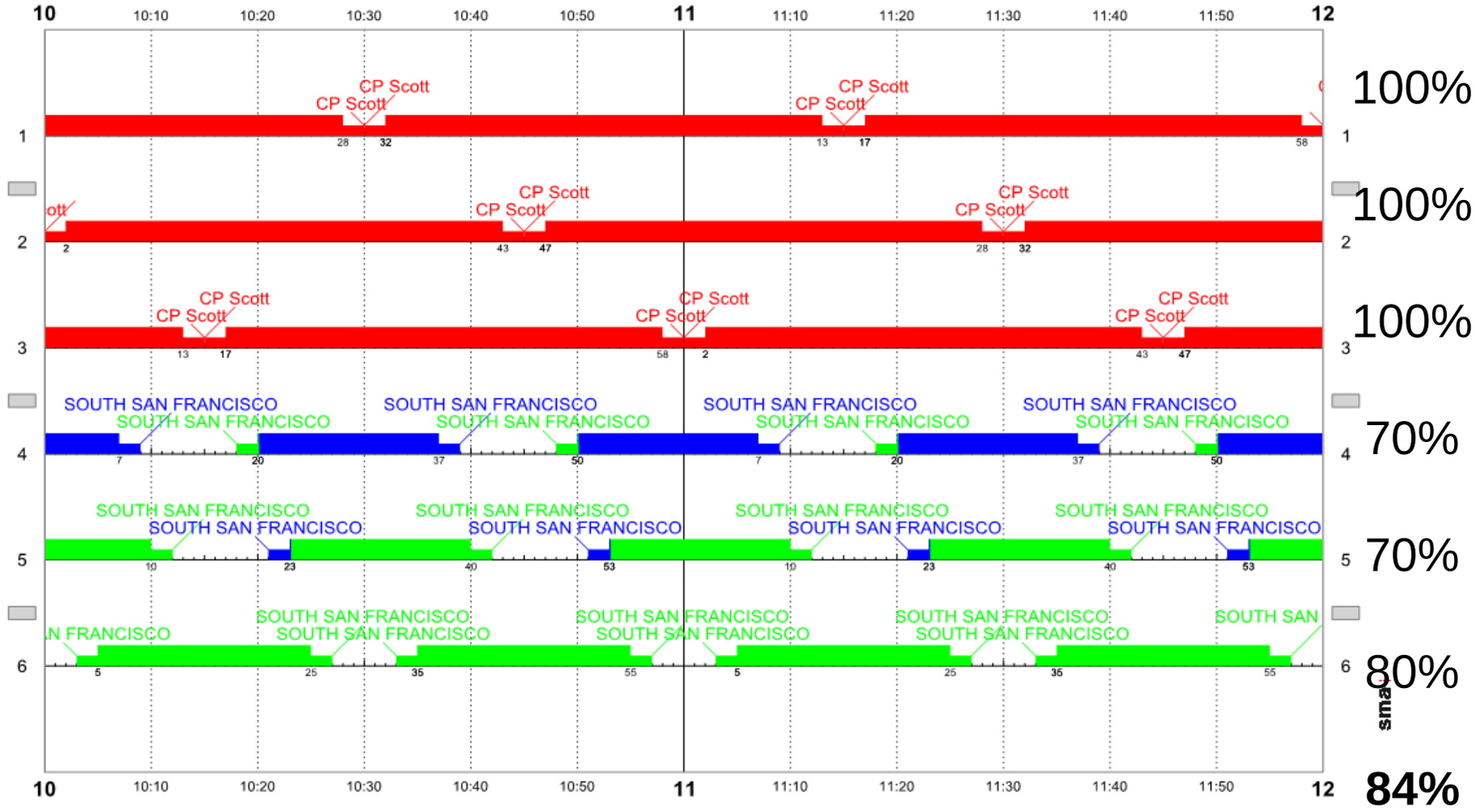
- 3 non-dedicated HSR platform tracks
- Higher capacity CP TTC
- 15 minute schedule interval

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3	15 min						Yes		
Max Capacity (5)							Yes		

3 Track Scenario

Optimizing Platform Occupation

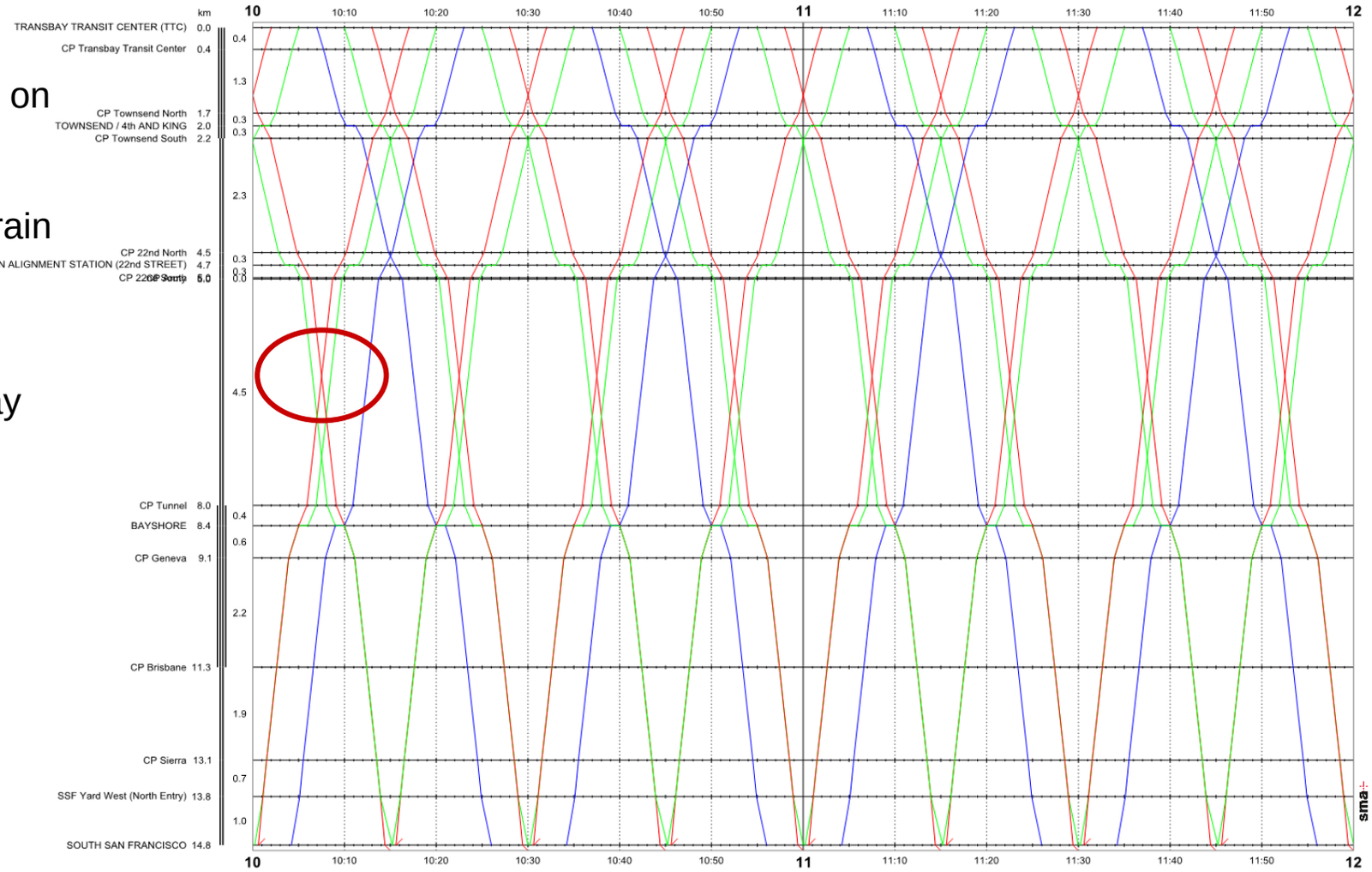
- HSR has 41 minute turnaround times
- Caltrain has 17/20 minute turnaround times
- Track 6 allows 20 minute Caltrain turnaround times



3 Track Scenario

Resulting Operations on the Line

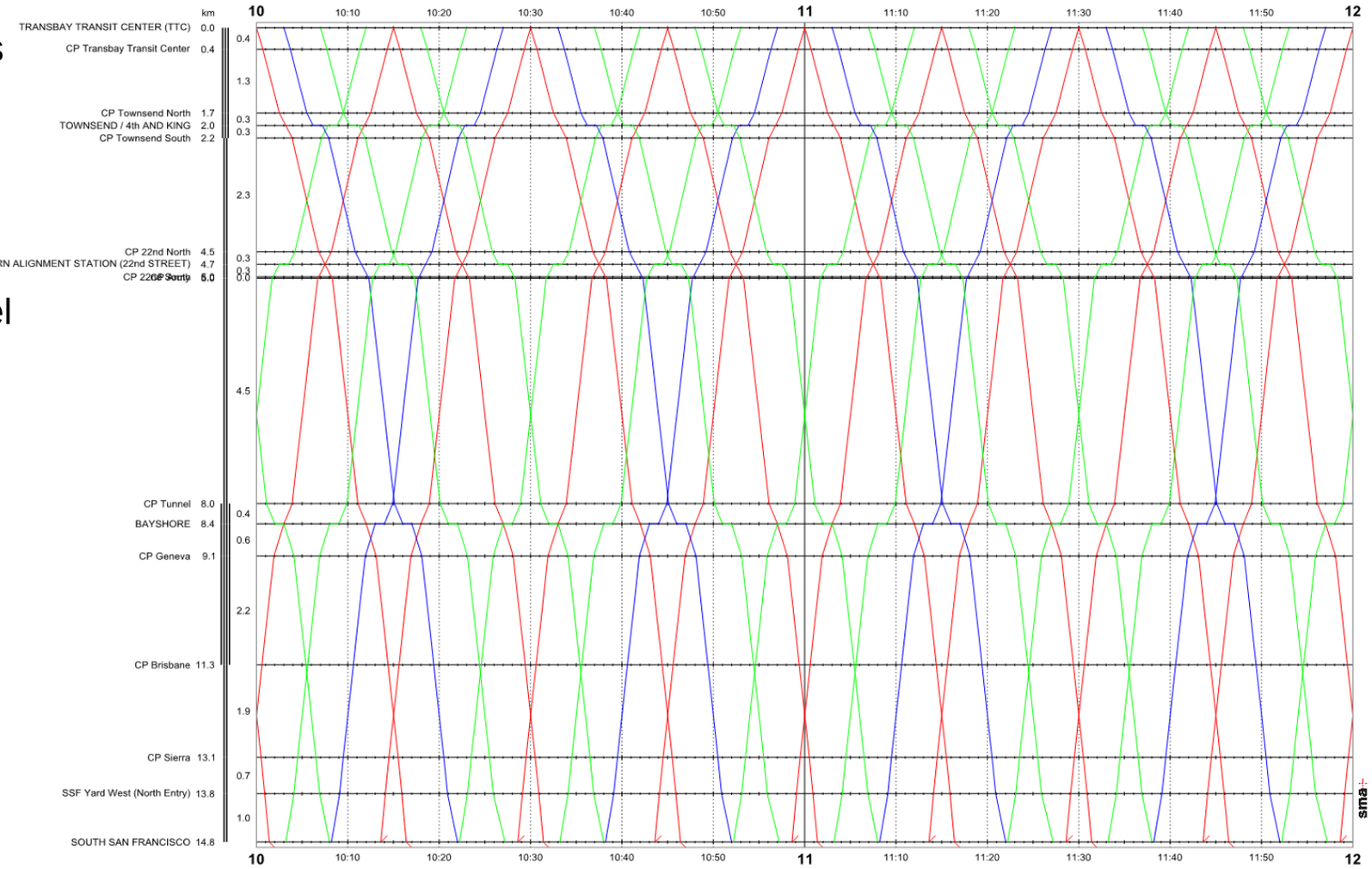
- Operations at the TTC fail to transition smoothly on the track in the tunnel
- Headways between Caltrain and HSR services cause regular conflicts
- Reducing dwell times may improve scenario



3 Track Scenario

Optimizing Line Throughput

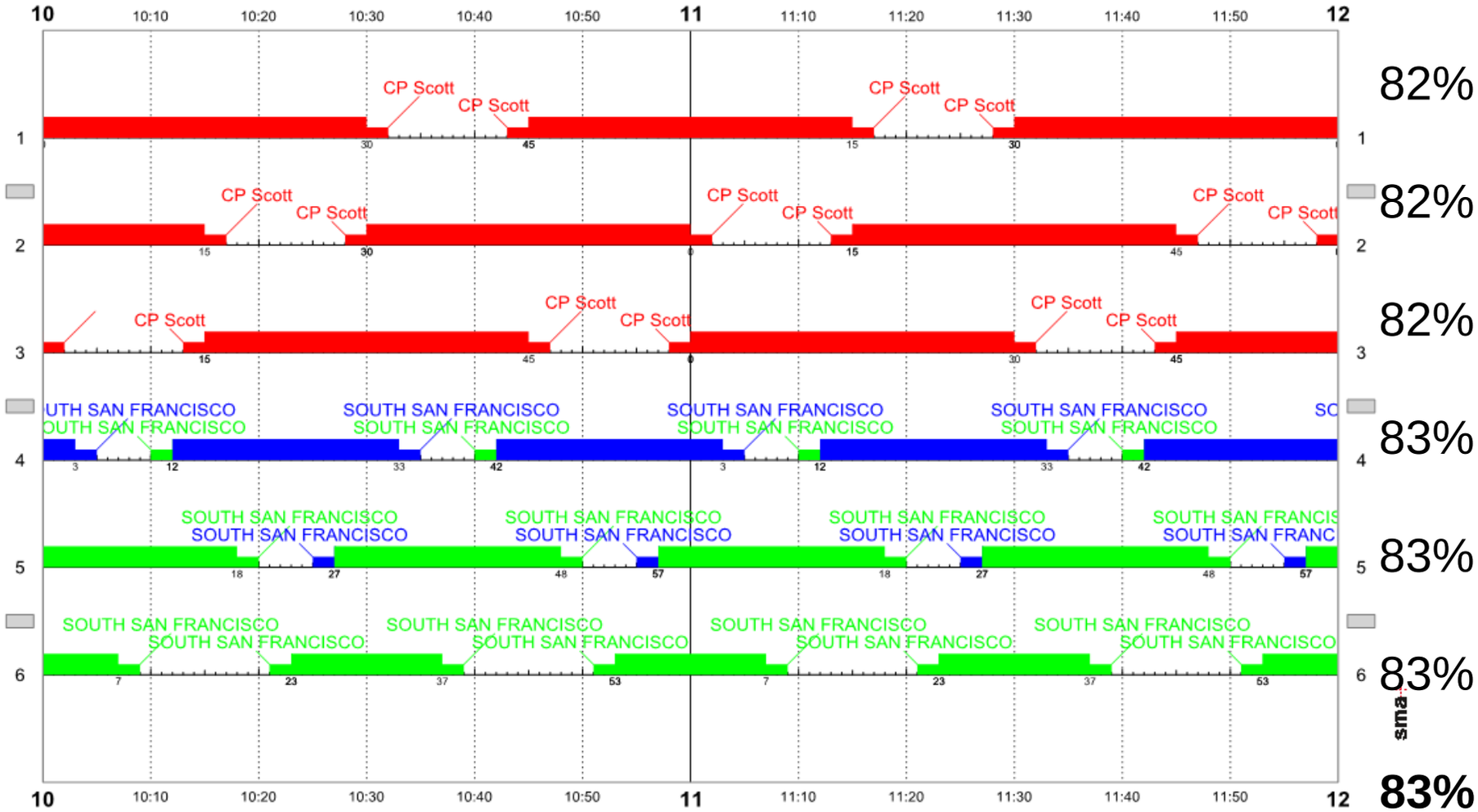
- Adjusted departure times (reduced dwell times) result in conflict-free line operations
- System relies on only 2 tracks in the tunnel



3 Track Scenario

Impact of Line Optimization on Platform Occupation

- HSR turnaround times shortened to 30 minutes
- Caltrain services have 14/21 minute turnaround times



3 Track Scenario
Conclusions

- Increased throughput to 10 trains or more to the TTC may be possible with higher capacity CP TTC and other modifications.
- Scenario requires shortened turnaround times for both HSR and Caltrain.

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3	15 min	Yes	30	14/21	2	83-84%	Yes	No	Normal
Max Capacity (5)							Yes		

Max Line Scenario

- Maximize Line Capacity – Fit as many trains on line as possible (15 trains) and see what effect this would have on platform occupancy and required turnaround times
- Higher capacity CP TTC

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3	15 min	Yes	30	14/21	2	83-84%	Yes	No	Normal
Max Capacity (5)							Yes		

Max Line Scenario

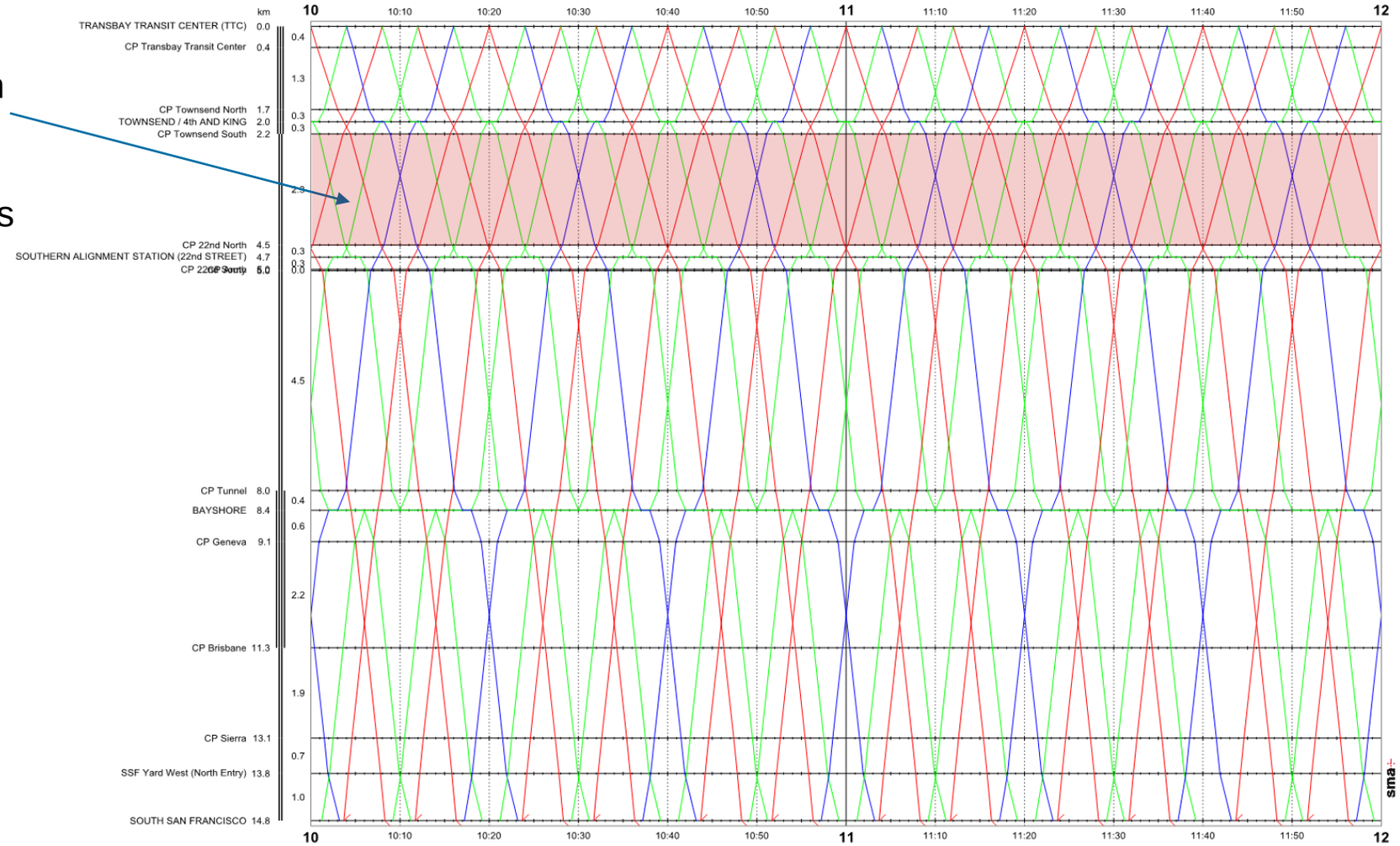
Initial Observations

- Theoretically, 15 trains per hour can run through the tunnel on 2 tracks at 4 minute headways, but known limitation is platform availability.
- Expanding the 4/6 blended service pattern up to a 6 HSR / 9 Caltrain pattern was attempted as a potentially useful “Max Line” scenario of 15 trains.

Max Line Scenario

Optimizing Line Throughput

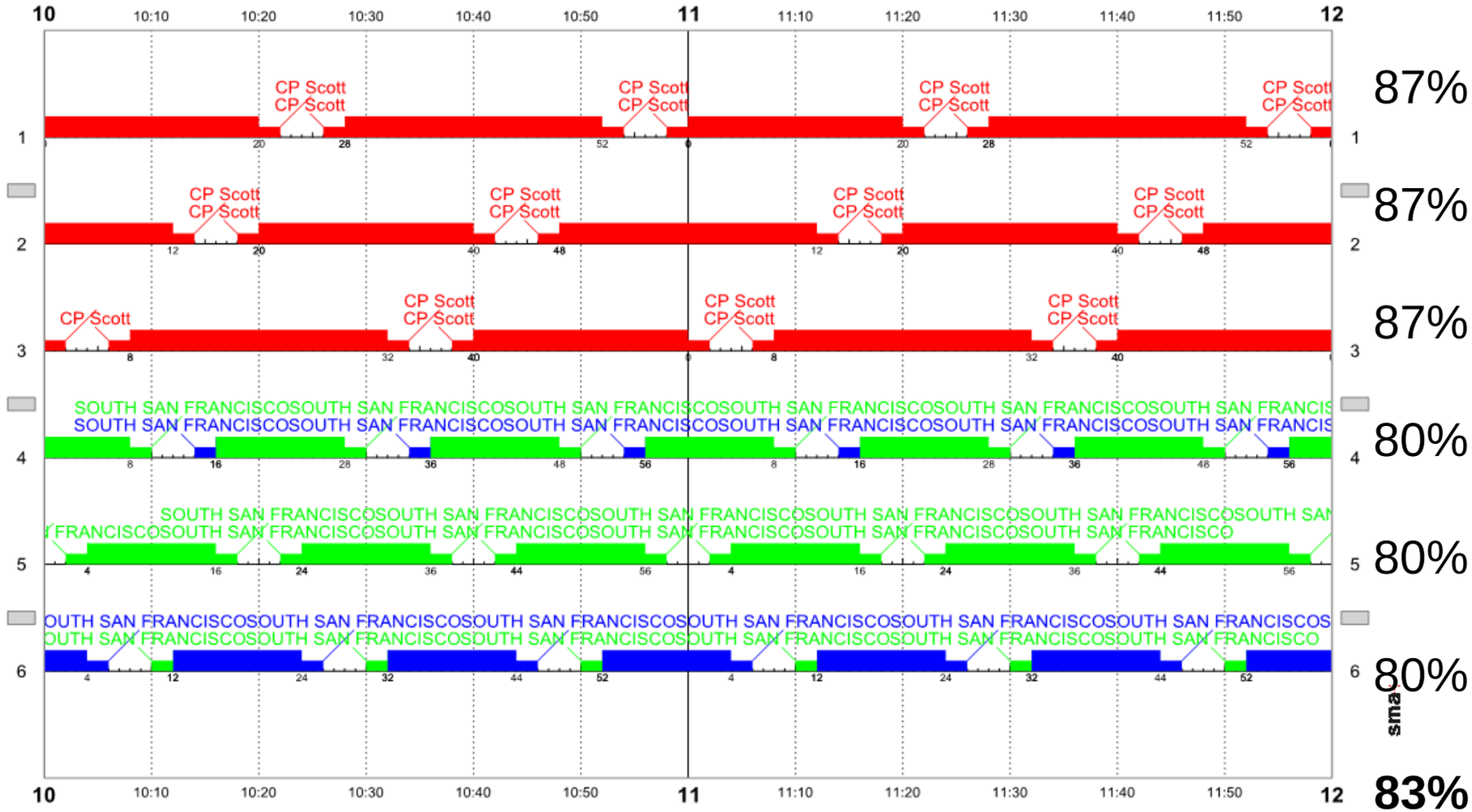
- Capacity constrained by 4 min headways in the tunnel
- Requires only 2 tracks in the tunnel
- Express and Local services could run normal stop patterns



Max Line Scenario

Impact of Line Optimization on Platform Occupation

- HSR has 20/24 minute turnaround times
- Caltrain services have 12 minute turnaround times
- Pedestrian flows at stations are not considered in this analysis



Max Line Scenario
Conclusions

- Increased throughput to 15 trains to the TTC may be possible.
- Scenario requires significantly shortened turnaround times for both HSR and Caltrain, on par with turnaround times achieved by foreign railways.
- Max Line scenario is incompatible with 45 min / 20 min turnaround times at the TTC (dwell times > 360 min).
- System capacity is a function of turnaround time – reductions in turnaround time increase platform capacity and allow for more train throughput.

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3	15 min	Yes	30	14/21	2	83-84%	Yes	No	Normal
Max Capacity (5)	Variable	No	20/24	12	2	83%	Yes	No	Normal

Overview of Scenarios

Platform Scenario		Base Assumptions							
No. of Platform tracks used by HSR	Schedule Interval	Dedicated Platforms	Resulting Turn Times		Tunnel tracks required	Platform Capacity used	Higher Capacity CP TTC	New Track and Signal Layout	Caltrain Express Stop Pattern
			HSR	Caltrain					
5	15 min	No	45	20	3	95%	Yes	Yes	Normal
	15 min	No	45	14/21	2	91%	Yes	No	No 4th/Town
4	15 min	Yes	45	7/13	3	79%	Yes	No	Add 22nd St.
	10 min	Yes	45	15	2	86%	Yes	No	Add 22nd St.
3	15 min	Yes	30	14/21	2	83-84%	Yes	No	Normal
Max Capacity (5)	Variable	No	20/24	12	2	83%	Yes	No	Normal

Platform Occupation and Dwell Times

- Multiple scenarios may support 10 trains or more (6/4 blended service) between South San Francisco and the TTC, with a higher capacity CP TTC.
- 45/20 minute turnaround around times can only be achieved using 5 non-dedicated platforms.
- Dedicated platform scenarios require Caltrain or HSR services to either have shorter turnaround times, or reduced capacity into the TTC.
- All scenarios have high platform occupation rates. (*Note: this study is unable to comment on the robustness of the system without more detailed analysis of how turnaround times are built-up including pad and recovery.*)
- Reduced turnaround times are key to unlocking greater TTC capacity.

Track and Signal Layout Observations

- Separation times at the TTC are critical to the system's capacity: 2 minute separation times should be made a design requirement.
- In scenarios that rely primarily on only 2 track operation in the tunnel, the third track could be used primarily as a dedicated HSR services or as a dedicated track for platfrom 6.
- Only one of the scenarios reviewed in this presentation relies on a revised track and signal layout to achieve reduced separation times; however, an alternative layout could offer long-term benefits to the system and make many scenarios more flexible.
- Engineering analysis is required to determine whether or not the track and signal layout suggested earlier in this presentation is feasible and whether it requires additional venting.
- Improving track and signal layout at the control points CP TTC and CP Townsend North would enable more flexible and efficient operation – tracks could be used bidirectionally more easily.

Thank you
for your attention!

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