ATTACHMENT A

INTERCEPT SURVEY (2013) PLAN AND RESULTS

FEHR & PEERS

ATTACHMENT A

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Subject: Caltrain Station Intercept Survey Results

SJ13-1440

Introduction

This memorandum summarizes Caltrain station intercept survey results conducted in spring 2013. The purpose of the intercept survey was to collect information on passenger mode of access to Caltrain. This information will be used to develop a ridership forecasting model, a mode of access model, and will be used in other analysis related to the Peninsula Corridor Electrification Program Environmental Impact Report (PCEP EIR).

Data Collection

A comprehensive intercept survey was conducted at 23 Caltrain stations in early June 2013. Eight stations were surveyed on Monday, June 3rd, eight stations were surveyed on Tuesday, June 4th, and seven stations were surveyed on Wednesday, June 5th, as summarized in **Table 1**. These dates were selected because they are before summer break for most schools and before finals week at Stanford. We chose to survey while school is in session because travel patterns are expected to be more representative of a typical week day. The surveys were conducted during the morning peak period, from 6:30 AM until 10:30 AM.

One to five surveyors were located on the platform of each station. A higher number of surveyors were assigned to stations with a higher number of AM passenger boardings. Surveyors asked waiting passengers if they would be willing to participate in an intercept survey. If the passenger agreed, the surveyor asked the survey questions and recorded the answers.

TABLE 1: SURVEY STATIONS AND DATES

Monday (6/3)	Tuesday (6/4)	Wednesday (6/5)
22nd Street	Millbrae	4th and King
San Mateo	Burlingame	Hillsdale
San Carlos	Belmont	San Bruno
South SF	Hayward Park	Bayshore
Redwood City	Sunnyvale	San Jose Diridon
Tamien	Menlo Park	Palo Alto
Santa Clara	San Antonio	Mountain View
California Ave.	Lawrence	

A total of 2,508 surveys were completed over the three day survey period. According to the 2013 annual ridership counts provided by Caltrain, on a typical weekday, a total of 18,384 passengers board at the 23 stations surveyed between 6:30 AM and 10:30 AM (including boardings in both directions). Therefore, the overall sampling rate is 14 percent of AM peak period boardings. A breakdown of the sampling rate per station is shown in **Table 2**.

TABLE 2 COMPLETED SURVEYS AND SAMPLING RATE PER STATION

Station	Surveys Completed	AM Peak Period Boardings	Sampling Rate
4th and King	151	2,794	5%
22nd Street	199	1,098	18%
Bayshore	41	109	38%
South San Francisco	59	120	49%
San Bruno	80	251	32%
Millbrae	249	1,431	17%
Burlingame	134	390	34%
San Mateo	140	798	18%
Hayward Park	30	91	33%
Hillsdale	204	1,318	15%
Belmont	79	189	42%
San Carlos	86	509	17%
Redwood City	79	1,022	8%
Menlo Park	83	436	19%
Palo Alto	132	934	14%
California Ave.	50	323	15%
San Antonio	79	310	25%
Mountain View	206	1,477	14%
Sunnyvale	102	1,589	6%
Lawrence	65	258	25%
Santa Clara	89	369	24%
San Jose Diridon	131	1,901	7%
Tamien	37	667	6%
TOTAL	2,508	18,384	14%

Survey Results

The survey included 19 questions related to both the trip origin and destination. Please see the pages following this memorandum for a blank copy of the full survey with all questions as presented to survey respondents. Passengers were asked both about the mode of transportation used to access their origin station and the mode used to egress their destination station. Overall the most used mode for accessing stations during the AM peak period was auto while the most used mode for egressing stations was walking.

As seen in **Figure 1**, the stations with the highest walk access mode share are Hayward Park, San Antonio, Burlingame, and California Avenue. The stations with the lowest walk access mode share are San Jose Diridon, Tamien and Millbrae. The stations with the highest bike access mode share are California Avenue, 4th and King, Palo Alto. The stations with the highest transit/shuttle access mode share are Millbrae, 4th and King, and Bayshore. The stations with the highest auto access mode share are Tamien, San Bruno, and San Jose Diridon. The stations with the lowest auto access mode share are 4th and King, San Antonio, and Hayward Park.

FIGURE 1: AM PEAK PERIOD ACCESS MODE SHARE TO ORIGIN STATION

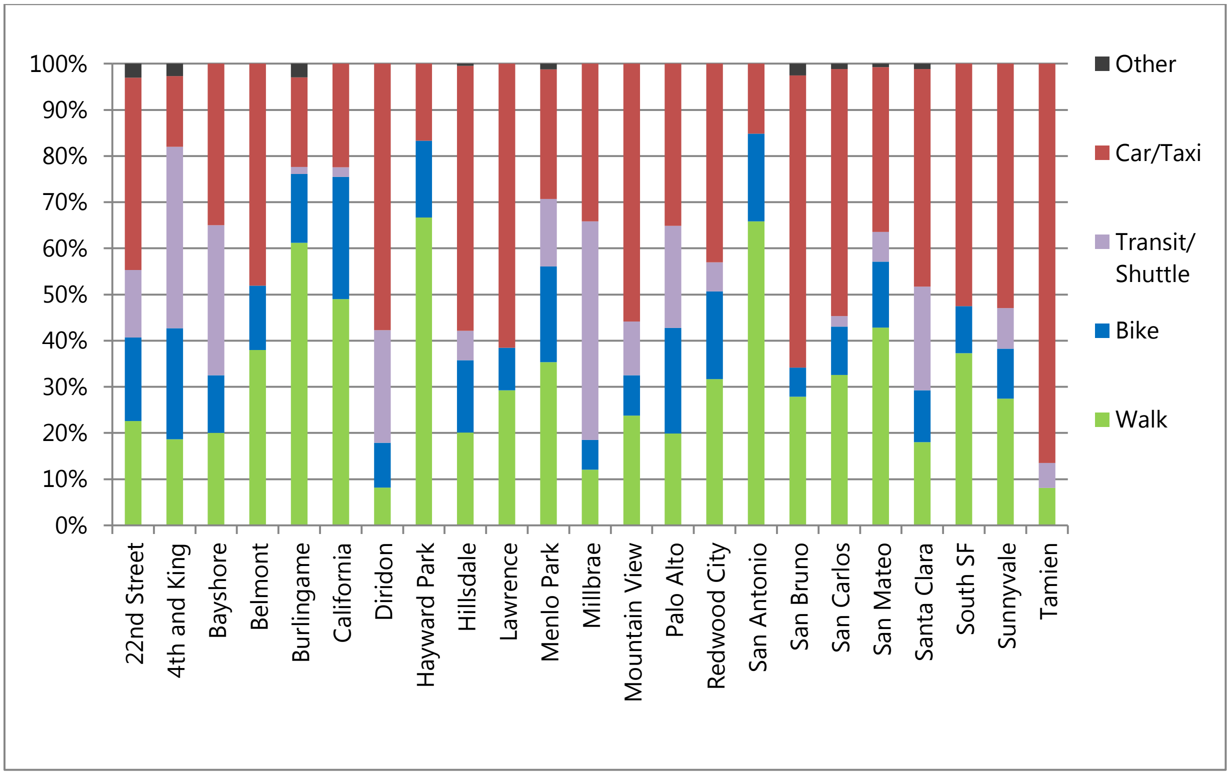


TABLE 3: AM PEAK PERIOD ACCESS MODE SHARE BY STATION

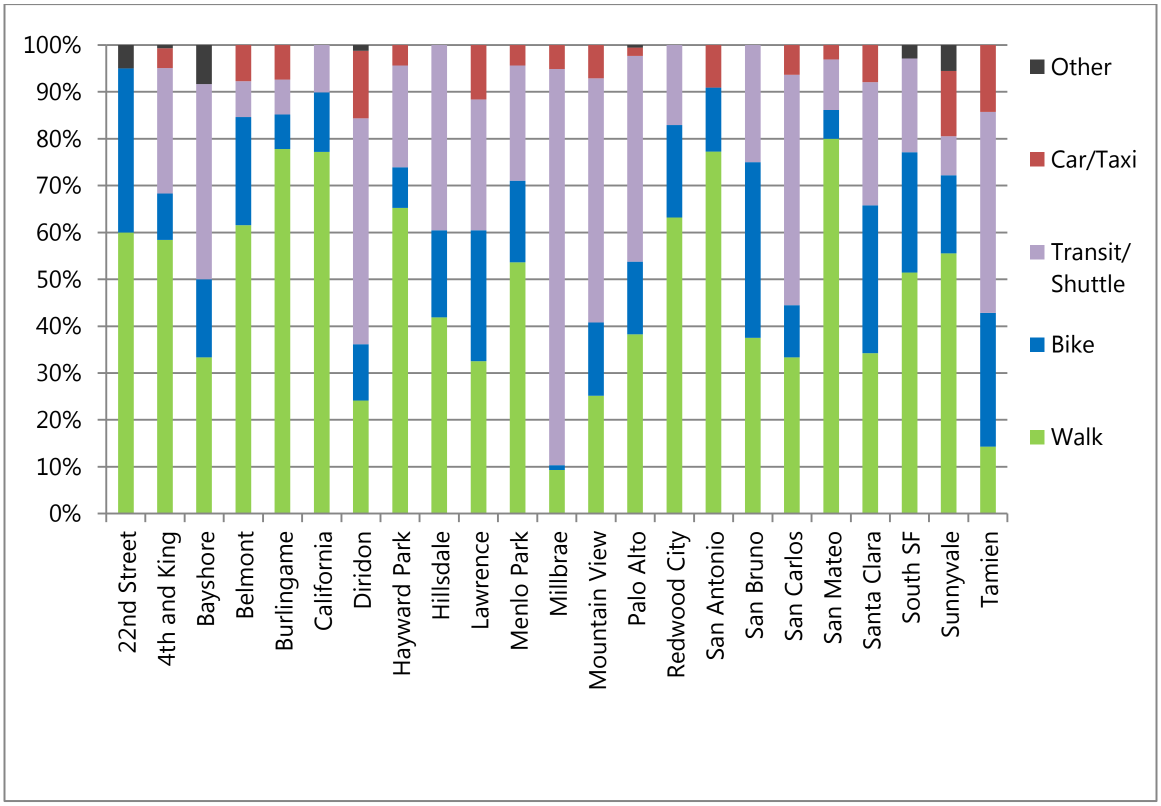
	Walk	Bike – parked at station	Bike - took on train	Transit / Shuttle	Drove Alone	Car – Dropped off	Carpool	Taxi	Other
22nd Street	23%	1%	18%	15%	27%	11%	2%	2%	3%
4th and King	19%	2%	22%	39%	2%	5%	1%	7%	3%
Bayshore	20%	0%	13%	33%	20%	15%	0%	0%	0%
Belmont	38%	1%	13%	0%	24%	19%	4%	1%	0%
Burlingame	61%	2%	13%	1%	7%	10%	1%	1%	3%
California	49%	10%	16%	2%	14%	6%	0%	2%	0%
Diridon	8%	0%	10%	24%	29%	27%	1%	1%	0%
Hayward Park	67%	0%	17%	0%	10%	7%	0%	0%	0%
Hillsdale	20%	0%	15%	6%	29%	24%	5%	0%	0%
Lawrence	29%	2%	8%	0%	22%	37%	2%	2%	0%
Menlo Park	35%	6%	15%	15%	15%	13%	0%	0%	1%
Millbrae	12%	0%	6%	47%	21%	12%	1%	0%	0%
Mountain View	24%	1%	8%	12%	30%	22%	3%	0%	0%
Palo Alto	20%	4%	19%	22%	14%	19%	0%	2%	1%
Redwood City	32%	3%	16%	6%	19%	15%	8%	1%	0%
San Antonio	66%	3%	16%	0%	8%	8%	0%	0%	0%
San Bruno	28%	0%	6%	0%	41%	19%	4%	0%	3%
San Carlos	33%	1%	9%	2%	27%	26%	1%	0%	1%
San Mateo	43%	1%	14%	6%	17%	16%	2%	0%	1%
Santa Clara	18%	2%	9%	22%	27%	17%	2%	1%	1%
South SF	37%	2%	8%	0%	29%	24%	0%	0%	0%
Sunnyvale	27%	0%	11%	9%	33%	18%	2%	0%	0%
Tamien	8%	0%	0%	5%	76%	11%	0%	0%	0%
System Average (weighted by number of AM boardings per station)	**24.3%**	**14.7%**		**10.8%**	**50.0%**				**0.2%**

The mode of access can be further broken down by whether cyclists parked their bike at the station or took their bike on the train and whether those arriving by auto drove alone, were dropped off, carpooled, or took a taxi. The detailed access mode split by station is provided in

Table 3. The California Avenue station has a fairly high share of cyclists parking their bike at the station; this may be because bike cars are too full at this station for cyclists to bring their bike on the train. The taxi mode share is highest at 4th and King, while the carpool mode share is highest at Redwood City. The drop off mode share is highest at the Lawrence, San Jose Diridon and San Carlos stations. The drive alone mode share is highest at the Tamien, San Bruno and Sunnyvale stations.

Figure 2 shows the egress mode share from each station during the AM peak period. The walk egress mode share was the highest at the San Mateo, San Antonio, Burlingame and California Avenue stations. The bike egress mode share was the highest at the San Bruno, 22nd Street, and Santa Clara stations. The transit/shuttle mode share was the highest at the Millbrae, Mountain View, and San Jose Diridon stations. The majority of passengers alighting at the Millbrae station transferred to BART. The auto egress mode share was highest at the Sunnyvale, Tamien and San Jose Diridon stations. Some passengers stated that they left an auto at a station to use for traveling between the Caltrain station and their destination while others were picked up at the station.

FIGURE 2: AM PEAK PERIOD EGRESS MODE SHARE FROM DESTINATION STATION



Those who parked at a station were asked whether they parked in a Caltrain lot, a non-Caltrain lot, or on the street. A breakdown of responses to this question can be seen in **Table 4**. Although most stations have a Caltrain parking lot, many riders are choosing to park either in an another lot or on the street.

TABLE 4: PARKING LOCATION BY STATION

Station	Caltrain Station Lot	Non-Caltrain Lot	On-Street Parking	Survey Respondents
22nd Street	0%	2%	98%	61
4th and King	0%	0%	100%	1
Bayshore	12%	0%	88%	8
Belmont	95%	0%	5%	22
Burlingame	70%	0%	30%	10
California	50%	33%	17%	6
Diridon	58%	21%	21%	39
Hayward Park	67%	0%	33%	3
Hillsdale	78%	6%	16%	69
Lawrence	44%	0%	56%	18
Menlo Park	50%	0%	50%	12
Millbrae	43%	50%	7%	54
Mountain View	73%	3%	24%	66
Palo Alto	72%	11%	17%	18
Redwood City	74%	13%	13%	15
San Antonio	33%	17%	50%	6
San Bruno	66%	3%	31%	35
San Carlos	56%	0%	44%	25
San Mateo	88%	12%	0%	26
Santa Clara	65%	15%	20%	26
South SF	94%	6%	0%	17
Sunnyvale	49%	20%	31%	35
Tamien	68%	21%	11%	28

Respondents were also asked where they were coming from and where they were going on their trip. The responses are summarized in **Table 5**. The majority of respondents were coming from home and going to work.

TABLE 5: TRIP PURPOSE OF SURVEY RESPONDENTS

Trip Purpose	Origin	Destination
Home	92.0%	2.4%
Work	1.5%	83.0%
Work-related activity	0.2%	1.9%
School	0.5%	3.3%
Medical/Dental	0.1%	0.8%
Shopping	0.0%	0.9%
Airplane (Trip)	0.6%	0.7%
Sports Event	0.1%	1.7%
Restaurant	0.0%	0.2%
Theater or Concert	1.6%	0.1%
Hotel	2.0%	0.2%
Visit Family / Friends	0.6%	1.5%
Personal Errands	0.7%	1.3%
Other	0.0%	1.9%

Respondents were also asked their household size, the number of vehicles owned by their household and their gender. Responses to these questions are summarized in **Table 6**, **Table 7**, and **Table 8**. Among those surveyed, the average household size is 2.7 persons, and the average household auto ownership is approximately 1.7 vehicles. Thirty-nine percent of those surveyed were female while 61 percent were male.

TABLE 6: HOUSEHOLD SIZE

Household Size	Percent of Respondents
1	16%
2	36%
3	21%
4	18%
5	6%
6	3%

TABLE 7: HOUSEHOLD VEHICLES

Household Vehicles	Percent of Respondents
0	13%
1	33%
2	37%
3 or more	17%

TABLE 8: GENDER

Gender	Percent of Respondents
Female	39%
Male	61%

PENINSULA CORRIDOR ELECTRIFICATION PROJECT EIR

Draft Questionnaire – Station Profile (Pedestrian Intercept) Surveys

May 13, 2013 version

Surveyor – fill in the following prior to talking to rider.

STATION		SURVEYOR	
SURVEY TIME			

Good morning! I'm conducting a survey for Caltrain. Would you be willing to take 3-4 minutes to answer some questions about your trip today?

INITIAL TRIP/TRAVEL DATA

1. How did you get to this Caltrain station for this trip? (select one)	
□$_1$ Walked all the way □$_2$ Bicycle □$_{2a}$ Parked at station □$_{2b}$ Taking bike on train □$_{2c}$ Bikeshare □$_3$ Bus, Train, or Other Transit ***SEE QUESTION 2***	□$_4$ Car (skip to question 3) □$_{4a}$ Drove alone □$_{4b}$ Dropped off □$_{4c}$ Drove with others/carpool/vanpool □$_{4d}$ Carshare □$_5$ Motorcycle/Moped □$_6$ Taxi
2. If you arrived by "Bus, Train, or Other Transit" which service did you use? (mark all that apply)	
□$_1$ AirTrain (*SF Airport*) □$_2$ BART □$_3$ Capitol Corridor □$_4$ Dumbarton Express □$_5$ Golden Gate Transit bus □$_6$ Muni bus (*SF*) □$_7$ Muni Metro/streetcar (*SF*) □$_8$ Samtrans bus □$_9$ San Joaquin train	□$_{10}$ Santa Clara VTA bus □$_{11}$ Santa Clara VTA light rail *Other Transit* □$_{12}$ Ferry □$_{13}$ Paratransit □$_{14}$ Caltrain Shuttle: ____________________________ □$_{15}$ Private Shuttle: _____________________________ □$_{16}$ Other: _____________________________
3. If you drove, where did you park? (select one)	
□$_1$ Caltrain station lot □$_2$ Non-Caltrain lot	□$_3$ On-street parking
4. If you drove and parked, what fee (if any) did you pay? (select one)	
□$_1$ None/Free	□$_2$ Parking fee for this trip: $_____________
5. Where did you just come from? (select one)	
□$_1$ Home □$_2$ Work □$_3$ Work-related activity □$_4$ School □$_5$ Medical/Dental □$_6$ Shopping □$_7$ Airplane (Trip)	□$_8$ Sports Event □$_9$ Restaurant □$_{10}$ Theater or Concert □$_{11}$ Hotel □$_{12}$ Visit friends/family □$_{13}$ Personal errands □$_{14}$ Other: _____________________________
6. And where is this place located?	
□ City: _____________________________	□ Zip Code: _____________________________
7. How long was your trip to the station this morning? (select one)	
□$_1$ ¼ mile (3-4 blocks) or less □$_2$ ¼ to ½ miles (between 3-4 and 6-8 blocks)	□$_3$ More than ½ mile

END OF THIS TRIP:

8. At which station **will you exit at the end of this one-way trip**?	
□$_1$ Station: _____________________________	□$_2$ City: _____________________________

9. After you exit the Caltrain system on this trip, how will you get to your destination?

□$_{1}$ Walk all the way
□$_{2}$ Bicycle
  □$_{2a}$ Bikeshare □$_{2b}$ Taking bike on train
□$_{3}$ Bus, Train, or Other Transit
  SEE QUESTION 10
□$_{4}$ Car
  □$_{4a}$ Drive own car parked at destination
  □$_{4b}$ Carshare □$_{4c}$ Will be picked up
  □$_{4d}$ Carpool/Vanpool
□$_{5}$ Taxi

10. If you will use "Bus, Train, or Other Transit" to get to your destination, which service did you use?

□$_{1}$ AirTrain (*SF Airport*)
□$_{2}$ BART
□$_{3}$ Capitol Corridor
□$_{4}$ Dumbarton Express
□$_{5}$ Golden Gate Transit bus
□$_{6}$ Muni bus (*SF*)
□$_{7}$ Muni Metro/streetcar (*SF*)
□$_{8}$ Samtrans bus
□$_{9}$ San Joaquin train
□$_{10}$ Santa Clara VTA bus
□$_{11}$ Santa Clara VTA light rail

Other Transit
□$_{12}$ Ferry
□$_{13}$ Paratransit
□$_{14}$ Caltrain Shuttle: ___________________________
□$_{15}$ Private Shuttle: ___________________________
□$_{16}$ Other: _____________________________

11. Where are you going? (select one)

□$_{1}$ Home
□$_{2}$ Work
□$_{3}$ Work-related activity
□$_{4}$ School
□$_{5}$ Medical/Dental
□$_{6}$ Shopping
□$_{7}$ Airplane (Trip)
□$_{8}$ Sports Event
□$_{9}$ Restaurant
□$_{10}$ Theater or Concert
□$_{11}$ Hotel
□$_{12}$ Visit friends/family
□$_{13}$ Personal errands
□$_{14}$ Other: _____________________________

12. And where is this place located?

□$_{1}$ City: _____________________________
□$_{2}$ Zip Code: _____________________________

13. How long will your trip be from the station to your destination? (select one)

□$_{1}$ ¼ mile (3-4 blocks) or less
□$_{2}$ ¼ to ½ miles (between 3-4 and 6-8 blocks)
□$_{3}$ More than ½ mile

RETURN TRIP:

14. Will you be making a return trip to **<u>this</u>** station today? (select one)

□$_{1}$ Yes   □$_{2}$ No return trip (one-way)
□$_{3}$ No-Other Station: ___________________________

15. If you are making a return trip, what time do you estimate you will return?

□ Time: ____________________________

16. If you are making a return trip, will you use the same travel mode to return to your place of origin? (select one)

□$_{1}$ Yes
□$_{2}$ No (list mode): __________________________

DEMOGRAPHIC QUESTIONS:

17. Including yourself, how many people currently live in your household? (select one)

□$_{1}$ 1
□$_{2}$ 2
□$_{3}$ 3
□$_{4}$ 4
□$_{5}$ 5
□$_{6}$ 6 or more

18. How many total vehicles does your household own? (select one)

□$_{1}$ 0
□$_{2}$ 1
□$_{3}$ 2
□$_{4}$ 3 or more

19. Gender? (select one)

□$_{1}$ Female
□$_{2}$ Male

THANK YOU!

ATTACHMENT B
LIST OF FUTURE ROADWAY PROJECTS

Note: The System Ridership Analysis using the VTA mode is presented in Appendix I in the PCEP EIR. The full list of roadway projects for future forecast years assumed in the VTA model are included in the following pages.

Attachment B: Plan Bay Area Roadway Projects Included in PCEP VTA Model Forecasts

RTPID	Project Title	Class	County	Mode	Construction End Year
240349	Widen I-280/Mariposa off-ramp	Expansion	San Francisco	Freeway	2014
240523	Implement HOV Lanes on U.S. 101 in San Francisco - Planning, Preliminary Engineering, and Envrionmental	Planning	San Francisco	Freeway	2015
230555	Reconstruct ramps on the east side of the San Francisco-Oakland Bay Bridge's Yerba Buena Island tunnel	System Management	San Francisco	Local interchange	2016
21549	Implement Bayview Transportation Improvements	Enhancement	San Francisco	Major Arterial	2017
240155	Implement Better Market Street - Transportation Elements	System Management	San Francisco	Major Arterial	2017
230490	Re-build and widen Harney Way to 8-lanes	Expansion	San Francisco	Major Arterial	2024
240534	Rehabilitate local bridges	Preservation	San Francisco	Major Arterial	2040
240543	Modify local road intersections (includes safety upgrades, signalization, and realignment)	System Management	San Francisco	Major Arterial	2040
240728	Implement San Francisco congestion pricing programs (includes Treasure Island Congestion Pricing and cordon pricing)	System Management	San Francisco	Major Arterial	2040
240483	Enhance highways in San Francisco (includes signs and landscaping)	System Management	San Francisco	Expressway	2040
240542	Manage freeways and expressways in San Francisco (includes non-ITS elements, performance monitoring, and corridor studies)	Planning	San Francisco	Expressway	2040
230704	Make Route 92 operational improvements to Chess Drive on- and off-ramps	Expansion	San Mateo	Local interchange	2012
21607	Modify University Avenue overcrossing of U.S. 101 to improve operational efficiency and safety (includes widening of overcrossing, constructing new southbound off-ramp and auziliary lane, and adding bicycle lanes)	System Management	San Mateo	Local interchange	2013
22261	Replace San Pedro Creek Bridge on Route 1	Preservation	San Mateo	Freeway	2013
240174	Implement signal interconnect between signals on Willow Road from Middlefield Avenue to Bay Road	System Management	San Mateo	Major Arterial	2013
22751	Improve safety on Route 1, including adding protected left and right turn lanes at Route 1, adding through lanes on Route 1 at signalized intersections, and constructing new pedestrian/bicycle path	Expansion	San Mateo	Expressway	2013
240169	Implement adaptive signal system between I-280 and Santa Cruz Avenue	System Management	San Mateo	Major Arterial	2014
21602	Reconstruct U.S. 101/Broadway interchange	System Management	San Mateo	Local interchange	2016
240133	Widen Millbrae Avenue between Rollins Road and U.S. 101 soutbound on-ramp and resurface intersection of Millbrae Avenue and Rollins Road	Expansion	San Mateo	Major Arterial	2016
230417	Modify U.S. 101/Holly Street interchange (includes widening eastbound to northbound loop to 2 lanes and eliminating northbound to westbound loop)	Expansion	San Mateo	Local interchange	2017
98204	Construct Route 1 (Calera Parkway) northbound and southbound lanes from Fassler Avenue to Westport Drive in Pacifica	Expansion	San Mateo	Expressway	2017
21604	Add northbound and southbound modified auxiliary lanes on U.S. 101 from Oyster Point to San Francisco County line	System Management	San Mateo	Freeway	2018
21606	Reconstruct U.S. 101/Willow Road interchange	System Management	San Mateo	Local interchange	2018
21608	Construct auxiliary lanes (one in each direction) on U.S. 101 from Marsh Road to Embarcadero Road	System Management	San Mateo	Freeway	2018
22227	Construct a 6-lane arterial from Geneva Avenue/Bayshore Boulevard intersection to U.S. 101/Candlestick Point interchange	Expansion	San Mateo	Major Arterial	2020
22756	Reconstruct U.S. 101/Candlestick Point interchange to full all-directional interchange	Expansion	San Mateo	Local interchange	2020
21603	Improve U.S. 101/Woodside Road interchange	Expansion	San Mateo	Local interchange	2021
22282	Improve operations at U.S. 101 near Route 92	System Management	San Mateo	Freeway to freeway interchange	2023
21615	Modify and reconstruct I-280/Route 1 interchange in northbound and southbound directions, including braided ramps	System Management	San Mateo	Freeway to freeway interchange	2024
22230	Add auxiliary lane in each direction on I-280 between Westborough and Hickey Boulevard	System Management	San Mateo	Freeway	2024
240161	Provide overcrossing at I-280/John Daly Boulevard	Expansion	San Mateo	Major Arterial	2026
21613	Widen Route 92 between San Mateo-Hayward Bridge to I-280, includes uphill passing lane from U.S. 101 to I-280	Expansion	San Mateo	Freeway	2027
22271	Widen Skyline Boulevard (Route 35) to 4-lane roadway from I-280 to Sneath Lane	Expansion	San Mateo	Major Arterial	2027
240060	Modify existing lanes on U.S. 101 from Whipple to County line to accommodate HOV/T lane	System Management	San Mateo	Freeway	2027
94644	Construct a westbound slow vehicle lane on Route 92 between Route 35 and I-280	Expansion	San Mateo	Major Arterial	2029
22229	Reconstruct U.S. 101/Sierra Point Parkway interchange (includes extension of Lagoon Way to U.S. 101)	Expansion	San Mateo	Local interchange	2030
21612	Improve access to and from the west side of Dumbarton Bridge on Route 84 connecting to U.S. 101, includes flyovers, interchange improvements, and conversion of Willow Road between Route 84 and U.S. 101 to expressway	System Management	San Mateo	Expressway	2030
21609	Improve local access at I-280/I-380 from Sneath Lane and San Bruno Avenue to I-380	System Management	San Mateo	Local interchange	2031
21892	Widen Woodside Road from 4-lanes to 6-lanes from El Camino to Broadway, includes adding shoulders	Expansion	San Mateo	Major Arterial	2032
240160	Construct southbound on- and off-ramps to U.S. 101 at Peninsula Avenue to add on and off ramps from southbound U.S. 101	Expansion	San Mateo	Local interchange	2033
21893	Widen Route 92 between Half Moon Bay city limits and Pilarcitos Creek alignment, includes widening of travel lanes and shoulders	System Management	San Mateo	Expressway	2034
22274	Install an Intelligent Transportation System (ITS) and a Traffic Operation System countywide	System Management	San Mateo	Major Arterial	2040
22279	Constrruct new itnerchange at U.S. 101/Produce Avenue	System Management	San Mateo	Local interchange	2040
230434	Implement local circulation improvements and traffic management programs countywide	System Management	San Mateo	Local interchange	2040
240087	Implement non-capacity Increasing local road Intersection modifications and channelization countywide	System Management	San Mateo	Local interchange	2040
240114	Implement operational and safety improvements on Route 1 between Half Moon Bay and Pacifica (includes acceleration lanes, deceleration lanes, turn lanes, bike lanes and enhanced crossings)	System Management	San Mateo	Expressway	2040
230531	Construct auxiliary lanes on U.S. 101 in Mountain View and Palo Alto, from Route 85 to Embarcadero Road	System Management	Santa Clara	Freeway	2013
240376	Implement improvements on Hacienda Avenue between Winchester Boulevard and San Tomas Aquino Road	System Management	Santa Clara	Major Arterial	2013
22839	Convert the HOV lane on Central Expressway between Sam Tomas and De La Cruz to a general purpose lane	System Management	Santa Clara	Expressway	2013
22829	Improve intersection at Fitzgerald Avenue (includes construction of a left-turn lane to Fitzerald Avenue and bike lanes and sidewalks)	System Management	Santa Clara	Major Arterial	2014
22944	Widen I-880 for HOV lanes in both directions from Route 237 in Milpitas to U.S. 101 in San Jose	Expansion	Santa Clara	Freeway	2014
230201	Widen Coleman Avenue from 4-lanes to 6-lanes between I-880 and Taylor Street	Expansion	Santa Clara	Major Arterial	2014
230385	Implement Palo Alto Street Smarts program	System Management	Santa Clara	Major Arterial	2014
240419	Upgrade Saratoga Signal System	System Management	Santa Clara	Local interchange	2014
230210	Rehabilitate San Tomas Expressway Box Culvert	Preservation	Santa Clara	Expressway	2014
21714	Widen U.S. 101 from Monterey Street to Route 129 - project development	Planning	Santa Clara	Freeway	2015
22932	Add turn lane on Watsonville Road Center	System Management	Santa Clara	Major Arterial	2015
230262	Improve interchange at Montague Expressway/U.S. 101	Expansion	Santa Clara	Freeway	2015

RTPID	Project Title	Class	County	Mode	Construction End Year
230705	Debt Service Payments		Santa Clara	Local interchange	2015
240379	Extend Buena Vista Avenue from Santa Teresa Boulevard to Monterey Road	Expansion	Santa Clara	Major Arterial	2015
240403	Widen Dixon Landing Road from 4-lanes to 6-lanes between North Milpitas Boulevard and I-880	Expansion	Santa Clara	Major Arterial	2015
240439	Route 85 express lanes between Route 87 and I-280: Convert HOV lane to express lane between U.S. 101 and I-280; Convert HOV lane and construct additional express lane between I-280 and Route 87; Convert HOV lane to express lane between Route 87 and southbound U.S. 101; Construct 1.1 mile auxiliary lane between South De Anza Boulevard northbound on-ramp and Stevens Creek Boulevard northbound off-ramp (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2015
240481	Convert Route 237 HOV lanes to express lanes between North First Street to Mathilda Avenue (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2015
240482	Implement express lanes on I-680 from Calaveras Boulevard to Montague Expressway (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2015
240710	Implement Lawrence Expressway/I-280 interchange project	System Management	Santa Clara	Freeway	2015
230267	Widen Montague Expressway to 8-lanes for HOV lanes between Lick Mill and Trade Zone boulevards and on Guadalupe River Bridge and Penitencia Creek Road	Expansion	Santa Clara	Expressway	2015
230269	Construct a new interchange at Trimble Road and Montague Expressway	System Management	Santa Clara	Expressway	2015
22878	Realign Wildwood Avenue to connect with Lawrence Expressway (includes new traffic signal at Lawrence Expressway/Wildwood Avenue intersection)	System Management	Santa Clara	Major Arterial	2016
230407	Widen off-ramp at southbound Route 17/Hamilton Avenue	Expansion	Santa Clara	Freeway	2016
240405	Improve intersection at Dixon Landing Road/Milpitas Boulevard	System Management	Santa Clara	Local interchange	2016
240506	Implement El Camino Real Regional Corridor improvements from Palo Alto Medical Foundation to Churchill Avenue	System Management	Santa Clara	Major Arterial	2016
240636	Construct 2-lane or 4-lane connection between Almaden Expressway and Winfield Boulevard (Chynoweth Ave. or Thornwood bridge will include construction of a new connector, bike lanes and sidewalks)	Expansion	Santa Clara	Major Arterial	2016
22814	Extend deceleration lane on Foothill Expressway	System Management	Santa Clara	Expressway	2016
22883	Close median and right-in-and-out access on Lawrence Expressway at De Soto Avenue, Golden State Drive, Granada Avenue, Lillick Drive, Buckley Street, and St. Lawrence/Lawrence Station on-ramp	System Management	Santa Clara	Expressway	2016
230246	Improve intersection at Lawrence Expressway/Prospect Road (includes providing a second left turn lane from Prospect Road eastbound to Lawrence Expressway northbound and modify existing traffic signals)	System Management	Santa Clara	Expressway	2016
22164	Construct Route 237 westbound on-ramp from Middlefield Road to Route 237 westbound	System Management	Santa Clara	Local interchange	2017
22910	Implement Intelligent Transportation System (ITS) facilities on the Santa Teresa Boulevard-Hale Avenue corridor between Day Road and Castro Valley Road	System Management	Santa Clara	Major Arterial	2017
230200	Extend Autumn Parkway from Julian Street to San Carlos Street and implement improvements from St. John Street to Park Avenue	Expansion	Santa Clara	Major Arterial	2017
230332	Construct grade separation at Rengstroff Avenue	System Management	Santa Clara	Major Arterial	2017
230411	Construct auxiliary lane on eastbound Route 237 from Mathilda Avenue to Fair Oaks Avenue	System Management	Santa Clara	Freeway	2017
230456	Widen Zanker Road from 4-lanes to 6-lanes	Expansion	Santa Clara	Major Arterial	2017
230466	Construct Caltrain grade separation at Branham Lane	System Management	Santa Clara	Major Arterial	2017
230471	Widen intersections and improve sidewalks throughout the city of Sunnyvale	System Management	Santa Clara	Local interchange	2017
230532	Improve interchange at Route 237/North 1st Street	System Management	Santa Clara	Freeway	2017
240404	Widen Calaveras Boulevard overpass from 4-lanes to 6-lanes	Expansion	Santa Clara	Major Arterial	2017
240411	Implement improvements on Santa Teresa Boulevard between Main Avenue and DeWitt Avenue	System Management	Santa Clara	Major Arterial	2017
240425	Widen intersection at El Camino Real/Lafayette Street	Expansion	Santa Clara	Local interchange	2017
240466	U.S. 101 express lanes between Whipple Avenue and Cochrane Road: Convert HOV lane to express lane between Whipple Avenue (in San Mateo County) and Santa Clara County line; Convert HOV lane into express lane and construct additional express lane between Santa Clara County line and Cochrane Road (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2017
240484	Implement express lanes on I-880 between the Alameda County Line and U.S. 101 (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2017
240570	Widen offramp at Trimble Road on Route 87	Expansion	Santa Clara	Freeway to freeway interchange	2017
22180	Construct auxiliary lanes on Central Expressway between Lawrence Expressway and Mary Avenue	System Management	Santa Clara	Expressway	2017
230242	Implement Capitol Expressway Traffic Operations System (TOS)	System Management	Santa Clara	Expressway	2017
230273	Widen Montague Expressway between Trade Zone and I-680	Expansion	Santa Clara	Expressway	2017
22010	Construct second exit lane on I-280 to Foothill Expressway	Expansion	Santa Clara	Local interchange	2018
22845	Construct auxiliary lane on southbound U.S. 101 from Ellis Street to eastbound Route 237	System Management	Santa Clara	Freeway	2018
230294	Widen and create new alignment for Route 152 (from Route 156 to U.S. 101)	Expansion	Santa Clara	Freeway	2018
230363	Construct interchange at I-880 and Montague Expressway (includes improvements to Montague Expressway)	Expansion	Santa Clara	Local interchange	2018
230410	Construct auxiliary lane on southbound U.S. 101 from Great America Parkway to Lawrence Expressway	System Management	Santa Clara	Freeway	2018
230445	Implement capacity increasing improvements at the intersection of Great America Parkway/Mission College Boulevard	Expansion	Santa Clara	Local interchange	2018
230449	Extend Charcot Avenue over I-880 as a new 2-lane roadway with bicycle and pedestrian improvements to connect to North San Jose employment center	Expansion	Santa Clara	Major Arterial	2018
230574	Improve the Route 85/Cottle Road interchange	Expansion	Santa Clara	Freeway	2018
240464	Convert Route 87 HOV lanes to express lanes between Route 85 and U.S. 101 (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2018
240611	Improve interchange at Route 85/El Camino Real	System Management	Santa Clara	Freeway	2018
22822	Implement expressway traffic information and advisory systems (includes installation of electronic information changeable message signs, advisory radio, cable TV feeds and web page to provide real time traffic information)	System Management	Santa Clara	Expressway	2018
230292	Implement Expressway and Cross Street signal coordiation	System Management	Santa Clara	Expressway	2018
21785	Widen interchange at U.S. 101/Blossom Hill Road	Expansion	Santa Clara	Freeway	2019
230255	Implement signal improvements on Santa Teresa Boulevard and San Martin Avenue	System Management	Santa Clara	Major Arterial	2019
230266	Implement traffic signal improvements on Santa Teresa Boulevard and Tilton Avenue	System Management	Santa Clara	Major Arterial	2019
230370	Improve interchange at I-680/Montague Expressway	Expansion	Santa Clara	Local interchange	2019
230457	Widen Oakland Road from 4-lanes to 6-lanes between U.S. 101 and Montague Expressway	Expansion	Santa Clara	Major Arterial	2019
230492	Improve interchange at U.S. 101/Old Oakland Road	Expansion	Santa Clara	Freeway	2019
230580	Improve interchange at Route 237/El Camino Real/Grant Road	Expansion	Santa Clara	Freeway	2019

RTPID	Project Title	Class	County	Mode	Construction End Year
230644	Implement miscellaneous intersection improvements in North San Jose	System Management	Santa Clara	Major Arterial	2019
240532	Improve interchanges on Route 152 at Frazier Lake Road, Bloomfield Road, Watsonville Road, and Ferguson Road	Expansion	Santa Clara	Major Arterial	2019
22156	Improve connector ramp at Route 85 northbound to Route 237 eastbound (includes widening off-ramp from Route 85 to Route 237 eastbound, constructing auxiliary lane on Route 237 eastbound between Route 85 on-ramp to Middlefield Road; constructing off-ramp on Route 237 eastbound between Route 85 and Dana Street)	Expansion	Santa Clara	Freeway to freeway interchange	2020
230425	Improve interchange at Route 87/Capitol Expressway/Narvaez Avenue	System Management	Santa Clara	Freeway	2020
230645	Implement improvements to the North First Street Core Area grid	Expansion	Santa Clara	Major Arterial	2020
240477	Implement express lanes on Route 237 between Mathilda Avenue to Route 85 (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2020
240554	Improve interchanges at Route 237/Mathilda Avenue and U.S. 101/Mathilda Avenue	System Management	Santa Clara	Local interchange	2020
21702	Improve interchange at U.S. 101/Buena Vista Avenue	Expansion	Santa Clara	Freeway	2021
22895	Implement operational interchange improvements at San Tomas Expressway/Route 17	System Management	Santa Clara	Expressway	2021
240485	Implement express lanes on U.S. 101 between Cochrane Road and Masten Avenue (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2022
240513	Implement express lanes on I-280 between Leland Avenue and Magdalena Avenue (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2022
230251	Implement Expressway TOS infrastructure improvements	System Management	Santa Clara	Expressway	2022
230265	Improve grade intersection at Montague Expressway/Mission College Boulevard	System Management	Santa Clara	Expressway	2022
240516	Implement express lanes on I-680 between Montague Expressway and US 101 (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2023
240517	Implement express lanes on I-880 between U.S. 101 and I-280 (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2023
22175	Widen Almaden Expressway from Coleman Avenue to Blossom Hill Road	Expansion	Santa Clara	Expressway	2024
22179	Widen Central Expressway from 4-lanes to 6-lanes between Lawrence Expressway and San Tomas Expressway	Expansion	Santa Clara	Expressway	2024
22843	Widen Lawrence Expressway from Moorpark Avenue/Bollinger Road to south of Calvert Drive	Expansion	Santa Clara	Expressway	2024
21704	Improve I-280 downtown access between 3rd Street and 7th Street	System Management	Santa Clara	Freeway	2025
21722	Improve interchange at U.S. 101 southbound Trimble Road/De la Cruz Boulevard/Central Expressway	Expansion	Santa Clara	Local interchange	2025
21786	Widen interchange at U.S. 101/Hellyer Avenue	Expansion	Santa Clara	Freeway	2025
22979	Improve interchange at U.S. 101/Zanker Road/Skyport Drive/Fourth Street	Expansion	Santa Clara	Freeway	2025
240514	Implement express lanes on I-280 between US 101 and Leland Avenue (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2025
240515	Implement express lanes on I-280 between southbound El Monte Road and Magdelena Avenue (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2025
22186	Widen San Tomas Expressway to 8-lanes between Route 82 to Williams Road	Expansion	Santa Clara	Expressway	2025
240491	Implement express lanes on U.S. 101 between Masten Avenue and 10th Street (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2026
240469	Implement express lanes on Route 17 between I-280 and Route 85 (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway	2028
240671	Improve interchange at I-280/Senter Road	Expansion	Santa Clara	Freeway	2029
230284	Montague Expressway & McCarthy/O'Toole Interchange Improvements	System Management	Santa Clara	Expressway	2029
230356	Construct interchange at Lawrence Expressway and Arques Avenue	System Management	Santa Clara	Expressway	2029
22965	Improve interchange at U.S. 101/Mabury Road/Taylor Street	Expansion	Santa Clara	Local interchange	2030
240492	Implement express lanes on U.S. 101 between 10th Street and Route 25 (included under VTA Express Lane Network RTPID #240742)	Expansion	Santa Clara	Freeway	2030
240436	Improve southbound U.S. 101 between San Antonio Road to Carleston Road/Rengstorff Avenue	System Management	Santa Clara	Freeway	2035
240441	Improve interchange at U.S. 101/Oregon Expressway/Embarcadero Road	System Management	Santa Clara	Freeway	2035
240468	Improve connector ramp at Route 237 westbound to Route 85 southbound (includes auxiliary lanes on Route 85 between El Camino Real and Route 87)	Expansion	Santa Clara	Freeway	2035
240473	Improve braided ramps on northbound I-280 between Foothill Expressway and Route 85	System Management	Santa Clara	Freeway to freeway interchange	2035
22134	Construct a lane on southbound U.S. 101 using the existing median from south of Story Road to Yerba Buena Road; modify the U.S. 101/Tully road interchange to a partial cloverleaf	Expansion	Santa Clara	Freeway	2040
240463	Convert Route 237 HOV lanes to express lanes between North First Street and I-880 (included under VTA Express Lane Network RTPID #240742)	System Management	Santa Clara	Freeway to freeway interchange	2040
240494	Implement System Operations and Management Program for Santa Clara County	System Management	Santa Clara	Major Arterial	2040
240742	VTA Express Lane Network	Expansion	Santa Clara	Freeway	2040

ATTACHMENT C
DIRECT RIDERSHIP MODEL AND STATION MOA/MOE METHODOLOGY:
CALIBRATION TECHNICAL MEMORANDUM

FEHR & PEERS

ATTACHMENT C

Date: January 22, 2014

To: Stacy Cocke, Caltrain
George Naylor, VTA
Rich Walter, ICF

From: Jerry Walters, Matt Haynes, Nikki Foletta, Kristen Carnarius, Jennifer Zeibarth, Fehr & Peers

Subject: Development of an Integrated VTA + Fehr & Peers Direct Ridership Model for Forecasting Caltrain Ridership and Access and Egress Mode Use for the Peninsula Corridor Electrification Project Enviornmental Impact Report (PCEP EIR)

SJ13-1440

Summary

This memo describes the process for the development of an integrated Santa Clara Valley Transportation Authority (VTA) and Fehr & Peers Direct Ridership Model (DRM) for forecasting Caltrain ridership, access, and egress mode use for the Peninsula Corridor Electrification Project Environmental Impact Report (PCEP EIR).

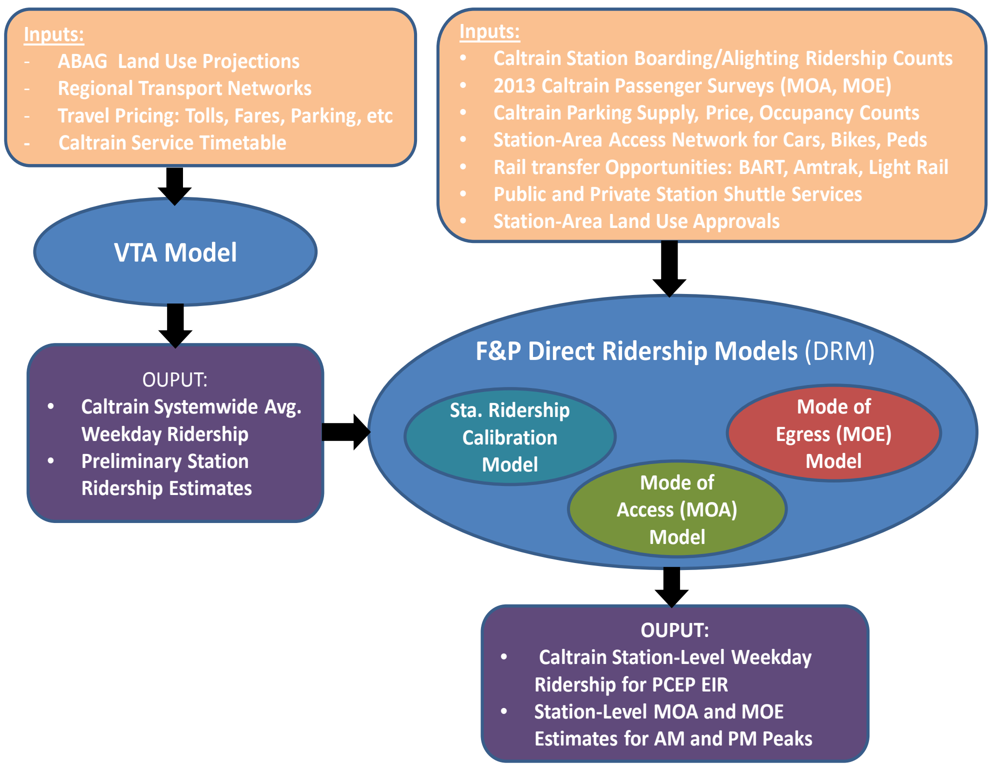
Broadly speaking, the VTA model was used to forecast future system-wide average weekday ridership for the PCEP EIR, while the Fehr & Peers DRM model was developed to refine the outputs from the VTA model to develop Caltrain station level ridership estimates for the stations within the PCEP project limits[1]. **Exhibit 1** depicts process for developing the PCEP EIR station-level ridership and access and egress estimates.

The Santa Clara Valley Transportation Authority (VTA) performs transit ridership forecasting for various efforts. The VTA travel demand model used to prepare the ridership forecasts for the Caltrain PCEP is the San Mateo City/County Association of Governments (C/CAG) Bi-County Model originally developed in 2009 to support the Grand Boulevard Initiative (GBI) Corridor

[1] The systemwide ridership forecasts prepared for the purposes of the PCEP EIR does not imply that VTA endorses with any subsequent findings made in the PCEP EIR, or in any other planning document, based on the ridership forecasts prepared by VTA staff.

Project and the San Mateo Countywide Transportation Plan (CTP) update. The model was initially validated to year 2005 conditions and made use of the Association of Bay Area Governments (ABAG) Committed Regional Plans socioeconomic data forecasts (informally known as ABAG projections 2011) to develop forecast year 2035 projections.

Exhibit 1: **PCEP EIR Station Level Ridership Process** (Dec 2013)



The VTA model used for the PCEP EIR addresses travel throughout the metropolitan area as it affects Caltrain ridership and access modes, taking into account population and employment densities, auto ownership rates, demographics, transit and highway travel conditions and other factors. It forecasts street and highway traffic and system ridership on all transit services in Santa Clara, San Mateo and San Francisco counties. The model does an exceptionally good job at estimating system-level Caltrain ridership and meets or exceeds industry standards for ridership accuracy within the Santa Clara and San Francisco corridor segments. However, as is true of even the best regional models, its scale leaves the model relatively insensitive to fine-grained local conditions, such as TOD, land use clustering, station area multi-modal circulation and local paratransit services. As a result, the model estimates of station-specific boardings differ from passenger counts by more than 20 percent at over half of the Caltrain stations.

Therefore, to produce the most reliable ridership estimates possible for the PCEP EIR, we've used the VTA model for system-level estimates and applied DRM to fine-tune the estimates for station level detail. We used "direct ridership" analytics to compare VTA model estimates to actual ridership and access modes at each station, and to develop a calibration process which adjusts VTA model outputs to address these factors and to better predict Caltrain station-by-station ridership without affecting the system-level estimates. The DRM analysis considered over 20 local land use and accessibility factors and identified four that capture station-level activity in a more fine-tuned manner than is possible with the regional model alone.

The DRM analysis discovered that, in addition to accurately system ridership, to about 1 percent of actual boardings, the VTA model also addresses most of the localized factors tested. However, the DRM process identified four station-specific factors to which the VTA model is relatively insensitive: the amount of private shuttle bus service provided at the station, the concentration of population and jobs within the walkable half-mile proximity to the station, a "betweenness" measure of local street and sidewalk network connectivity, and a variable to account for the differences in the model's aggregation of land use between the San Mateo and Santa Clara County segments of the Caltrain corridor.

By incorporating these four factors, the DRM was able to calibrate Caltrain boarding estimates to better match actual 2013 Caltrain ridership. Compared with the original VTA model estimates, the DRM calibration:

- Improves the ridership estimates at 18 of the 23 stations studied
- Reduces the inaccuracy in estimating overall Caltrain ridership and average station boardings by 70 percent
- Reduces the percent root-mean-square error (RMSE), an indicator that amplifies the importance of large errors and doesn't allow station overestimates and underestimates to cancel one another, by 24 percent
- Improves VTA ridership estimates at different points in time, as seen through DRM performance testing with historic data from 2005 and 2010

The VTA model also provides estimates of the proportions of passengers arriving and departing each station via driving, transit, or walk and bike modes, based on average region-wide surveys. To refine these estimates for the PCEP EIR, DRM models were developed to forecast modes of access and modes of egress at each Caltrain station using intercept passenger surveys conducted at each station in 2013 (Attachment A). The surveys identified the actual proportions of riders accessing and egressing each station by auto (park-ride, kiss-ride), transit, walking and bicycling.

Through our DRM modeling analysis, Fehr & Peers found that the following factors could be used to replicate the actual access and egress mode shares: parking supply and price, frequency of feeder bus, rail, and private shuttle service to station, street network intersection density, percent coverage of bike lanes, local population and employment density, and Caltrain service headways. The mode of access model is more than 50 percent more accurate than the VTA model for all access modes. Individually, the DRM access/egress model is, more than 55 percent more accurate for park-ride, and more than 45 percent more accurate for kiss-ride auto mode shares, key metrics to be used in determining the traffic and parking impacts associated with Caltrain ridership. The mode of egress model is more than 50 percent more accurate than the VTA model for all egress modes.

In summary, the PCEP EIR uses a combination of VTA model and Direct Ridership Model estimates. The VTA model produces estimates of system-level Caltrain ridership and preliminary estimates of station use. The station-specific estimates are further refined though DRM analysis in a manner that does not affect the VTA system level forecasts. This DRM approach includes both the estimate of total number of daily riders at each station and the proportions arriving and departing by the available station access and egress modes in the AM peak period.

1.0 Introduction

As part of the PCEP environmental analysis, estimates of system-wide and station ridership are needed to evaluate potential transportation impacts resulting from the proposed project. Ridership forecasting provides estimates of the total number of passengers that will ride Caltrain as a result of the project, and it also provides information on how access to individual stations along the Caltrain corridor will change in the future.

The Peninsula Corridor Electrification Project consists of converting Caltrain from diesel-hauled to electric multiple unit (EMU) trains for service between the Fourth and King Street Caltrain Station in San Francisco and the Tamien Station in San Jose.

In 2019 service between San Jose and San Francisco would utilize a mixed fleet of EMU's and existing diesel locomotives. After 2019, diesel locomotives will be replaced with EMUs over time as they reach the end of their service life. Caltrain's diesel-powered locomotive service would continue to be used to provide service between the San Jose Diridon Station and Gilroy.

For the purposes of analysis required as part of the PCEP EIR, prototypical Caltrain schedules were input into the VTA model to obtain system-wide Caltrain ridership. The VTA model was first calibrated on a system-wide level to 2013 conditions. Once the results were within 1.4 percent, the future scenarios were modeled: the No Project, the mixed fleet Project Scenario (model year 2020) and the Cumulative Scenario (model year 2040) which assumed a fully electrified fleet between San Francisco. The Project and Cumulative scenarios assume a peak hour increase in Caltrain service from 5 to 6 trains per peak hour per direction. Service between San Jose Diridon and Gilroy Stations is assumed to remain diesel at existing service levels (three round trips per weekday).

VTA develops and maintains a four-step travel forecasting model for Santa Clara and San Mateo counties, along with San Francisco and other adjacent travel markets. The model estimates trips throughout the metropolitan area by various modes, including Caltrain and access-modes to Caltrain. The model is sensitive to multiple factors including population and employment densities, auto ownership rates, demographics (age, income level, household size, etc.), and transit network connections. However, because its scope is regional, it is not able to "zoom in" to all of the details of extremely localized conditions. The model is relatively insensitive to certain factors that may be important to Caltrain riders at individual stations, such as local pedestrian and bicycle network connectivity and availability of employer-operated shuttles.

We have developed a calibration process, which adjusts VTA model outputs using factors found to be correlated to Caltrain station level ridership as well variables for which the VTA model might be over- or undercompensating. The calibrated Caltrain boarding estimates were found to better match actual Caltrain ridership for 2013 than the original VTA model estimates. We will use this calibration process to adjust VTA model estimates for Caltrain station ridership forecasts for future scenarios. The calibration process is described below.

The VTA model is capable of estimating mode of access for walk, park-and-ride, kiss-and-ride, and transit. The model is much more accurate at the system level with significant variation for individual stations and, like most regional models, the VTA model is not able to estimate bike mode of transit access. The mismatch between the modes that the VTA model is capable of providing and the observed market shares, it is difficult to assess the accuracy of the model for mode of access estimation, although the VTA model predicts shares of walk and drive access close to observed shares at a system level,

To develop reliable station-specific access and egress forecasts, Fehr & Peers developed AM peak period mode of access (MOA) and mode of egress (MOE) DRM models for the 23 Caltrain stations within the PCEP project limits that presently offer weekday service. The MOA model determines the proportion of those arriving at each station in the AM period that do so via each of the primary available modes: park-and-ride, kiss-and-ride, transit, walking and cycling. The MOE model does the same for those egressing the each station in the AM period. For PM peak forecasts, the access mode proportions are projected to be the same as the modal proportions used to egress each station in the AM period, and the PM egress proportions are expected to be the same as the AM access proportions. Development and application of these models are also described below.

2.0 System-wide and Station Level Ridership

For purposes of the Caltrain PCEP EIR calibration was performed for all stations providing service all day during weekdays that are within the PCEP project study area (San Francisco to Tamien Stations). This includes 23 stations. The calibration excludes Broadway, Atherton and Stanford Stadium Stations because these stations do not receive weekday service. Stations south of Tamien are also excluded, as they are located outside the study area. College Park is not included because it only serves two trains per day in each direction, meaning its ridership is much lower than other stations on the corridor.

Table 1 shows a comparison of observed versus modeled year 2013 Caltrain boardings for the stations included in the calibration. Caltrain provided observed average weekday boardings for February 2013. The VTA model performs well in terms of estimating aggregate boardings. The VTA model generally overestimates boardings at stations within San Mateo County and underestimates boardings within Santa Clara County.

TABLE 1: CALTRAIN 2013 BOARDINGS COMPARISON

	Observed Boardings[1]	Modeled Boardings[2]	Error
All Counties	46,551	46,948	+397
San Francisco County	12,292	12,204	-88
San Mateo County	15,050	16,960	+1,910
Santa Clara County	19,404	18,242	-1,162

Notes

1. Caltrain 2013; does not include Broadway, Atherton, Stanford Stadium, and College Park, which do not receive weekday Caltrain service, and stations south of Tamien in San José, which are outside of the PCEP project limits.
2. VTA model 2013 Baseline Run, 7/30/2013

2.1 Fehr & Peers' Direct Ridership Model (DRM) Methodology and Calibration Process

Region-wide travel demand models perform well when estimating aggregate travel demand, such as system-wide transit boardings, but are not intended for precise estimates of station-specific boardings. While the VTA model is the appropriate tool for system level forecasts and approximate station level estimates, it does not address station-by-station conditions in the detail desired for the most accurate estimates of station traffic and parking impacts. **Figure 1** presents observed and VTA model estimated boardings for each station. While model estimates are quite accurate at some stations (e.g. San Antonio, Santa Clara), model estimates are off by more than 20 percent at stations such as Bayshore, South San Francisco, San Bruno, Millbrae, Burlingame, Hayward Park, San Carlos and Sunnyvale. Direct Ridership Models (DRM), including the model developed by Fehr & Peers for the PCEP EIR, use regression analyses to estimate station ridership based on station level input variables, but are not responsive to large changes to the transportation network, such as major shifts in travel patterns or infrastructure. Therefore, for future Caltrain ridership forecasts, it is beneficial to start with the VTA model as a base, in order to capture the impact of regional changes, and perform an adjustment using variables either not included in the VTA model or that require further adjustment.

We developed a calibration equation that estimates the difference between the VTA model station boardings and the observed station boardings. The difference between VTA model boardings per station and observed boardings per station was used as the dependent variable in an Ordinary Least Squares regression analysis. 2013 data were used for the analysis. We identified a set of variables that had been successfully used to create previous Direct Ridership Models and that were found to be either not included in the VTA model or included at a level of aggregation more consistent with regional model Transportation Analysis Zone (TAZ) geography that does not allow highly precise focus at the station-specific level. The set was then tested as independent variables in order to determine which variables had the highest correlation to the dependent variable. **Table 2** summarizes the variables tested. **Table 3** summarizes the information included in the calculation of the pedestrian environment factor variable.

Figure 1 Uncalibrated VTA model and Observed Boardings per Station

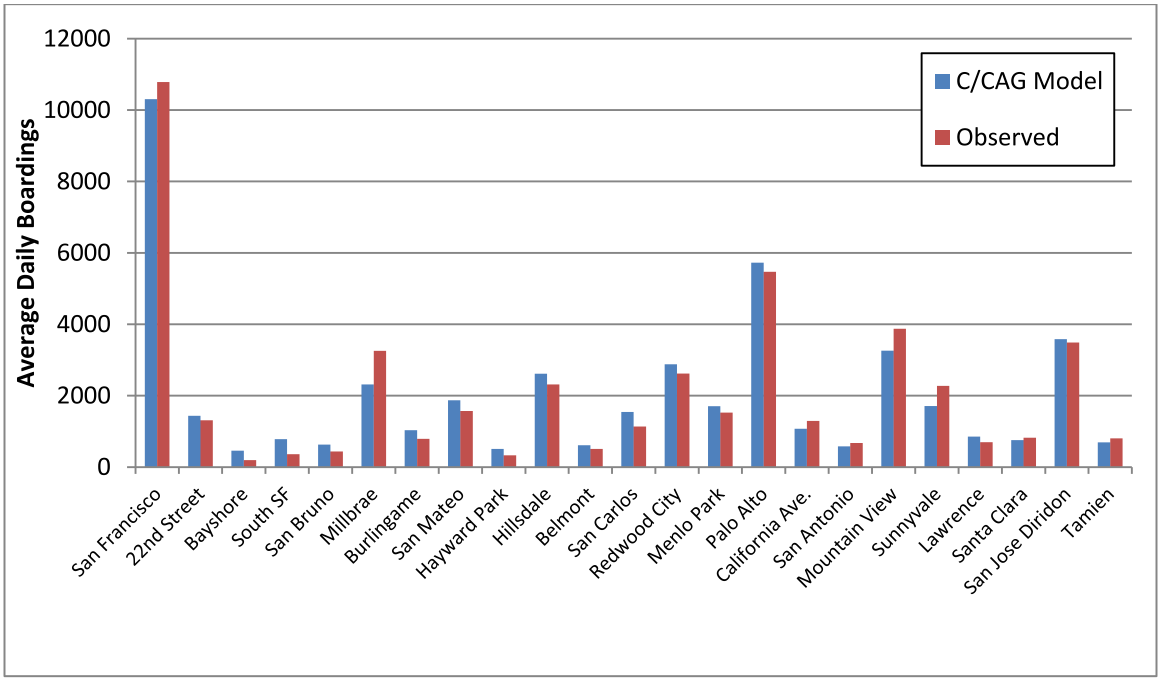


TABLE 2: CALIBRATION EQUATION VARIABLES TESTED FOR DIRECT RIDERSHIP MODEL	
Variable	**Description**
Population	Population within ½ mile radius of station (divided by 1,000)
Jobs	Jobs within ½ mile radius of station (divided by 1,000)
Pop + Jobs	Population plus total jobs within ½ mile radius of station (divided by 1,000)
Trains per Day	Daily Caltrain trains stopping at the station
AM Bullet Trains	Daily bullet trains stopping at the station in the AM
Caltrain Frequency Factor	Trains per Day+ AM Bullet Trains
Caltrain Parking Supply	Number of parking spaces at the Caltrain station
Caltrain Parking Occupancy	Occupancy rate of parking spaces at the Caltrain station
Caltrain Parking Charged	Categorical variable indicating a station charges for parking, 1=charges for parking, 0=parking is free
Offsite Parking	Number of on-street parking spaces within ¼ mile of the station available for long-term parking (metered parking and permit parking excluded)
Total Parking	Caltrain Parking Supply + Offsite Parking
AM Private Shuttles	Number of employer or campus shuttles serving station during the AM period
AM Public Shuttles	Number of public shuttles serving station during the AM period
AM Transit Factor	Factor incorporating number of buses and BART trains serving the station during the AM period
AM Rail Factor	Factor incorporating the number of light rail, Altamont Commuter Express (ACE), Capitol Corridor, Amtrak, and BART trains serving the station during the AM period
Pedestrian Environment Factor	Factor evaluating the quality of the pedestrian realm within ¼ mile of the station, including consideration of : sidewalk completeness, directions of pedestrian access to the station, presence of crosswalks, quality of sidewalk, density of street trees, and roadway characteristics such as speed limit and number of lanes
Class 1 Bikeways	Length of Class 1 bicycle facilities (i.e. trails) within 1 mile of the station
Class 2 Bikeways	Length of Class 2 bicycle facilities (i.e. bicycle lanes) within 1 mile of the station
Class 3 Bikeways	Length of Class 3 bicycle facilities (i.e. bicycle routes) within 1 mile of the station
Bikeway Miles	Length of Class 1 + Class 2 + Class 3 bicycle facilities within 1 mile of the station
Bikeway Density Factor	Factor incorporating Pop + Jobs and Bikeway Miles
Intersection Density	Number of intersections within ½ mile radius of station

TABLE 2: CALIBRATION EQUATION VARIABLES TESTED FOR DIRECT RIDERSHIP MODEL	
Variable	**Description**
Betweenness[2]	A measure of walkability of the station area, calculated as the fraction of the shortest paths between pairs of intersections that pass by a particular intersection, calculated for the 4 closest intersections to the station
Closeness[1]	A measure of the walkability of the station area, calculated as the inverse of the cumulative distance required to reach from an intersection to all other intersections within ½ mile, calculated for the 4 closest intersections to the station
Reach[1]	A measure of the walkability of the station area, calculated as the number of surrounding intersections each intersection can reach, calculated for the 4 closest intersections to the station
Go Pass Level	Rank variable (1-5) indicating the number of employees for which Go Pass[3] is available within ½ mile of the station
Go Pass Use Ratio	Percentage of passengers that use the Go Pass per station
Auto Transit Travel Time Ratio	Auto travel time along US 101 divided by Caltrain travel time for all station-pairs along the Caltrain line, weighted by the number of passengers who travel between the respective origin and destination
TAZ Size	Average size of travel analysis zones (TAZs) in square miles that intersect the station area (½ mile around the station)
County	Categorical variables indicating the county to which the station belongs

Sources: VTA model, Fehr & Peers, Caltrain

[2] Betweenness, Closeness, and Reach were calculated using Urban Network Analysis, an ArcGIS toolbox developed by City Form Lab at the Massachusetts Institute of Technology (MIT)
[3] The Caltrain Go Pass is an annual pass for unlimited rides on Caltrain available to employees, paid for by employers at a discounted rate.

TABLE 3
EXISTING PEDESTRIAN ENVIRONMENT AND AMENITIES IN STATION AREAS

Station	Wheelchair Accessibility	Directions of Pedestrian Access	Sidewalk Completeness	Presence of Crosswalks	Density of Street Trees	Near Freeway	Maximum Posted Speed Limit on Adjacent Streets (mph)	Traffic Calming on Surrounding Streets
4th and King	Lifts on both platforms	4	75 %	3	1	No	35 mph on King Street	No
22nd Street	No lift available	4	75 %	2	2	Yes	25 mph on 22nd Street/ Pennsylvania Street	No
Bayshore	Lifts on both platforms	3	25 %	2	1	No	35 mph on Tunnel	No
South SF	No lift available	2	75 %	1	1	Yes	35 mph on East Grand Avenue	Yes
San Bruno	Lifts on both platforms	4	50 %	1	1	No	30 mph on Huntington Avenue	Yes
Millbrae	Lifts on both platforms	4	75 %	1	2	No	35 on El Camino Real	No
Broadway	No lift available	4	75 %	1	2	Yes	35 mph on Carolan Avenue/ California Drive	Yes
Burlingame	Lifts on both platforms	4	100 %	2	2	No	25 mph on Howard Avenue	No
San Mateo	Lifts on both platforms	4	100 %	3	2	No	25 mph on B Street	Yes
Hayward Park	Lifts on both platforms	4	50 %	2	2	Yes	30 mph on Delaware Street	No
Hillsdale	Lifts on both platforms	3	75 %	1	1	No	35 mph on Hillsdale Blvd./El Camino	No

TABLE 3 EXISTING PEDESTRIAN ENVIRONMENT AND AMENITIES IN STATION AREAS								
Station	Wheelchair Accessibility	Directions of Pedestrian Access	Sidewalk Completeness	Presence of Crosswalks	Density of Street Trees	Near Freeway	Maximum Posted Speed Limit on Adjacent Streets (mph)	Traffic Calming on Surrounding Streets
Belmont	Lifts on both platforms	4	75 %	3	2	No	35 mph on El Camino	No
San Carlos	Lifts on both platforms	4	75 %	1	2	No	35 mph on El Camino	Yes
Redwood City	Lifts on both platforms	4	100 %	2	2	No	35 mph on El Camino	Yes
Atherton	No lift available	4	25 %	0	3	No	25 mph on Fair Oaks Lane	No
Menlo Park	Lifts on both platforms	4	100 %	3	3	No	35 mph on El Camino	Yes
Palo Alto	Lifts on both platforms	4	75 %	2	3	No	35 mph on El Camino	Yes
California Avenue	Lifts on both platforms	2	75 %	2	2	No	35 mph on Alma Street	Yes
San Antonio	Lifts on both platforms	3	75 %	3	2	No	45 mph Central Expressway	Yes
Mountain View	Lifts on both platforms	3	75 %	3	2	No	45 mph on Central Expressway	Yes
Sunnyvale	Lifts on both platforms	4	75 %	3	1	No	35 mph on Mathilda Avenue	No
Lawrence	Lifts on both platforms	2	50 %	0	1	No	40 mph on Kifer Road	No
Santa Clara	Lifts on both platforms	3	75 %	3	2	No	35 on El Camino Real	No
College Park	No lift available	2	75 %	1	3	No	40 on Coleman Avenue	No

TABLE 3 EXISTING PEDESTRIAN ENVIRONMENT AND AMENITIES IN STATION AREAS								
Station	Wheelchair Accessibility	Directions of Pedestrian Access	Sidewalk Completeness	Presence of Crosswalks	Density of Street Trees	Near Freeway	Maximum Posted Speed Limit on Adjacent Streets (mph)	Traffic Calming on Surrounding Streets
San Jose Diridon	Lifts on both platforms	3	100 %	3	1	No	35 mph on W Santa Clara Street	No
Tamien	Lifts on both platforms	2	75 %	3	2	Yes	35 mph on W Alma Avenue	Yes
Source: Fehr & Peers, Caltrain								

Variables were selected for the DRM calibration model based on their contribution to the overall goodness-of-fit of the model. The calibration model was further scrutinized on its ability to accurately predict boardings at a higher number of stations than the VTA model and by its RMSE, a measure of model accuracy.

The variables found to produce the best overall calibration equation are the following, and are further detailed below:

- AM Private Shuttles Serving Station
- Population + Jobs in Station Area
- Street Network Betweenness in Station Area
- Station Location in San Mateo County
- No constant term (also known as regression through the origin)

The VTA model does a reasonable job of accounting to the ridership effects of all of the other variables listed in Table 2 (e.g. offsite parking and the length of Class I bicycle facilities) to the extent that they influence Caltrain ridership. With the DRM used to calibrate the VTA model applied, the combined model predicts boardings more accurately than the unadjusted VTA model at 18 of 23 stations. The boardings calibration equation has an R^2 value of 0.46, meaning it accounts for 46 percent of the variation between the VTA model outputs and the observed boardings. RMSE is a measure of model accuracy that measures the typical difference (standard deviation) between modeled and observed values. Because it is based on squared errors, positive and negative errors do not cancel each other, and larger errors create substantially larger values of RMSE. The model's percent RMSE is 0.13 compared with a percent RMSE of 0.17 for the VTA model alone. The final equation to calculate the calibrated daily station boardings estimate, using both the VTA model output and the calibration equation is the following:

*Station Boardings = VTA model Station Boardings Estimate + 35.5 * AM Private Shuttles – 10.8 * Pop+Jobs + 0.086 * Betweenness – 159 * San Mateo County*

The calibration equation adds boardings for the number of private shuttles serving the station in the AM period and degree of connectivity of the roadway network within one-half mile of the station. The calibration subtracts boardings at all San Mateo County stations and for the combination of population and jobs within one-half mile of the station. The variables are described in more detail below.

AM Private Shuttles

Due to high concentrations of employment and other land development near, but not walkable to, many Caltrain stations, shuttles are heavily used to for the "last mile" connection. Both publicly and privately operated shuttles service many of the stations. Several shuttle variables were tested in the calibration, all station specific, including number of public shuttles, number of private shuttles, total number of shuttles, and daily versus in the AM period. The only shuttle variable found significant was the *AM Private Shuttles* variable. Because the dependent variable is the difference between the actual number of boardings and the VTA model estimate of boardings, the low statistical significance of the public shuttle variables implies that the VTA model already adequately addresses the relationship between public shuttles and ridership. We conclude that the VTA model captures the effect of public shuttles on daily boardings but does not fully capture the effect of private shuttles.

The variable *AM Private Shuttles* can be viewed as an important descriptor of the level of transit access of the station. Because private shuttles are typically employer-based, the variable also reflects employment intensity indirectly served by each station. The calibration process found that the VTA model underestimates the effect of private shuttles serving a station on ridership at that station. The calibration equation accounts for this by adding 35.5 daily boardings per productive private shuttle that serves the station during the AM period, recognizing that the peak hour service level is also a reflection of the amount of shuttle service at other times of day as well.

Population Plus Jobs in Station Area

The Population Plus Jobs in Station Area variable represents the density of the reasonable walking distance of the station, including residential population, retail, and non-retail jobs. For each TAZ, the VTA model uses ABAG *Projections 2011* population and employment to estimate the number of trips associated with the TAZ and the accessibility of the TAZ. The calibration process found that the VTA model slightly overestimates the impact of density in the station area (within one-half mile of the station). This may mean that, proportionally, the model underestimates the effect of development somewhat further away, by not fully capturing the effectiveness of local bike networks, local shuttles, and well-designed pedestrian connections that encourage walk access from even beyond ½ mile. The calibration equation accounts for this by subtracting 10.8 boardings per 1,000 residents plus jobs in the station area.

Street Network Betweenness

The variable *Betweenness* is a measure of roadway network connectivity that serves as a proxy for the walkability of the station area. *Betweenness* is defined as the fraction of shortest paths between pairs of intersections in the station area that pass by a given intersection and was measured for the four intersections closest to the station. Areas with a connected network facilitate easier and more direct walking paths. Walkability has been known to influence transit ridership. The calibration process found that the VTA model underestimates the impact of network connectivity in the station area. Considered together with the activity density variable described above, the betweenness variable helps account for the importance of a combination of development density, even beyond one-half mile distance, and the robustness and directness of the local multi-modal circulation network in the station area. The calibration equation accounts for this by adding 0.086 boardings per increase in level of connectedness within the station area.

San Mateo County Variable

The VTA model generally overestimates daily boardings for San Mateo County stations, while boardings for Santa Clara and San Francisco Counties are slightly underestimated. One potential explanation is that the average size of TAZs around San Mateo County stations is larger than the TAZs around Santa Clara County stations. Larger TAZ size indicates less refined land use placement and perhaps an exaggeration of the population and employment close to the station. A variable for TAZ size is preferable to an indicator variable but was not found to improve model performance over the variable for San Mateo County stations. The calibration accounts for these modeling differences between the counties by removing 159 boardings from all San Mateo County stations.

2.2 Direct Ridership Model Calibrated Ridership Results

As shown in Exhibit 1 (please see page 2), the Direct Ridership calibration model was applied to the VTA model outputs for 2013 in order to generate calibrated daily boarding estimates per station. The DRM MOA and MOE models were also used to produce refined estimates of the proportions of rides arriving and departing each station via different access and egress modes. The DRM station ridership values were compared to observed boardings provided by Caltrain for February 2013 in the following tables and figures.

Table 4 shows a comparison of model performance. Year 2013 data were used to generate the calibration equations. The calibrated direct ridership model predicted boardings closer to observed values than the VTA model. The boarding estimates at 18 of the 23 stations are closer to observed boardings in the calibrated model than in the VTA model. The calibrated model also reduces percent RMSE by almost one-fourth, and eliminates about three-fourths of the VTA model error in estimating total system boardings.

The calibrated model also improves estimates for 2010 and 2005 when applied to VTA model runs of the same years. The VTA model estimates for 2010 and 2005 are not directly comparable to the 2013 estimates as the VTA models are different between years. Nevertheless, the calibrated DRM model improves estimates for all three years when used to adjust the results of the best available 4-step model. A comparison of boardings per station for Observed, VTA model and DRM calibrated model for each model year can be seen in **Figure 3** – **Figure 5**.

TABLE 4: DIRECT RIDERSHIP MODEL PERFORMANCE

	2013		
	Observed	**VTA model**	**Calibrated Model**
System Boardings[1]	46,551	46,947	46,420
Boardings Model Percent RMSE[2]	-	17 percent	13 percent
Number of Stations at which Calibrated Model Outperforms VTA model	-	-	18 out of 23

Notes:

1. 2013 system values do not include Broadway, Atherton, Stanford Stadium, College Park, and all stations south of Tamien
2. RMSE = Root Mean Square Error

Sources: Caltrain, VTA model, Fehr & Peers

Figure 3 Observed, VTA model and Calibrated Model Caltrain Boardings per Station (2013)

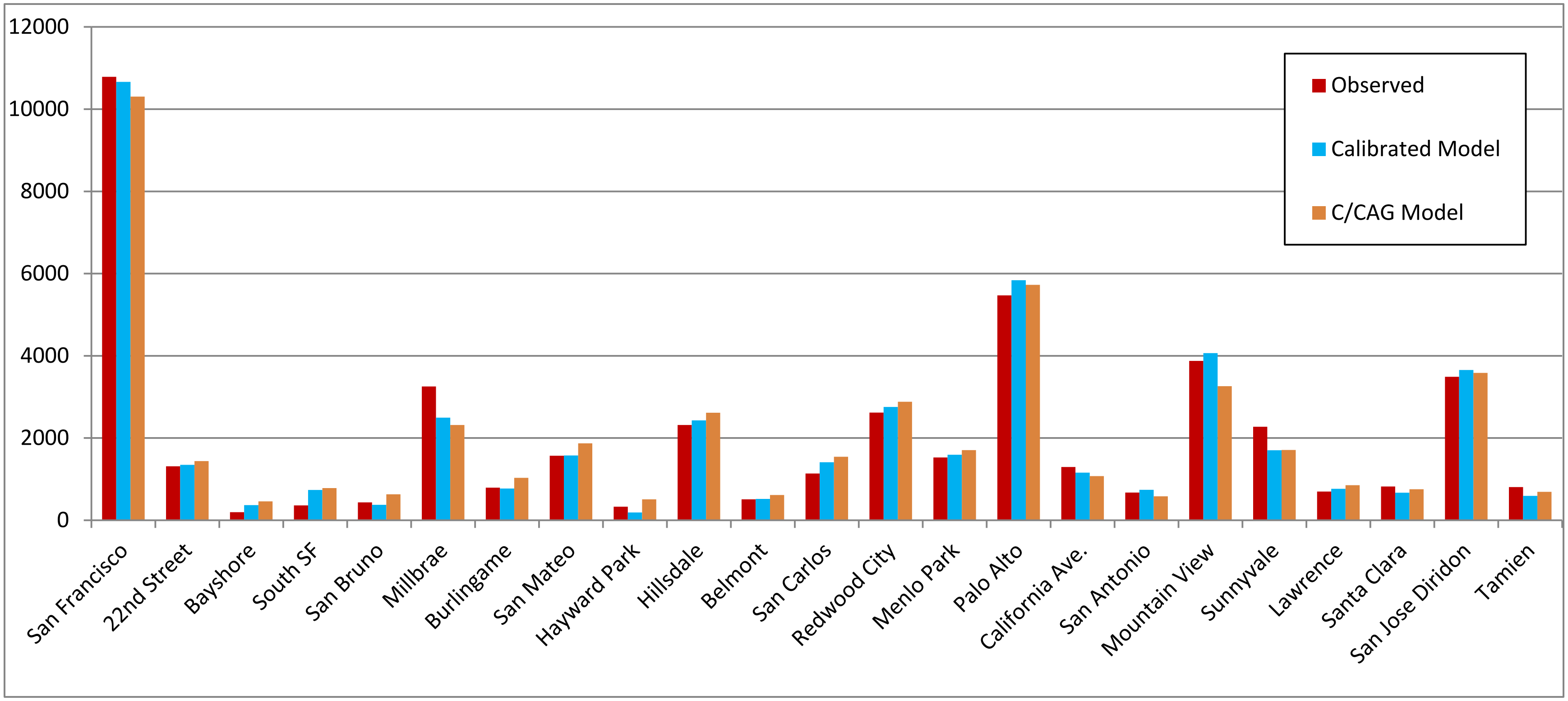


Figure 4 Observed, VTA model and Calibrated Model Caltrain Boardings per Station (2005)

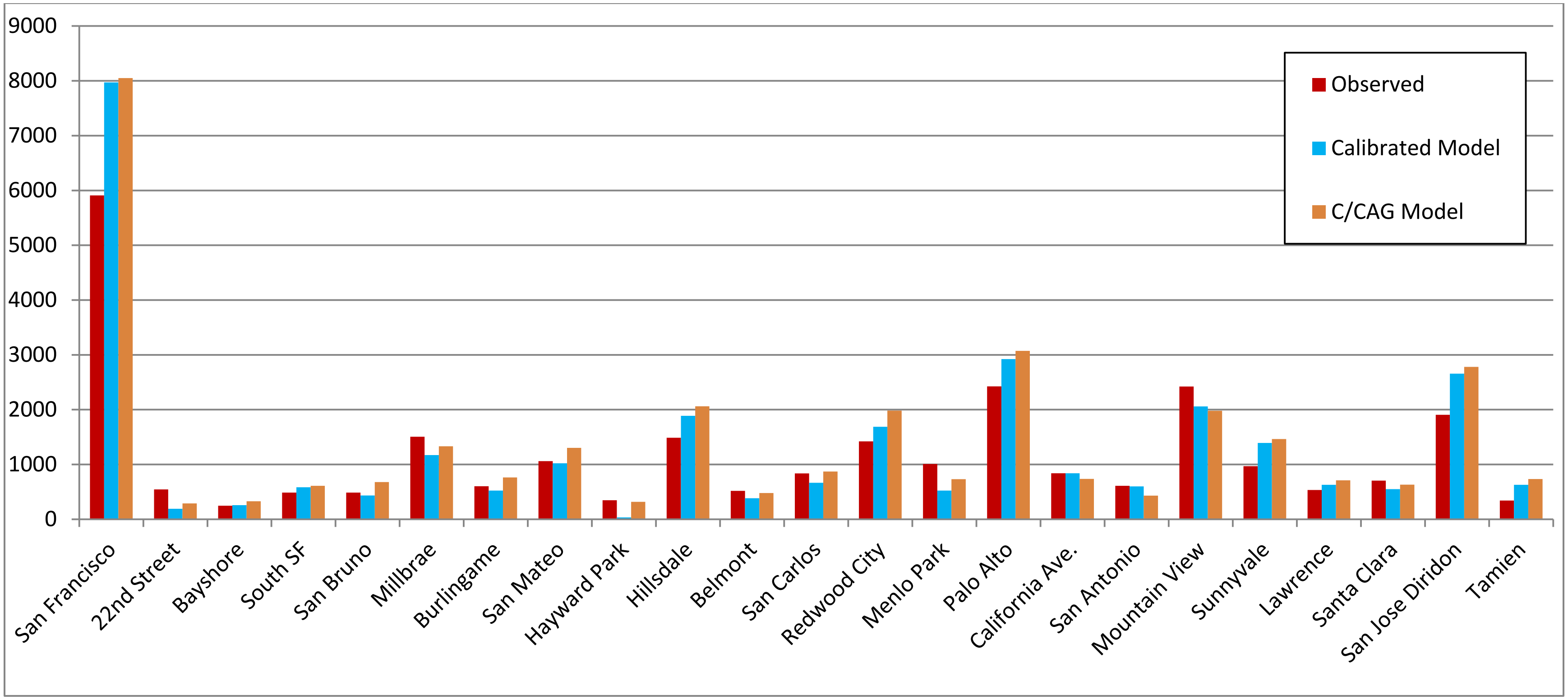
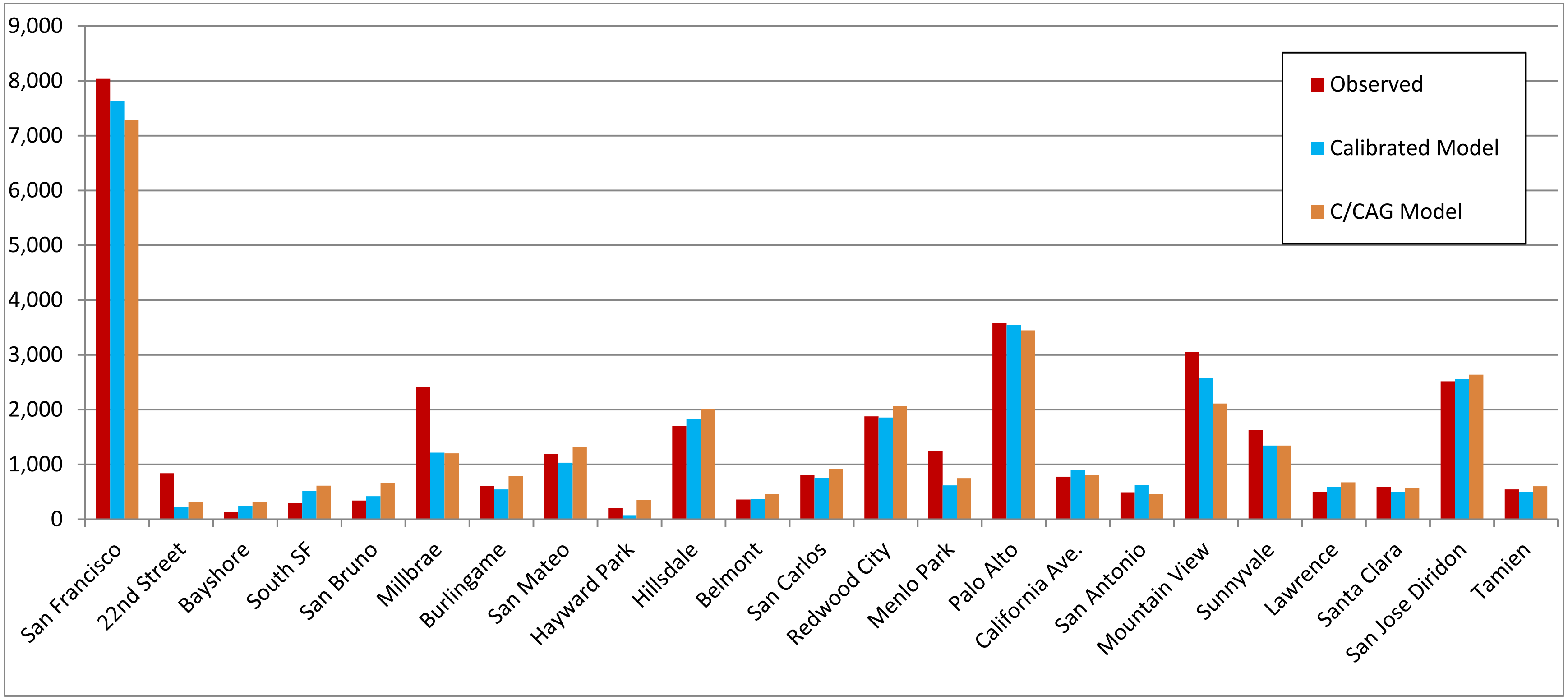


Figure 5 Observed, VTA model and Calibrated Model Caltrain Boardings per Station (2010)



The Calibrated Model improves estimates of daily boardings at 16 of 23 stations for 2005 and 17 of 23 stations for 2010 conditions. The percent RMSE of the 2005 VTA model is 0.48 while the percent RMSE of the calibrated model is 0.42. The percent RMSE of the 2010 VTA model is 0.29 while the percent RMSE of the calibrated model is 0.24.

As a final step in the model calibration process, a station-specific adjustment factor was estimated to adjust the calibrated model results to match the actual results, based on a methodology recommended by the Transportation Research Board report NCHRP 255 *Highway Traffic Data for Urbanized Area Project Planning and Design*. At the system-wide level, the ridership estimate at all stations is to scaled to match the system boarding totals produced by the VTA model with is within about 1.4 percent of the actual system ridership count. At a station-specific level, the process assumes that, once the systematic factors affecting station boardings were accounted for in the models, the unique characteristics of individual stations and their specific catchment population and business should be measured and accounted for in forecasting. The unique station factors are calculated by comparing the 2013 calibrated model estimate at the station with the actual 2013 station boardings. Because it is based primarily on the unique attributes of each station, rather than upon systematic factors such as frequency of train service or surrounding land use and feeder access, which are captured in the VTA model and DRM, the station-specific adjustment determined for the base year is assumed to also affect the future year forecasts. The station-specific factor, based on the difference between the base year calibrated model estimates and the observed base year boardings is applied to future year model results. As recommended in NCHRP 255, if the percent error of the base year (2013) calibrated model boardings for a station is less than 50 percent, the ratio of the base year actual boardings to base year model calibrated boardings is used to adjust the future year calibrated model results. If the percent error is greater than 150 percent, the difference between the actual boardings and base year model calibrated boardings is used to adjust future year calibrated model results. Otherwise the average of the ratio and the difference are used to adjust future year calibrated model results. This method was used to adjust the station-specific model forecasts produced by the combined VTA model and Fehr & Peers DRM calibration for all future scenarios.

3.0 Mode of Access

This section describes the relationship between the VTA and DRM Caltrain station-specific mode of access model. The DRM implements a process similar to the VTA model, estimating the proportions of total ridership arriving at a station by individual access modes. Compared with the VTA model, it takes into consideration a greater number of factors and it includes a more detailed measurement of local accessibility around each station, and it differentiates the access choices among a greater number of available modes, considering bicycling as a key option. Exhibit 1 (please see page 2) illustrates how the access model fits within the overall integrated VTA and DRM process.

The VTA model approximates the mode of access to Caltrain stations for based on regional factors. To incorporate local differences among individual stations, the DRM examines station-specific accessibility factors and relates them to each station's observed access mode shares. collected through rider surveys conducted in June 2013 by Fehr & Peers. In part because it doesn't directly focus on kiss-and-ride and bicycle access to transit, the VTA model generally under-estimates walk/bike mode share, over-estimates transit mode share, over-estimated park and ride mode share and under-estimates kiss and ride mode share when compared to observed values.

3.1 Mode of Access Model Development

Fehr and Peers developed an MOA model to estimate the mode of access during the AM peak period. This model is a logit model, transformed via Berkson's method to a linear regression model, which jointly predicts mode shares for each of five access modes (walk, bike, transit, park and ride, kiss and ride), using results from the intercept survey as the dependent variable in the model. The variables listed in Table 2 were tested as independent variables in various model runs. Variables were selected for the final mode of access model based on their contribution to the overall goodness-of-fit of the model, or concurrence between the DRM MOA estimate and the surveyed share of riders approaching each station by each mode.

A utility function was created for each access mode. The variables selected for the final utility equations of the AM access mode share model are summarized in **Table 5**. Certain variables were included in the utility function for more than one access mode. Table 5 lists the variables included in the model and in which mode utility equation the variable is included. A "+" sign indicates a positive coefficient meaning that as the variable increases the mode share for that mode increases while a "-" sign indicates a negative coefficient meaning as the variable increases the mode share for that mode decreases. Because the mode of access model proportions the given station boardings into the respective access modes, the model variables have both direct effects on the mode as listed in the **Table 5**, and indirect effects on the other modes. For example, the bikeway density factor directly increases bicycle use as an access mode, and in doing so, reduces the amount of access occurring by each other mode.

TABLE 5: VARIABLES INCLUDED IN AM MODE OF ACCESS MODEL

	Walk	Bike	Transit	Park & Ride	Kiss & Ride
Pop + Jobs	+				
Intersection Density	+				
Bikeway Density Factor		+			
AM Transit Factor			+		
Caltrain Frequency Factor			+	+	+
Caltrain Parking Supply				+	
Caltrain Parking Charged				-	

The Mode of Access model has been developed such that as the proportion (or likelihood) of one mode increases, the likelihood of using the other modes decreases. The station access mode share is estimated according to the following equation:

$$P_i = \frac{e^{V_i}}{\sum_{j \in J} e^{V_j}}$$

$$where\ i, j = particular\ modes\ of\ access$$

$$P_i = probability\ of\ using\ mode\ i\ to\ access\ the\ station$$
$$J = the\ set\ of\ all\ possible\ modes\ of\ access\ to\ Caltrain$$
$$= \{Walk, Bike, Transit, Park\ and\ Ride\ (PNR), Kiss\ and\ Ride\ (KNR)\}$$
$$V_i = linear - in - parameters\ utility\ fucntion = \boldsymbol{\beta} * \boldsymbol{X}$$
$$\boldsymbol{X} = a\ vector\ of\ explanatory\ variables$$
$$\boldsymbol{\beta} = a\ vector\ of\ coefficients$$

The following are the utility functions for each mode:

$$Vwalk = 0.066 * (Pop + Jobs) + 0.007 * IntersectionDensity$$

$$Vbike = 0.90 + 0.91 * BikewayDensityFactor$$

$$Vtransit = -2.81 + 0.022 * AMTransitFactor + 0.028 * CaltrainFrequencyFactor$$

$$Vpnr = 1.91 + 0.002 * ParkingSupply + 0.025 * CaltrainFrequencyFactor - 2.5 * CaltrainParkCharged$$

$$Vknr = -0.99 + 0.025 * CaltrainFrequencyFactor$$

Population + Jobs in Station Area

Employment and population within a station area has a positive sign for walk access. It reflects the development density in a station area, a variable that has been shown to increase the propensity to walk. The model suggests that as employment and population increases within the station area (one-half mile radius around the station) that the proportion of passengers walking to the station would increase.

Intersection Density

Intersection Density has a positive coefficient for walk access. Higher levels of intersection density mean that there are a greater number of more direct station access connections in the station area, This generally increases street network connectivity and decreases walk distances, and reduces street widths and crossing difficulty thus making the area more walkable. This suggests that as the number of intersections in the station area increases, Caltrain riders will be more likely to walk.

Bikeway Density Factor

Bikeway Density Factor has a positive sign for bicycle access. The Bikeway Density Factor is a combination of population, employment and bicycle roadway miles within a station area. Population and employment were measured for the area within ½ mile of the station. Bicycle roadway miles is the sum of the length of Class 1, Class 2, and Class 3 bicycle facilities within 1 mile of the station. The Bicycle Density Factor was created using Factor Analysis, a method for combining multiple variables that are related to each other into a single value. While it would not be possible to include all three variables separately in the bicycle utility function due to multicollinearity issues, factor analysis allows multiple variables to be linearly combined, each weighted according to its contribution to explaining the variation among the 23 stations with weekday service within the PCEP project limits[4]. The weights, or “factor loadings”, of each variable used to create the Bikeway Density Factor are shown in **Table 6**.

TABLE 6: BIKEWAY DENSITY FACTOR LOADINGS	
Variable	**Loading**
Population	0.069
Employment	0.810
Bicycle Roadway Miles	0.074

Caltrain Frequency Factor

The Caltrain Frequency Factor has a positive sign for the Transit, Park and Ride (PNR) and Kiss and Ride (KNR) access modes. The variable is a combination of the number of trains that serve the station in one day and the number of bullet trains that serve the station before noon. The variable suggests that as Caltrain service to a station increases, Transit, PNR, and KNR mode share increases. This suggests that riders would be willing to take transit or drive further to get to a station with more frequent or more direct Caltrain service.

AM Transit Factor

The AM Transit Factor has a positive sign for the transit access mode. The variable is a combination of number of buses and BART trains with a transfer opportunity at the station that serve the station during the AM peak period. Since BART has a much higher capacity than buses, the number of BART trains received a higher weighting than buses. As the supply of bus and BART transit increases during the AM period, the proportion of passengers arriving by a form of transit is likely to increase. The variable combining bus and BART transfers was more significant than a variable combining buses, BART and light rail.

[4] Excluded stations without weekday services and/or outside PCEP project limits: Broadway, Atherton, College Park, Stanford Stadium and stations south of Tamien.

Caltrain Parking Supply

Parking supply within Caltrain lots has a positive sign for the Park and Ride (PNR) access mode. As the number of parking spaces at the station increases, passengers are more likely to arrive by automobile and park in the lot.

Caltrain Parking Charged

Caltrain Parking Charged is a 0/1 variable indicating that a Caltrain station lot charges for parking. A 1 indicates that the station charges for parking while a 0 indicates that the Caltrain station lot is free. This variable has a negative sign for the Park and Ride (PNR) access mode, indicating that charging for parking causes passengers to be less likely to arrive by automobile and park in the lot.

3.2 Mode of Access Model Results

The VTA model predicts the walk and bike modes share combined while the Fehr & Peers' DRM separates these modes. Considering the following four access modes: 1) walk/bike, 2) transit, 3) park and ride, and 4) kiss and ride, the Fehr & Peers model's percent RMSE is 0.36 compared with a percent RMSE of 0.82 for the VTA model. Percent RMSE is a demanding measure of model accuracy, an indicator that amplifies the importance of large errors and doesn't allow station overestimates and underestimates to cancel one another. **Table 7** shows a comparison of the percent RMSE for each access mode. Figures 6, 7 and 8 show a comparison of the Fehr & Peers model mode of access estimates compared to observed values and VTA model estimates for the 6-9AM peak period by station for each county indicating that the Fehr & Peers model reduces error by more than 50 percent.

TABLE 7: MODE OF ACCESS MODEL COMPARISON		
Mode	**Percent RMSE (Fehr & Peers Model)**	**Percent RMSE (VTA model)**
Walk/Bike	27 percent	56 percent
Transit	61 percent	181 percent
Park and Ride (PNR)	35 percent	81 percent
Kiss and Ride (KNR)	40 percent	73 percent
Overall	**36 percent**	**82 percent**

Sources: Caltrain, VTA model, Fehr & Peers DRM

The Fehr & Peers DRM predicts the auto (PNR + KNR) mode share more accurately than the VTA model at 17 of the 23 stations. The exceptions are as follows: San Francisco, South San Francisco, Burlingame, Hillsdale, Menlo Park, and San Antonio stations.

The Fehr & Peers DRM under-predicts auto access mode share at the San Francisco station, compared to observed intercept survey results. The San Francisco station has high transit access and high levels of population and employment density in the station area, which would cause the model to predict high transit and walk/bike mode shares. The station has no dedicated Caltrain parking spaces, which would cause the model to predict a lower PNR mode share. However, since there is on-street parking available in the station area, the model may not be capturing the influence of these parking spaces on the auto access mode share.

The Fehr & Peers model under-predicts auto access mode share at the South San Francisco station. The intersection density of the station area is high, which would cause the model to predict a high walk access mode share. However, the station is located in a very inaccessible location blocked by a freeway, and does not have sufficient ADA access. These factors, which would discourage walk/bike access to the station, are not fully accounted for in the model.

The Fehr & Peers DRM over-predicts auto access mode share at the Burlingame station. Observed walk and bike access at this station is among the highest of any Caltrain station, per the 2013 passenger intercept survey. The station has the highest length of Class I bicycle facilities in the station area and among the highest density of households in the station area. While these variables are included in the Bikeway Density Factor, they seem to have greater influence at Burlingame than at other stations, and the factor may not be accurately capturing the unique influence of these features on the walk and bike mode share at Burlingame.

The Fehr & Peers DRM over-predicts auto access mode share at the Hillsdale station. The station has among the highest number of Caltrain parking spaces of any station, which would cause the model to predict a high PNR access mode share. However, the occupancy of the parking lot is near capacity. Difficulty in finding a parking space may discourage riders from driving to the station, causing the observed auto access mode share to be lower than the modeled value. The impact of parking lot occupancy may not be fully accounted for in the model.

The Fehr & Peers DRM over-predicts auto access mode share at the Menlo Park station. The station has one of the highest bike access mode shares of any station, per the Fehr & Peers 2013 passenger intercept survey. While the length of bicycle facilities in the station area is average, the percent of the roadway network which has Class II bicycle facilities present is higher than for most other stations. Like Burlingame, the high bicycle facility coverage in the area may have an unusually high influence on the walk and bike mode shares not fully accurately accounted for in the model.

The Fehr & Peers DRM over-predicts auto access mode share at the San Antonio station. The walk/bike access mode share at this station is the highest of all stations observed. The length of Class II facilities in the station area is the second highest among all stations and the percent of the roadway network which has Class II bicycle facilities is the third highest among all stations. The population density is also among the highest of all station areas. These factors contribute to a high walk and bike access mode shares. Although the Bikeway Density Factor incorporates some of these measures, it may not be completely capturing the influence of these features on the walk/bike mode share of the San Antonio station.

As is the case with all of the stations, the final calibration step (station-specific adjustments) is used to correct the model imprecision at these stations. Similar to the DRM ridership model, this step involves adjusting the mode share estimates per station to match the actual (2013 intercept passenger survey) results. The adjustment accounts, for example, for that fact that the model has a tendency to overestimate auto access at stations such as Burlingame and Menlo Park and underestimate auto use at South San Francisco and Lawrence. Because it is based primarily on the unique attributes of each station, rather than upon systematic factors such as surrounding land use and feeder access which are captured in the DRM, the station-specific adjustment factors remain constant when applied to future year estimates.

Figure 6 AM Access Mode Share for Stations in San Francisco County: Observed, VTA model and Fehr & Peers Model (prior to station-specific adjustment)

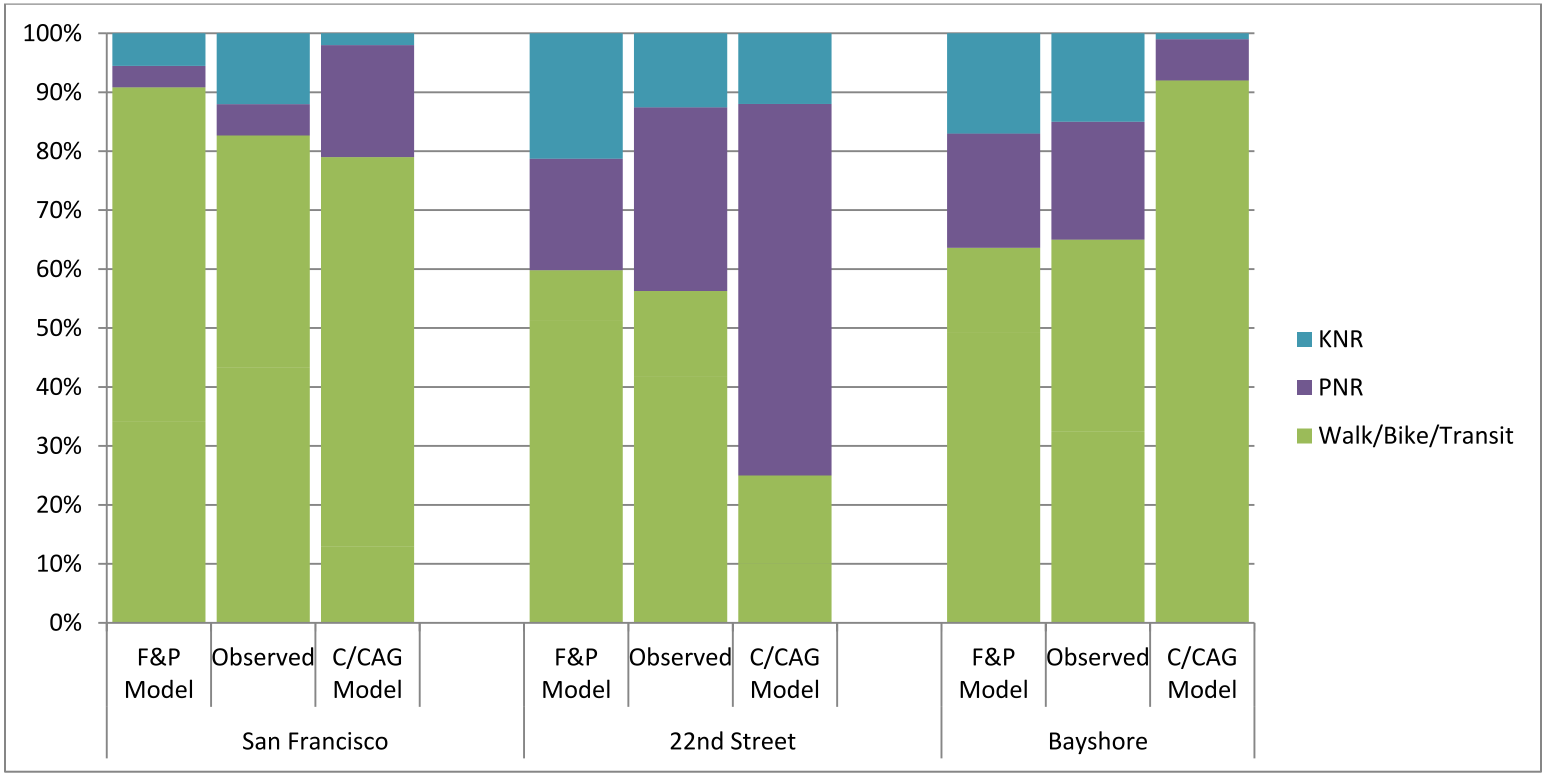


Figure 7 AM Access Mode Share for Stations in San Mateo County: Observed, VTA model and Fehr & Peers Model (prior to station-specific adjustment)

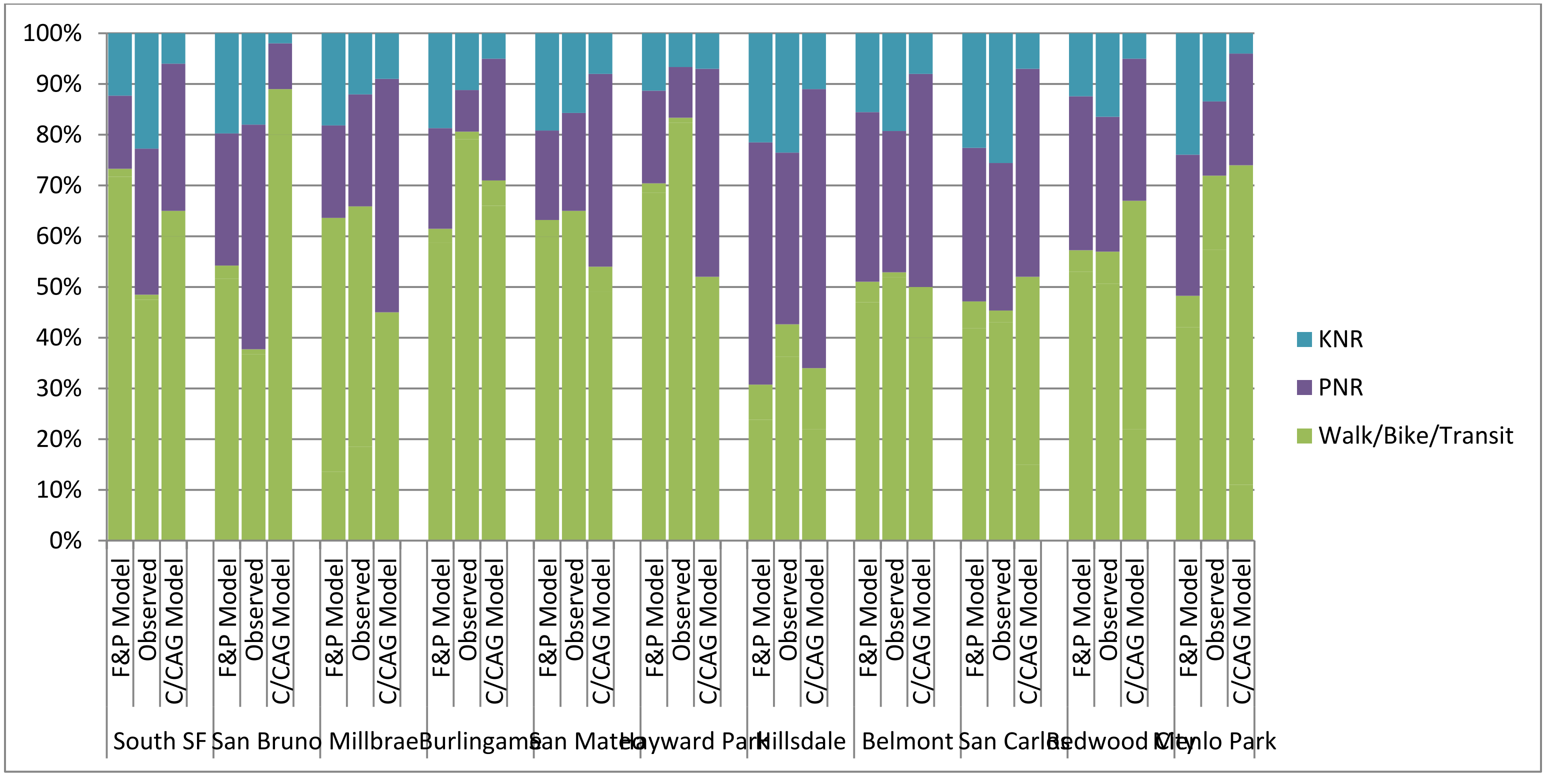
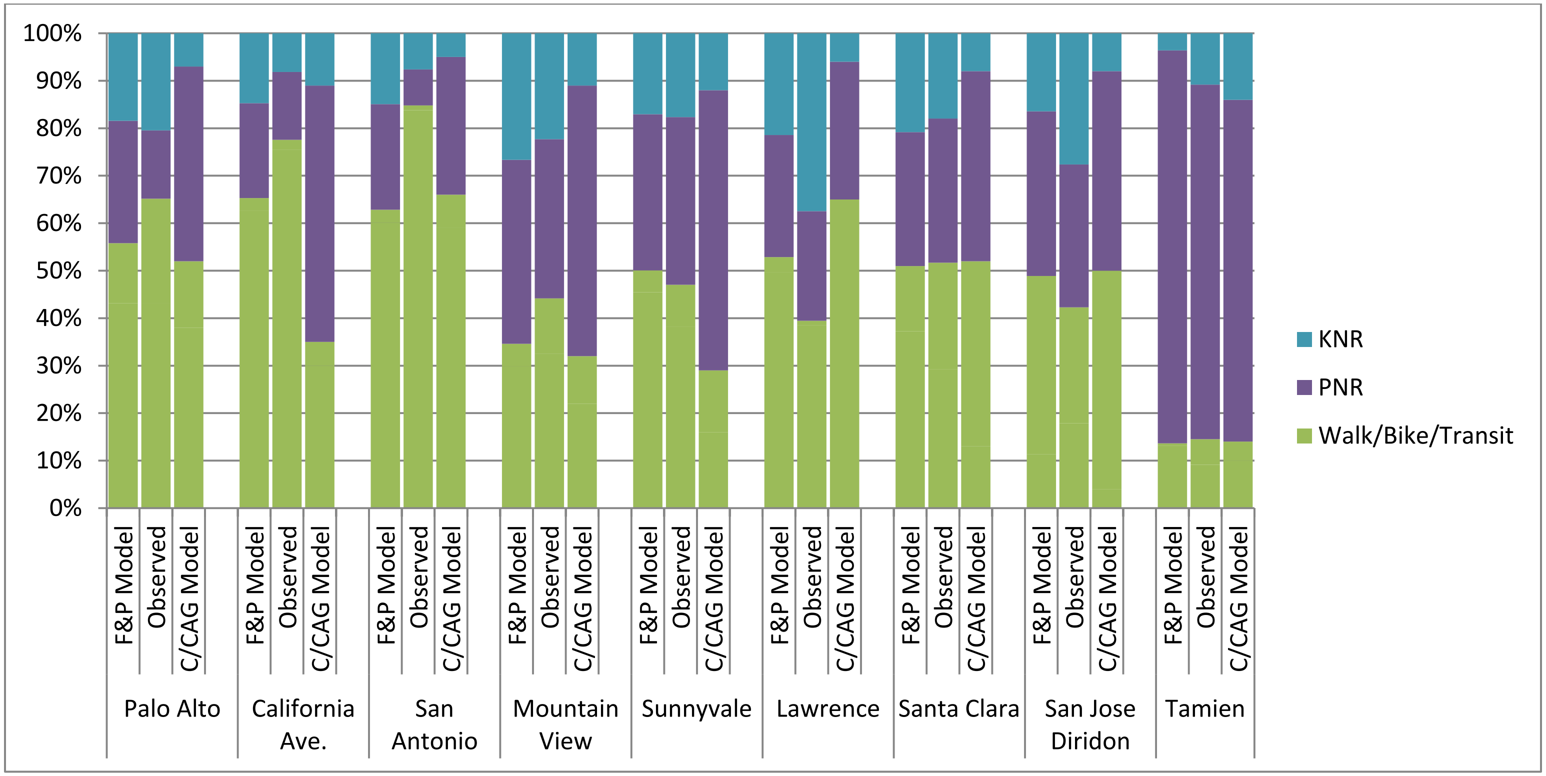


Figure 8 AM Access Mode Share for Stations in Santa Clara County: Observed, VTA model and Fehr & Peers Model (prior to station-specific adjustment)



4.0 Mode of Egress

This section describes the relationship between the VTA and DRM Caltrain station-specific MOE modeling. Like the VTA model, the DRM estimates the proportions of total ridership departing each station by individual mode. Compared with the VTA model, it takes into consideration a greater number of factors and it includes a more detailed measurement of land use proximity and the availability of local services and network connections. The MOE DRM is used to more directly link the estimates of the modes of egress from the Caltrain station with the modes used by alighting passengers as observed through passenger intercept surveys conducted in June 2013 by Fehr & Peers. One key difference between the VTA model and the survey and DRM is that the VTA model assumes that no riders use a car to egress a Caltrain station. The DRM captures the fact that the intercept surveys indicated that some riders egress via carshare vehicles or other cars parked at the station or are picked up at the station. Exhibit 1 (please see page 2) illustrates how the mode of egress model fits within the overall integrated VTA and DRM.

4.1 Mode of Egress Model Development

Fehr and Peers developed a mode of egress model to estimate the mode of egress during the AM peak period. This model is a logit model, transformed via Berkson's method to a linear regression model, which jointly predicts mode shares for each of five egress modes: walk, bike, transit, park and ride, kiss and ride (pick-up). It uses results from the intercept survey as the dependent variable in the model. The variables listed in Table 2 were tested as independent variables in various model runs. Variables were selected for the final mode of egress model based on their contribution to the overall goodness-of-fit of the model.

A utility function was created for each egress mode. The variables selected for the final utility equations of the AM egress mode share model are summarized in **Table 8**. Certain variables were included in the utility function for more than one access mode. Table 8 lists the variables included in the model and in which mode utility equation the variable is included. A "+" sign indicates a positive coefficient meaning that as the variable increases the mode share for that mode increases.

TABLE 8: VARIABLES INCLUDED IN AM MODE OF EGRESS MODEL					
	Walk	**Bike**	**Transit**	**Park & Ride**	**Kiss & Ride**
Pop + Jobs	+	+			
Intersection Density	+				
AM Private Shuttles			+		
AM Rail Factor			+		
Caltrain Frequency Factor				+	+

The mode of egress model has been developed such that as the proportion (or likelihood) of one mode increases, the likelihood of using the other modes decreases. The station egress mode share is estimated according to the following equation:

$$P_i = \frac{e^{V_i}}{\sum_{j \in J} e^{V_j}}$$

$$where\ i, j = particular\ modes\ of\ access$$

$$P_i = probability\ of\ using\ mode\ i\ to\ egress\ the\ station$$
$$J = the\ set\ of\ all\ possible\ modes\ of\ egress\ to\ Caltrain$$
$$= \{Walk, Bike, Transit, Park\ and\ Ride\ (PNR), Kiss\ and\ Ride\ (KNR)\}$$
$$V_i = linear - in - parameters\ utility\ fucntion = \boldsymbol{\beta} * \boldsymbol{X}$$
$$\boldsymbol{X} = a\ vector\ of\ explanatory\ variables$$
$$\boldsymbol{\beta} = a\ vector\ of\ coefficients$$

The following are the utility functions for each mode:

$$Vwalk = 0.099 * (Pop + Jobs) + 0.012 * IntersectionDensity$$

$$Vbike = 1.09 + 0.058 * (Pop + Jobs)$$

$$Vtransit = 1.51 + 0.091 * AMPrivateShuttles + 0.032 * AMRailFactor$$

$$Vpnr = -2.14 + 0.024 * CaltrainFrequencyFactor$$

$$Vknr = -1.86 + 0.028 * CaltrainFrequencyFactor$$

Population + Jobs in Station Area

Employment and population within a station area has a positive sign for walk egress and bike egress. These land use amount also serves as a measure of development density in a station area, a variable that has been shown to increase the propensity to walk. The model suggests that as employment and population increases within the station area (one-half mile radius around the station) that the proportion of passengers walking and biking from the station would increase.

Intersection Density

Intersection Density has a positive coefficient for walk egress. Higher levels of intersection density mean that there are more intersections in the station area, which generally increases street network connectivity and decreases walk distances, thus making the area more walkable. This suggests that as the number of intersections in the station area increases, Caltrain riders will be more likely to walk.

Caltrain Frequency Factor

The Caltrain Frequency Factor has a positive sign for the Park and Ride (PNR) and Kiss and Ride (KNR) egress modes. The variable is a combination of the number of trains that serve the station in one day and the number of bullet trains that serve the station before noon. The variable suggests that as Caltrain service to a station increases it draws passengers from further away, and PNR, and KNR mode share increases.

AM Private Shuttles

AM Private Shuttles has a positive sign for the transit egress mode. The variable is the hourly number of private shuttles arriving to the station during the AM period. As the number of private shuttles increases during the AM period, the proportion of passengers egressing the station by transit is likely to increase, as many riders use the shuttles for their last mile connection between the Caltrain station and work.

AM Rail Factor

AM Rail Factor has a positive sign for the transit egress mode. The variable is a combination of number of light rail trains, Amtrak trains and BART trains with a transfer opportunity at the station that serve the station during the AM peak period. As the number of rail transfer opportunities increases during the AM period, the proportion of passengers egressing by a form of transit is likely to increase. The variable combining light rail, Amtrak and BART transfers was found to be more significant than a variable that also included bus transfers. This suggests that passengers are more likely to use light rail, Amtrak or BART rather than bus for the last mile connection from Caltrain to their destination.

4.2 Mode of Egress Model Results

The VTA model predicts the walk/bike mode share combined while Fehr & Peers' DRM separates these modes. Comparing the two models for the same four egress modes (walk/bike, transit, park and ride, kiss and ride0, the Fehr & Peers model cuts VTA model RMS in half. For all four modes, the Fehr & Peers percent RMSE is 0.43 versus 0.86 for the VTA model. **Table 9** shows a comparison of the percent RMSE for each access mode. Figures 9, 10 and 11 show a comparison of the Fehr & Peers DRM mode of egress estimates compared to VTA model estimates in ability to replicate observed egress mode use by station. In addition to improving overall accuracy, the DRM captures that fact that a number of stations generate station-egress auto trips, including KnR pick-ups, cars parked at or near the station, carshare vehicles and taxis. The Fehr & Peers 2013 passenger intercept survey results found that more than three-fourths of the stations fell into this category

TABLE 9: MODE OF EGRESS MODEL COMPARISON

Mode	Percent RMSE (Fehr & Peers Model)	Percent RMSE (VTA model)
Walk/Bike	21 percent	44 percent
Transit	54 percent	106 percent
Park and Ride	145 percent	174 percent
Kiss and Ride	139 percent	167 percent
Overall	**43 percent**	**86 percent**

Sources: Caltrain, VTA model, Fehr & Peers

As with the ridership and mode of access models, the final calibration step is to apply station-specific adjustments to correct the model imprecision compared to the 2013 Caltrain passenger intercept surveys. The adjustments address the fact that the model slightly overestimates auto egress at stations such as 22nd Street and Bayshore and underestimates auto use at stations such as Burlingame and San Antonio for reasons similar to those discussed in the MOA section above. This step involves adjusting the mode share estimates per station to match the actual (intercept survey) results. These constant station-specific adjustment factors will then be applied to future year estimates to capture unique attributes of each station beyond the systematic factors such as surrounding land use and feeder access captured in the DRM.

Figure 9 AM Egress Mode Share for Stations in San Francisco County: Observed, VTA model, and Fehr & Peers Model (before station-specific adjustments)

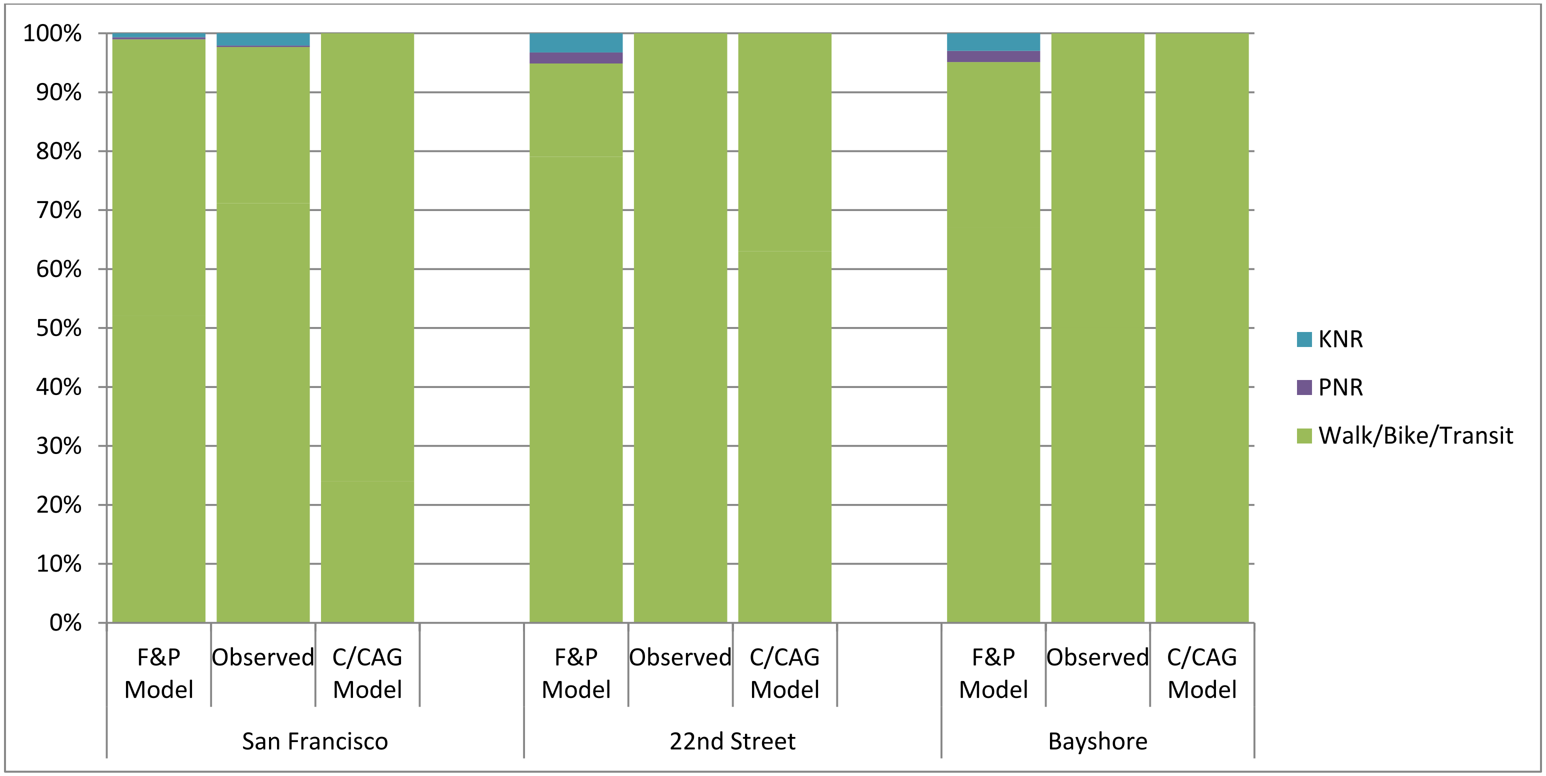


Figure 10 AM Egress Mode Share for Stations in San Mateo County: Observed, VTA model, and Fehr & Peers Model (before

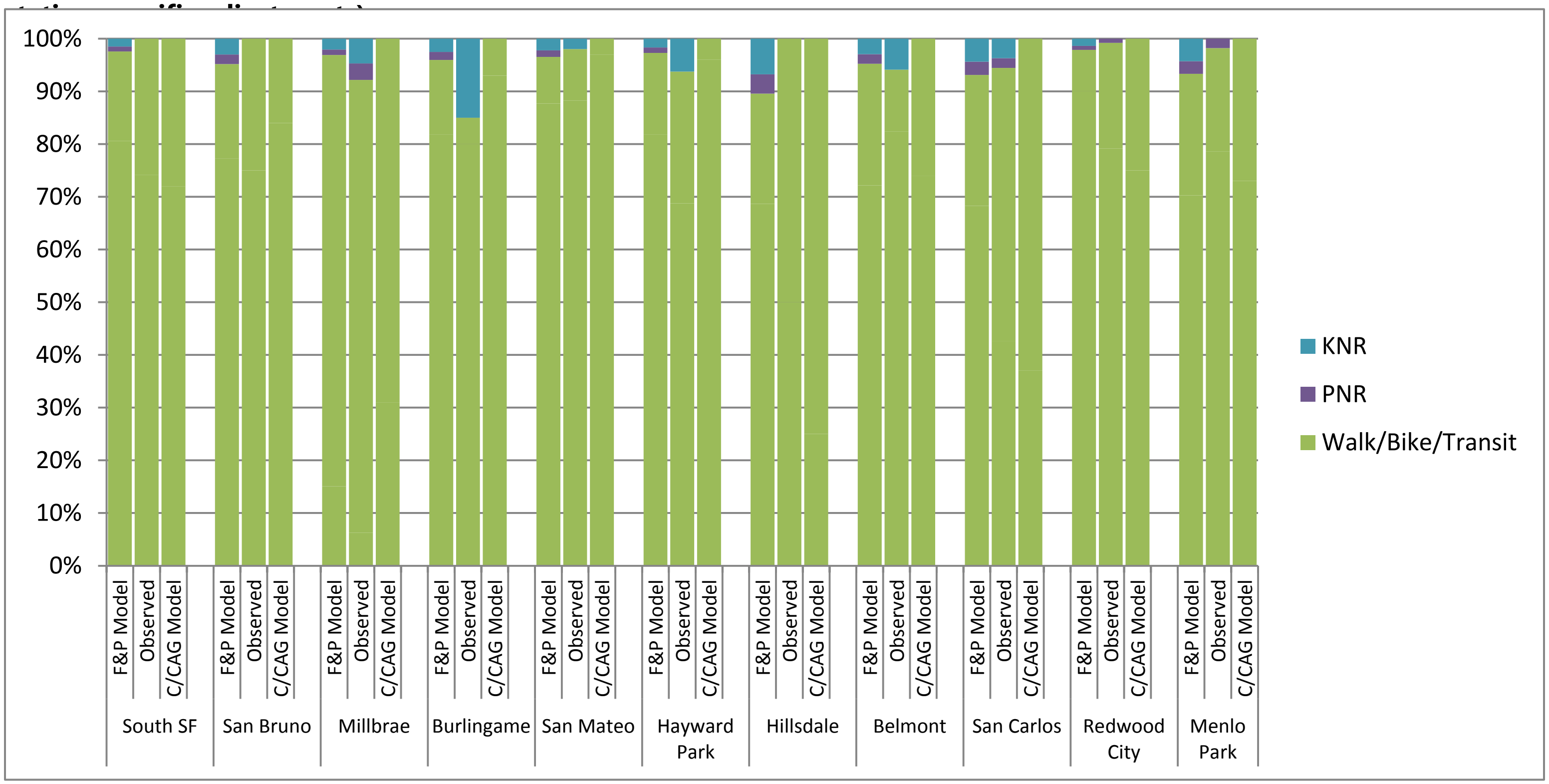
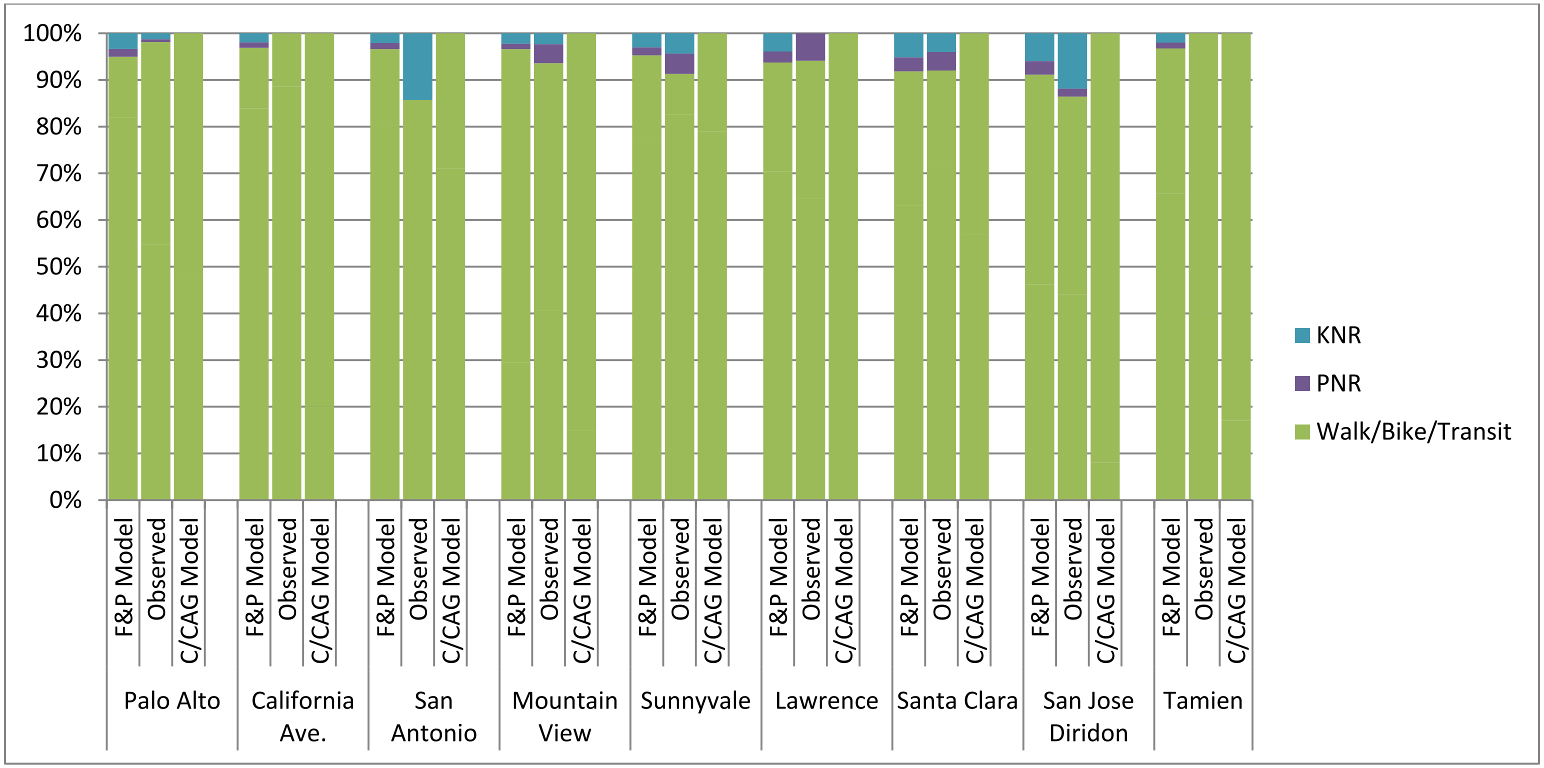


Figure 11 AM Egress Mode Share for Stations in Santa Clara County: Observed, VTA model, and Fehr & Peers Model (before station-specific adjustments)



ATTACHMENT D
DIRECT RIDERSHIP AND STATION MOA/MOE FORECASTS FOR 2020 AND 2040

ATTACHMENT D

Date: January 22, 2014

To: Stacy Cocke, Caltrain
George Naylor, VTA
Rich Walter, ICF

From: Jerry Walters, Matt Haynes, Nikki Foletta, Lindsey Hilde, Fehr & Peers

Subject: Caltrain Ridership Forecasts for 2020 and 2040

SJ13-1440

This memo describes the methods and results of forecasting 2020 and 2040 transportation impacts for the Caltrain Electrification Project EIR. It covers the forecasts of Caltrain ridership and station-area traffic and parking in each year for the No Project and PCEP Electrification Project conditions. The overall process involves the following steps:

1. Application (by VTA) of the regional VTA multi-modal transportation model to produce initial estimates of system and station ridership and access mode use.
2. Adjusting the VTA results to account for localized factors not covered in detail in the regional model, including station-area land use concentrations and local accessibility accommodations. The adjustments are calibrated to current conditions. The results include calibrated daily and peak period ridership by station, and proportions of riders arriving and departing each station via park-ride, kiss-ride, transit, walking and cycling.
3. Translation of the peak period park-ride and kiss-ride forecasts into estimates of peak traffic generation and maximum parking accumulations at each station.

The process and results of each step are described in greater detail below.

1.0 VTA Model Ridership Forecasts

Land Use Growth by 2020

Land use assumptions for 2020 were derived from the VTA travel demand model. VTA updated its model for the Peninsula Corridor Electrification Project (PCEP) to reflect 2013 base year conditions. The model was also adjusted and validated to year 2013 Caltrain system ridership. As discussed in Section 1.1 of the Transportation Impact Analysis (TIA) Caltrain system ridership has been increasing since 2005, and it was important that the VTA models accurately reflect the current high level of ridership. The 2013 model networks were updated from the original base year 2005 for both transit and highway network changes, including information on both public and private shuttles serving the Caltrain corridor, updated socioeconomic data forecasts prepared by ABAG, and updated background transportation improvements as defined in the recently adopted Plan Bay Area Regional Transportation Plan.

1.1 2020 Regional Population and Employment Growth

The socioeconomic data sets used as inputs to prepare the ridership forecasts were based on the ABAG Sustainable Community Strategy (SCS) prepared in September 2012. These datasets are accepted by the MTC to reflect regional model consistency for models used by the Congestion Management Agencies and were used to develop the regional travel demand forecasts for Plan Bay Area.

Table 1 shows households, population, and jobs for the years 2013 and 2020 for the project corridor. Overall, the Caltrain service area is projected to experience significant growth in households, population and jobs, with fairly balanced levels of growth spread out between the three counties that comprise the service area. In the short-term horizon from 2013 to 2020, jobs are increasing as a percentage of total faster than either households or population, worsening the current oversupply of jobs relative to employed residents of the corridor.

TABLE 1: PROJECTED POPULATION AND EMPLOYMENT IN 2013 AND 2020

San Francisco County	2013	2020	Percent Increase: 2013 to 2020
Households	355,600	379,100	6.6%
Population	824,200	884,300	7.3%
Jobs	598,000	671,600	12.3%
San Mateo County	**2013**	**2020**	**Percent Increase: 2013 to 2020**
Households	263,400	276,900	5.1%
Population	730,800	772,000	5.6%
Jobs	366,000	412,100	12.6%
Santa Clara County	**2013**	**2020**	**Percent Increase: 2013 to 2020**
Households	624,300	672,500	7.7%
Population	1,828,700	1,959,900	7.2%
Jobs	978,600	1,103,000	12.7%
Study Area Total	**2013**	**2020**	**Percent Increase: 2013 to 2020**
Households	1,243,300	1,328,500	6.9%
Population	3,383,700	3,616,200	6.9%
Jobs	1,942,600	2,186,700	12.6%

Source: VTA, 2014

Changes in 2020 Regional Transit Connections

For the forecast years, the project list from Plan Bay Area was used to code in improvements for the forecast years 2020 and 2040. The anticipated opening year for projects identified in Plan Bay Area was provided by MTC for each project. The list of assumed background highway and transit projects for forecast year 2020 is shown in **Table 2** This list includes projects in the Study as well as key projects a regional traveler would consider transferring to in order to complete an inter-regional trip in the San Francisco Bay Area.

TABLE 2: LIST OF REGIONAL BACKGROUND TRANSIT PROJECTS FOR FORECAST YEAR 2020

Description	Jurisdiction
Transbay Transit Center Phase 1	Multi-County
Caltrain Service Improvements (CBOSS, PTC)	Multi-County
Union City Intermodal, DRC Segment G Improvement	Alameda
SF Congestion Pricing - CBD Cordon	San Francisco
Caltrain Bayshore Intermodal Terminal	San Mateo
SamTrans BRT - Palo Alto to Daly City	San Mateo
Infrastructure to support SamTrans Rapid Bus	San Mateo
El Camino Real BRT	Santa Clara
Stevens Creek BRT	Santa Clara
BART Extension to Berryessa	Santa Clara
Tasman Express Long-T Alum Rock to MTV	Santa Clara
Van Ness BRT "Center A" Scenario	San Francisco
MUNI T Line Central Subway to Chinatown	San Francisco
Geary BRT	San Francisco
Geneva-Harney BRT	San Francisco
SMART Rail	Multi-County
Oakland BRT (Telegraph BRT - AC Transit)	Alameda

Source: VTA, 2014

1.2 Changes in Caltrain Capacity and Operations for 2020 Conditions

This section describes the assumptions included in the 2020 No Project and Project scenarios analyzed for this impacts analysis. 2020 No Project assumptions are largely unchanged from existing conditions in 2013, with the exception of adding advanced train control technology and the relocation of the San Bruno in Zone 1. The key change in the 2020 scenario is the electrification of the Caltrain fleet working in conjunction with advanced train control technology to provide higher frequency and more dependable service to the Study Area.

2020 No Project Scenario

The 2020 No Project scenario is mostly identical to existing Caltrain capacity and operations. The two main changes that are part of the 2020 No Project scenario are:

- Relocation of the San Bruno Station from 297 Huntington Avenue to the new station location at the intersection of San Bruno Avenue and Huntington Avenue. The relocation includes the removal of three at-grade crossings at San Bruno, San Mateo, and Angus Avenues.
- Implementation of the Caltrain Communications Based Overlay Signal System (CBOSS) Positive Train Control (PTC) advanced signal system (CBOSS PTC).

System Changes

Caltrain's fleet presently consists of diesel locomotive-hauled, bi-level passenger cars. Caltrain operates 46 northbound and 46 southbound (for a total of 92) trains per day between San Jose and San Francisco during the week. Weekday trains are a mix of Baby Bullets, Limited, and Local trains. Eleven trains in each direction are "Baby Bullet" express service trains that make the trip between San Francisco and San Jose in less than one hour. Local trains operate at the shoulders of peak periods and serve to transition the service from peak to off-peak. Limited-stop trains operate as Skip-stop for one-half of the route and Locals for the other half. Local trains stop at all weekday stations along the Caltrain corridor.

Service is frequent during the peak periods. Caltrain operates five trains per peak hour at a speed of 79 miles per hour. Headways at the station-level are discussed in more detail later in this memorandum. The prototypical schedule under the No Project scenario in 2020 is identical to the 2013 schedule. As a result, no schedule changes would occur between existing conditions and the 2020 No Project scenario.[1]

Table 3 displays daily trains system-wide by service type in the 2020 No Project scenario. **Table 4** displays daily peak and off-peak train frequencies system-wide in the 2020 No Project scenario. Because there is no change in the operating schedule between 2013 and 2020 No Project, train frequencies throughout the day would remain as they are now.

[1] Analysis is based on prototypical operating schedules for years 2020 and 2040.

TABLE 3: DAILY TRAINS BY SERVICE TYPE, 2020 NO PROJECT SCENARIO

Service/Train Type	Existing / 2020 No Project
Daily Bullet Trains	22
Limited Trains	42
Local Trains	28
Total Daily Trains (system-wide)	92

Sources: "Schedules." (2013) *San Mateo County Transit District*; Santa Clara Valley Transportation Authority, 2013; Fehr & Peers, 2013.

TABLE 4: DAILY PEAK AND OFF-PEAK TRAIN FREQUENCIES, 2020 NO PROJECT SCENARIO

Service/Train Type	Existing / 2020 No Project
Early Morning Off-Peak (4:00AM – 5:59 AM)	6
AM Peak (6:00 – 8:59 AM)	27
Midday (9:00 AM – 3:59 PM)	20
PM Peak (4:00 – 6:59 PM)	30
Evening Off-Peak (7:00 PM – 2:00 AM)	9
Total Daily Trains (system-wide)	92

Sources: "Schedules." (2013) *San Mateo County Transit District*; Santa Clara Valley Transportation Authority, 2013; Fehr & Peers, 2013
Note: Time periods include all trains that departed either from 4th & King Station in San Francisco (Southbound) and the San Jose Diridon Station (Northbound) within the hours specified.

Station-Specific Changes

Similarly, daily train frequencies at the station-level would remain unchanged between existing conditions and 2020 No Project (**Table 5**). Travel times between stations also do not change between existing and 2020 No Project. Travel times for 2020 Project and No Project are discussed in the next section.

TABLE 5: DAILY CALTRAIN TRAINS BY STATION, 2020 NO PROJECT SCENARIO

Stations	Existing / 2020 No Project
4th & King	92
22nd Street	58
Bayshore	40
South San Francisco	46
San Bruno	56
Millbrae	82
Broadway	0
Burlingame	58
San Mateo	70
Hayward Park	40
Hillsdale	74
Belmont	46
San Carlos	64
Redwood City	72
Atherton	0
Menlo Park	66
Palo Alto	86
California Ave.	52
San Antonio	46
Mountain View	80
Sunnyvale	62
Lawrence	56
Santa Clara	58
College Park	4
San Jose Diridon	92
Tamien	40

Source: "Stations." (2013) San Mateo County Transit District.
Note: Transbay Terminal Station will not be in place until the 2040 Project Scenario

Table 6 displays average scheduled headways by station for existing/2020 No Project. Scheduled headways, or the time between arrivals of vehicles moving in the same direction at a station, vary by time of day, station, and service type. As **Table 6** illustrates, headways at bullet stations, such as 4th & King, Mountain View, and San Jose Diridon, are shorter than stations with only Limited and Local service. Broadway and Atherton stations would continue to be weekend-only stations in the No Project scenario.

TABLE 6: AVERAGE HEADWAYS, PEAK AND OFF-PEAK PERIODS, 2020 NO PROJECT SCENARIO

Stations	Existing/2020 No Project		
	AM Peak	PM Peak	Off-Peak
4th & King	0:17	0:15	0:46
22nd Street	0:36	0:42	0:57
Bayshore	0:59	0:59	0:58
South San Francisco	0:45	0:43	0:58
San Bruno	0:29	0:30	0:48
Millbrae	0:19	0:20	0:46
Broadway	No service	No service	No service
Burlingame	0:28	0:26	0:48
San Mateo	0:20	0:20	0:47
Hayward Park	1:00	0:59	0:58
Hillsdale	0:18	0:17	0:46
Belmont	0:54	0:59	0:48
San Carlos	0:24	0:24	0:47
Redwood City	0:23	0:23	0:48
Atherton	No service	No service	No service
Menlo Park	0:24	0:21	0:48
Palo Alto	0:18	0:15	0:46
California Ave.	0:39	0:36	0:48
San Antonio	0:54	1:01	0:48
Mountain View	0:15	0:16	0:46
Sunnyvale	0:39	0:44	0:48
Lawrence	0:32	0:31	0:48
Santa Clara	0:28	0:30	0:48
College Park	N/A	N/A	N/A
San Jose Diridon	0:14	0:18	0:46
Tamien	0:27	0:32	1:20

Source: Peninsula Corridor Joint Powers Board, 2013. Fehr & Peers, 2013.

Advanced Signal System

The 2020 No Project scenario will include the full implementation of Caltrain Communications Based Overlay Signal System (CBOSS) Positive Train Control (PTC) Project. Caltrain is currently controlled by a wayside block signal system that constrains capacity. The CBOSS PTC Project is a complementary, but separate component within the Caltrain Modernization program. Currently in construction, this project will increase the operating performance of the current signal system, improve the efficiency of grade crossing warning functions, and automatically stop a train when there is violation of speed or route. This project, which includes implementation of safety improvements mandated by federal law, is scheduled to be operational by 2015 as mandated by the Federal Railroad Administration (FRA) per the *Railroad Safety Improvement Act of 2008*.

2020 Project Scenario

The 2020 Project Scenario consists of converting Caltrain from diesel-hauled to EMU trains for service between the 4th and King Street Station in San Francisco and the Tamien Station in San Jose.

The 2020 Project Scenario includes the following main changes from existing conditions:

- Conversion of Caltrain from diesel-hauled to EMU trains for service between the 4th and King Street Station in San Francisco and the Tamien Station in San Jose.
- Installation of new electrical infrastructure, including Traction Power Supply Substations and overhead wire systems
- Operation of up to six Caltrain trains per peak hour, per direction at operating speeds of up to 79 mph
- CBOSS PTC advanced signaling system (in place by 2015)
- Inclusion of all changes in 2020 regional transit connections summarized earlier in this memorandum
- Relocation of the San Bruno Station from 297 Huntington Avenue to the new station location at the intersection of San Bruno Avenue and Huntington Avenue

System Changes

In 2019, service between San Jose and San Francisco would use a mixed fleet of EMUs and diesel locomotives, with approximately 75% of the service being electric and 25% being diesel. After 2019, diesel locomotives would be replaced with EMUs over time as they reach the end of service life. Caltrain’s diesel-powered locomotive service would continue to be used to provide service between the San Jose Diridon Station and Gilroy.[2]

EMUs are more economically and environmentally efficient than the current diesel-powered locomotives. In addition, EMUs can accelerate and decelerate faster than diesel vehicles. The procurement of the EMU vehicle fleet is an entirely separate project in the Caltrain Modernization Program. The electrification system envisioned for the corridor would be configured in such a way that it would support the future operation of California HSR. High-speed rail construction and operations would be the subject of a separate environmental analysis to be conducted by CHSRA and FRA.

The level of Caltrain operations and, therefore, fleet requirements under PCEP are based on six trains per peak hour per direction from Tamien Station in San Jose to San Francisco, with a mixed EMU and diesel locomotive fleet. The project would require the installation of 130 to 140 single-track miles of overhead contact system (OCS) for the distribution of electrical power to the electric rolling stock. Caltrain service would also include six diesel-powered trains per day in the San Jose to Gilroy segment in 2019.

The 2020 Project service consists of a mixed fleet (75% fully electrified/25% diesel) with CBOSS PTC signal control. Combined, these two improvements allow for significant capacity and operating performance improvements for all service types.

The frequencies of trains in the peak and off-peak would also change in the 2020 Project Scenario. **Table 7** displays daily peak and off-peak train frequencies in the 2020 Project Scenario. Although the number of early morning off-peak trains would decrease, trains in all other time period categories would increase, as compared to existing conditions and 2020 No Project. In the AM Peak, 11 more trains would be added. In the PM peak period six more trains would be added to the schedule. Midday trains increase by six and one more evening train would be added. The greatest service gains, as measure by train frequencies, occur in the AM and PM peak.

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[2] The Project only includes electrification to a point approximately 2 miles south of Tamien Station. The Union Pacific Corridor south of this point would not be electrified by the Project.

TABLE 7: DAILY PEAK AND OFF-PEAK TRAIN FREQUENCIES, 2020 PROJECT SCENARIO

Service/Train Type	2013 (Existing)	2020 Project
Early Morning Off-Peak (4:00AM – 5:59 AM)	6	4
AM Peak (6:00 – 8:59 AM)	27	38
PM Peak (4:00 – 6:59 PM)	30	36
Midday (9:00 AM – 3:59 PM)	20	26
Evening Off-Peak (7:00 PM – 2:00 AM)	9	10
Total Daily Trains (system-wide)	92	114

Sources: "Schedules." (2013) *San Mateo County Transit District*; Santa Clara Valley Transportation Authority, 2013; Fehr & Peers, 2013
Note: Time periods include all trains that departed either from 4th & King Station in San Francisco (Southbound) and the San Jose Diridon Station (Northbound) within the hours specified.

Station-Specific Changes

Table 8 displays daily trains by station in the 2020 Project Scenario as compared to existing conditions and 2020 No Project scenario. The total number of daily trains serving each station increases across the Study Area, with the exception of College Park, which Caltrain would continue to serve with four trains daily. Two stations that do not have weekday service in existing conditions and the 2020 No Project scenario would have weekday service in the 2020 Project Scenario: Broadway and Atherton.

TABLE 8: DAILY CALTRAIN TRAINS BY STATION, 2020 NO PROJECT AND 2020 PROJECT SCENARIOS

Stations	Existing (2013) and 2020 No Project	2020 Project Daily Trains
4th & King	92	114
22nd Street	58	90
Bayshore	40	66
South San Francisco	46	78
San Bruno	56	66
Millbrae	82	114
Broadway	0	54
Burlingame	58	66
San Mateo	70	96
Hayward Park	40	66
Hillsdale	74	102
Belmont	46	66
San Carlos	64	78
Redwood City	72	102
Atherton	0	54
Menlo Park	66	96
Palo Alto	86	108
California Ave.	52	66
San Antonio	46	66
Mountain View	80	108
Sunnyvale	62	84
Lawrence	56	66
Santa Clara	58	66
College Park	4	4
San Jose Diridon	92	114
Tamien	40	48

Source: "Stations." (2013) San Mateo County Transit District.
Note: Transbay Terminal Station will not be in place until the 2040 Project scenario

Table 9 displays average scheduled headways by station for 2020 No Project and 2020 Project Scenarios (based on the prototypical 2020 schedule). Overall, 2020 Project would improve headways at most stations, improving wait times and service frequency for passengers. No headway greater than one hour exists in the 2020 No Project scenario.

TABLE 9: AVERAGE HEADWAYS, 2020 NO PROJECT AND 2020 PROJECT SCENARIOS

	Existing/2020 No Project/ 2040 No Project			2020 Project		
	AM Peak	PM Peak	Off-Peak	AM Peak	PM Peak	Off-Peak
Transbay Terminal	N/A	N/A	N/A	N/A	N/A	N/A
4th & Townsend	N/A	N/A	N/A	N/A	N/A	N/A
4th & King	0:17	0:15	0:46	0:10	0:09	0:37
22nd Street	0:36	0:42	0:57	0:19	0:19	0:37
Bayshore	0:59	0:59	0:58	0:28	0:29	0:37
South San Francisco	0:45	0:43	0:58	0:21	0:22	0:37
San Bruno	0:29	0:30	0:48	0:29	0:29	0:37
Millbrae	0:19	0:20	0:46	0:09	0:09	0:37
Broadway	No service	No service	No service	0:54	1:00	0:37
Burlingame	0:28	0:26	0:48	0:29	0:30	0:37
San Mateo	0:20	0:20	0:47	0:13	0:12	0:37
Hayward Park	1:00	0:59	0:58	0:28	0:30	0:37
Hillsdale	0:18	0:17	0:46	0:11	0:11	0:37
Belmont	0:54	0:59	0:48	0:29	0:30	0:37
San Carlos	0:24	0:24	0:47	0:22	0:22	0:37
Redwood City	0:23	0:23	0:48	0:11	0:11	0:37
Atherton	No service	No service	No service	0:52	1:00	0:37
Menlo Park	0:24	0:21	0:48	0:13	0:13	0:37
Palo Alto	0:18	0:15	0:46	0:10	0:10	0:37
California Ave.	0:39	0:36	0:48	0:30	0:30	0:37
San Antonio	0:54	1:01	0:48	0:30	0:30	0:37
Mountain View	0:15	0:16	0:46	0:11	0:10	0:37
Sunnyvale	0:39	0:44	0:48	0:19	0:20	0:37
Lawrence	0:32	0:31	0:48	0:29	0:30	0:37
Santa Clara	0:28	0:30	0:48	0:29	0:30	0:37
College Park	0:00	0:00	0:00	No service	No service	No service
San Jose Diridon	0:14	0:18	0:46	0:10	0:09	0:37
Tamien	0:27	0:32	1:20	0:30	0:30	0:55

Source: Peninsula Corridor Joint Powers Board, 2013. Fehr & Peers, 2013.

Advanced Signal System

Like the 2020 No Project scenario, the 2020 Project Scenario will include the full CBOSS PTC system. CBOSS PTC combined with the EMU fleet would improve headways and operation flexibility by allowing trains to travel closer together along the right-of-way. This translates to more frequent and dependable passenger service. In addition, Because EMU trains are more efficient than the current diesel-powered locomotives, EMUs would help improve operational capacity as they can accelerate and decelerate faster than diesel-hauled vehicles. As a result, EMUs would provide faster and/or more frequent service to more stations and by extension, more passengers.

1.3 2040 Changes in Background Conditions

Land Use Growth by 2040

Land use assumptions for 2020 were derived from the VTA travel demand model. The 2013 VTA model networks were updated from the original base year 2005 for both transit and highway network changes, including an update of both public and private shuttles serving the Caltrain corridor, updated 2040 socioeconomic data forecasts prepared by ABAG, and updated background transportation improvements as defined in the recently adopted Plan Bay Area Regional Transportation Plan.

Regional Population and Employment Growth

The socioeconomic data sets used as inputs to prepare the ridership forecasts were based on the ABAG Sustainable Community Strategy (SCS) prepared in September 2012. These datasets are accepted by the MTC to reflect regional model consistency for models used by the Congestion Management Agencies and were used to develop the regional travel demand forecasts for Plan Bay Area.

Table 10 shows households, population, and jobs for the years 2013, 2020 and 2040 for the project corridor. Overall, the Caltrain service area is projected to experience significant growth in households, population and jobs, with fairly balanced levels of growth spread out between the three Counties that comprise the service area. In the long-term horizon from 2013 to 2040, households and population increase as a percentage basis at a similar pace as jobs, with population growth between 2020 and 2040 making up for the lag in population relative to employment between 2013 and 2020. For the full corridor, jobs per capita is projected to be slightly lower in 2040 than it is in 2013. Santa Clara County households, population, and jobs grow at a slightly faster rate than San Francisco and San Mateo Counties on both a percentage and absolute basis.

TABLE 10: PROJECTED POPULATION AND EMPLOYMENT IN 2013, 2020 AND 2040

TABLE 10: PROJECTED POPULATION AND EMPLOYMENT IN 2013, 2020 AND 2040

San Francisco County	2013	2020	Percent Increase 2013 to 2020	2040	Percent Increase 2013 to 2040
Households	355,600	379,100	6.6%	447,200	25.8%
Population	824,200	884,300	7.3%	1,076,300	30.6%
Jobs	598,000	671,600	12.3%	760,200	27.1%
San Mateo County	**2013**	**2020**	**Percent Increase 2013 to 2020**	**2040**	**Percent Increase 2013 to 2040**
Households	263,400	276,900	5.1%	316,900	20.3%
Population	730,800	772,000	5.6%	899,200	23.0%
Jobs	366,000	412,100	12.6%	462,900	26.5%
Santa Clara County	**2013**	**2020**	**Percent Increase 2013 to 2020**	**2040**	**Percent Increase 2013 to 2040**
Households	624,300	672,500	7.7%	819,600	31.3%
Population	1,828,700	1,959,900	7.2%	2,411,700	31.9%
Jobs	978,600	1,103,000	12.7%	1,263,800	29.1%
Study Area Total	**2013**	**2020**	**Percent Increase 2013 to 2020**	**2040**	**Percent Increase 2013 to 2040**
Households	1,243,300	1,328,500	6.9%	1,583,700	27.4%
Population	3,383,700	3,616,200	6.9%	4,387,200	29.7%
Jobs	1,942,600	2,186,700	12.6%	2,486,900	28.0%

Source: VTA, 2014

Changes in 2040 Regional Transit Connections

The project list from Plan Bay Area was used to code in improvements for the forecast years 2020 and 2040. Year of opening for projects identified in Plan Bay Area were provided by MTC for each project. The list of assumed background highway and transit projects for forecast year 2040 is shown in **Table 11**. This list includes projects in the Study as well as key projects a regional traveler would consider transferring to in order to complete an inter-regional trip in the San Francisco Bay Area. All 2020 projects are also included.

TABLE 11: LIST OF REGIONAL BACKGROUND HIGHWAY AND TRANSIT PROJECTS FOR FORECAST YEAR 2040

Description	Jurisdiction
Transbay Transit Center Phase 1	Multi-County
Caltrain Service Improvements (CBOSS, PTC)	Multi-County
Transbay Center/Caltrain DTX Phase 2	Multi-County
Union City Intermodal, DRC Segment G Improvement	Alameda
Commuter Rail service - Peninsula and East Bay (DRC service)	Alameda
Southern Intermodal Terminal - MUNI T line to Caltrain Bayshore	San Francisco
SF Congestion Pricing - CBD Cordon	San Francisco
Redwood City to SF Ferry Service	San Mateo
Caltrain Bayshore Intermodal Terminal	San Mateo
SamTrans BRT - Palo Alto to Daly City	San Mateo
Infrastructure to support SamTrans Rapid Bus	San Mateo

TABLE 11: LIST OF REGIONAL BACKGROUND HIGHWAY AND TRANSIT PROJECTS FOR FORECAST YEAR 2040

Description	Jurisdiction
Mineta San Jose APM Connector	Santa Clara
El Camino Real BRT	Santa Clara
Stevens Creek BRT	Santa Clara
BART Extension to Berryessa	Santa Clara
BART Extension to Santa Clara (Phase 2)	Santa Clara
Tasman Express Long-T Alum Rock to MTV	Santa Clara
Van Ness BRT "Center A" Scenario	San Francisco
MUNI T Line Central Subway to Chinatown	San Francisco
MUNI E Line	San Francisco
Ferry Service to Treasure Island	San Francisco
Geary BRT	San Francisco

TABLE 11: LIST OF REGIONAL BACKGROUND HIGHWAY AND TRANSIT PROJECTS FOR FORECAST YEAR 2040

Description	Jurisdiction
Geneva-Harney BRT	San Francisco
Central Subway to North Beach	San Francisco
SMART Rail	Multi-County
Oakland BRT (Telegraph BRT - AC Transit)	Alameda

Source: VTA, 2014

1.4 Changes in Caltrain Capacity and Operations for 2040 Conditions

This section describes the assumptions included in the 2040 No Project and Project Scenarios. The 2040 No Project assumptions are identical to 2020 No Project assumptions. The key change in the 2040 Project Scenario as compared to the 2020 Project Scenario is the addition of the Downtown Rail Extension, which will extend Caltrain and HSR service to the Transbay Transit Center in Downtown San Francisco.

2040 No Project

The 2040 No Project scenario includes the same assumptions as 2020 No Project. The operating schedule and rolling stock would remain as they are in existing conditions. As with the 2020 No Project scenario, the 2040 No Project scenario assumes the relocation of the San Bruno station and the inclusion of the CBOSS PTC system.

2040 Project

The 2040 Project Scenario includes the following main assumptions

- Continued use EMU trains and the accompanying electrical infrastructure in the Study Area

- Operation of up to six Caltrain trains per peak hour, per direction at operating speeds of up to 79 mph
- Inclusion of all changes 2040 regional transit connections summarized earlier in this memorandum, most notably the Downtown Rail Extension to the Transbay Transit Center.
- Continued use of CBOSS PTC advanced signaling system

Outside the Study Area, Gilroy Shuttle Service will continue to operate on diesel-hauled locomotives to San Jose Diridon. Like all other scenarios, the 2040 Project Scenario will include the full CBOSS PTC system. Federal law requires the CBOSS PTC system to be interoperable with all rail service along the Caltrain corridor including high-speed rail. Caltrain is working in close coordination with the California High Speed Rail Authority (CHSRA) to ensure the project is compatible with future HSR service.

System Changes

The major change assumed in the 2040 Project Scenario is the extension of service from the current northern terminus of Caltrain service at 4th & King to the Transbay Transit Center (currently under construction) which is located in downtown San Francisco at Main and 2nd Streets and is currently under construction. The addition of the Transbay Transit Center increases the total number of stations in the Study Area from 27 to 28. The extension of service between 4th & King was clears through a prior separate environmental review process by TJPA. When completed, The Transbay Transit Center will not only service Caltrain but a number of other regional and state-wide transit systems, improving connectivity from the Caltrain system to other systems.

The 2040 Project Scenario operating schedule assumes six Caltrain trains per peak hour, per direction at a maximum speed of 79 miles per hour. The schedule is a mix of baby bullets and non-baby bullet trains. Northbound trains in the Study Area begin service at either Tamien or Diridon Stations and terminate at 4th & King or the Transbay Transit Center. Southbound trains in the Study Area begin service at either the Transbay Transit Center or the 4th & King Station and terminate at either Tamien or San Jose Diridon stations.

Outside the study area, Gilroy Shuttle Service will continue to operate on diesel-hauled locomotives to San Jose Diridon. The three northbound trains that depart from Gilroy in the AM peak operate as bullet trains upon reaching San Jose Diridon until terminating at the 4th & King Station. Southbound, trains that serve Gilroy operate in a similar fashion, with the exception of Local train 467 with a longer travel time due to stopping at almost all stations along the corridor.

Table 12 displays daily trains in the 2040 Project Scenario, system-wide by service type (as per the 2040 prototypical schedule). In the AM peak, NB bullet trains are defined as all trains with travel time of less than or equal to one hour and five minutes (1:05) and southbound bullet trains are those with a total travel time of less than or equal to one hour and ten minutes (1:10). In the PM peak, northbound bullet trains are all trains with a total travel time less than or equal to one hour and six minutes (1:06) and southbound bullet trains are those with a total travel time of less than one hour and ten minutes (1:10). **Table 13** displays system-wide daily peak and off-peak train frequencies for all No Project and Project Scenarios.

TABLE 12: SYSTEM-WIDE DAILY TRAINS BY SERVICE TYPE, 2040 PROJECT SCENARIO

Service/Train Type	Existing/2020 No Project/2040 No Project	2020 Project	2040 Project
Daily Bullet Trains	22	24	35
Non-Baby Bullet Trains	70	90	79
Total Daily Trains	92	114	114

Sources: "Schedules." (2013) *San Mateo County Transit District*; Santa Clara Valley Transportation Authority, 2013; Fehr & Peers, 2013.

TABLE 13: DAILY PEAK AND OFF-PEAK TRAIN FREQUENCIES, ALL NO PROJECT AND PROJECT SCENARIOS

Service/Train Type	Existing/2020 No Project/2040 No Project	2020 Project	2040 Project
Early Morning Off-Peak (4:00AM – 5:59 AM)	6	4	4
AM Peak (6:00 – 8:59 AM)	27	38	36
PM Peak (4:00 – 6:59 PM)	30	36	28
Midday (9:00 AM – 3:59 PM)	20	26	36
Evening Off-Peak (7:00 PM – 2:00 AM)	9	10	10
Total Daily Trains (system-wide)	92	114	114

Note: Time periods include all trains that departed either from 4th & King Station in San Francisco (Southbound) and the San Jose Diridon Station (Northbound) within the hours specified. Sources: "Schedules." (2013) *San Mateo County Transit District*; Santa Clara Valley Transportation Authority, 2013; Fehr & Peers, 2013.

Station-Specific Changes

Table 14 displays daily trains serving stations in the Study Area in the 2040 Project Scenario as compared to existing conditions/2020 No Project/2040 No Project and 2020 Project Scenarios. Compared to existing conditions, the total number of daily trains serving the majority of stations increases, with the exception of College Park where trains would decrease from four to one daily. In comparison to the 2020 Project Scenario, 2040 Project introduces some gains in train frequency at the station-level. Many stations would experience an increase in the number of trains, while some experience slight decreases, including: 4th & King, 22nd Street, Bayshore, South San Francisco, Broadway, San Mateo, Hayward Park, Menlo Park, College Park, and Tamien.

Bullet Trains in the 2040 Project Scenario would have more scheduled stops than existing bullet trains, meaning bullet trains would serve more stations. An average of 13 stops are made at stations served by bullet trains in the 2040 Project scenario, compared to the average of seven stops made by bullet trains in all other scenarios and existing conditions. The following stations only have bullet service in the 2040 Project Scenario: Bayshore; South San Francisco; San Bruno; Broadway; Hayward Park; Belmont; San Carlos; Atherton; Menlo Park; California Avenue; San Antonio; Lawrence; and Santa Clara. Tamien do not have bullet trains in the 2040 Project Scenario.

TABLE 14: DAILY CALTRAIN TRAINS BY STATION, 2040 PROJECT SCENARIO

Stations	Existing (2013) and 2020 No Project	2020 Project Daily Trains	2040 Project Daily Trains
Transbay Center	Not applicable	Not applicable	66
San Francisco	92	114	48
22nd Street	58	90	84
Bayshore	40	66	54
South San Francisco	46	78	60
San Bruno	56	66	66
Millbrae	82	114	114
Broadway	0	54	51
Burlingame	58	66	66
San Mateo	70	96	90
Hayward Park	40	66	54
Hillsdale	74	102	102
Belmont	46	66	66
San Carlos	64	78	78
Redwood City	72	102	102
Atherton	0	54	54
Menlo Park	66	96	90
Palo Alto	86	108	114
California Ave.	52	66	66
San Antonio	46	66	66
Mountain View	80	108	114
Sunnyvale	62	84	90
Lawrence	56	66	66
Santa Clara	58	66	66
College Park	4	4	1
San Jose Diridon	92	114	114
Tamien	40	48	46

Source: Fehr & Peers, 2013

Table 15 displays average scheduled headways for all PCEP and No Project scenarios in 2020 and 2040. Headways at a some stations increase in 2040 No Project as compared to Existing Conditions/2040 No Project because trains would be stopping at the following additional stations, depending on the service type: Transbay Center, 4th & Townsend, Broadway, and Atherton. Bullet trains in 2040 Project would also stop at more stations that would not have bullet service under 2040 No Project. Adding stops brings service to more stations, but also increases trip time due to the time needed to decelerate, dwell, and accelerate a train safely and efficiently.

TABLE 15: AVERAGE HEADWAYS, PEAK AND OFF-PEAK PERIODS, ALL NO PROJECT AND PROJECT SCENARIOS

Stations	Existing/2020 No Project/ 2040 No Project			2020 Project			2040 Project		
	AM Peak	PM Peak	Off-Peak	AM Peak	PM Peak	Off-Peak	AM Peak	PM Peak	Off-Peak
Transbay Terminal	N/A	N/A	N/A	N/A	N/A	N/A	0:30	0:30	0:36
4th & Townsend	N/A	N/A	N/A	N/A	N/A	N/A	0:30	0:30	0:36
4th & King	0:17	0:15	0:46	0:10	0:09	0:37	0:15	0:15	No service
22nd Street	0:36	0:42	0:57	0:19	0:19	0:37	0:35	0:35	0:36
Bayshore	0:59	0:59	0:58	0:28	0:29	0:37	1:00	1:00	0:36
South San Francisco	0:45	0:43	0:58	0:21	0:22	0:37	0:44	0:45	0:36
San Bruno	0:29	0:30	0:48	0:29	0:29	0:37	0:29	0:30	0:36
Millbrae	0:19	0:20	0:46	0:09	0:09	0:37	0:09	0:10	0:36
Broadway	No service	No service	No service	0:54	1:00	0:37	No service	No service	0:36
Burlingame	0:28	0:26	0:48	0:29	0:30	0:37	0:29	0:30	0:36
San Mateo	0:20	0:20	0:47	0:13	0:12	0:37	0:14	0:14	0:36
Hayward Park	1:00	0:59	0:58	0:28	0:30	0:37	1:00	1:00	0:36
Hillsdale	0:18	0:17	0:46	0:11	0:11	0:37	0:12	0:12	0:36
Belmont	0:54	0:59	0:48	0:29	0:30	0:37	0:30	0:30	0:36
San Carlos	0:24	0:24	0:47	0:22	0:22	0:37	0:22	0:22	0:36
Redwood City	0:23	0:23	0:48	0:11	0:11	0:37	0:12	0:12	0:36
Atherton	No service	No service	No service	0:52	1:00	0:37	1:00	1:00	0:36
Menlo Park	0:24	0:21	0:48	0:13	0:13	0:37	0:15	0:14	0:36

TABLE 15: AVERAGE HEADWAYS, PEAK AND OFF-PEAK PERIODS, ALL NO PROJECT AND PROJECT SCENARIOS

Stations	Existing/2020 No Project/ 2040 No Project			2020 Project			2040 Project		
	AM Peak	PM Peak	Off-Peak	AM Peak	PM Peak	Off-Peak	AM Peak	PM Peak	Off-Peak
Palo Alto	0:18	0:15	0:46	0:10	0:10	0:37	0:10	0:09	0:36
California Ave.	0:39	0:36	0:48	0:30	0:30	0:37	0:30	0:30	0:36
San Antonio	0:54	1:01	0:48	0:30	0:30	0:37	0:30	0:29	0:36
Mountain View	0:15	0:16	0:46	0:11	0:10	0:37	0:10	0:09	0:36
Sunnyvale	0:39	0:44	0:48	0:19	0:20	0:37	0:19	0:20	0:36
Lawrence	0:32	0:31	0:48	0:29	0:30	0:37	0:30	0:30	0:36
Santa Clara	0:28	0:30	0:48	0:29	0:30	0:37	0:30	0:30	0:36
College Park	0:00	0:00	0:00	No service	No service	No service	No service	0:00	0:00
San Jose Diridon	0:14	0:18	0:46	0:10	0:09	0:37	0:10	0:09	0:36
Tamien	0:27	0:32	1:20	0:30	0:30	0:55	0:25	0:29	1:00

Notes:
-Headways are expressed in hour and minutes (hh:mm) and represent an average of all northbound and southbound trains that depart within the time period specifications detailed below
AM Peak = 6:00 – 8:59 AM
PM Peak = 4:00 – 6:59 PM
Off Peak= Early Morning (4:00 – 5:59 AM); Midday (9:00 AM- 3:59 PM); Evening Off-Peak (7:00 PM – 2:00 AM)
-No service indicates that there is no service during the time period in question.
Source: Peninsula Corridor Joint Powers Board, 2013. Fehr & Peers, 2013.

1.5 VTA Model Forecasts of Caltrain Ridership

Table 16 presents the 2020 and 2040 ridership forecasts produced by the VTA travel model for No Project and PCEP conditions. Under No Project conditions, Caltrain systemwide daily ridership is projected to increase by about 10,000 daily boardings by 2020 and another 27,000 by 2040, to a total of almost 84,000. With the Project in 2020, system ridership is projected to increase by another 12,000 riders above No Project levels, reaching a total of about 69,000, or 47% above 2013 levels. With the project in 2040, system ridership is projected to be about 111,000 daily riders, a 135% increase over 2013.

The station-by-station ridership estimates in **Table 16** are uncalibrated figures. The following chapter describes how these estimates are calibrated to produce the final estimates of ridership by station for each of the forecast cases.

TABLE 16: UNCALIBRATED CALTRAIN BOARDINGS BY STATION BY SCENARIO

Station	2013 Observed	2020 Model No Project	2020 Model PCEP	2040 Model No Project	2040 Model PCEP
Transbay Terminal	N/A	N/A	N/A	N/A	8,527
SF	10,760	12,347	13,692	15,891	14,529
22nd	1,303	2,108	2,479	3,089	3,525
Bayshore	190	816	1,186	1,610	2,455
SSF	373	1,038	1,378	1,688	1,949
San Bruno	451	674	693	1,104	1,311
Millbrae	3,259	2,882	3,775	4,790	6,643
Broadway	0	0	558	0	619
Burlingame	780	1,129	1,010	1,536	1,650
San Mateo	1,570	2,052	2,230	2,844	3,579
Hayward Park	334	647	980	1,269	1,212
Hillsdale	2,278	3,036	3,695	4,407	6,430
Belmont	508	623	868	912	1,190
San Carlos	1,170	1,823	1,909	2,486	2,495
Redwood City	2,588	3,226	3,454	5,627	6,124
Atherton	0	0	444	0	570
Menlo Park	1,571	1,750	1,685	2,374	2,329
Palo Alto	5,613	6,630	8,280	10,319	14,219
Cal Avenue	1,261	1,192	1,164	1,722	1,283
San Antonio	643	674	782	1,080	1,268
Mountain View	3,834	3,849	5,253	5,879	8,841
Sunnyvale	2,272	2,030	2,456	2,641	3,481
Lawrence	688	1,102	1,370	1,639	2,005
Santa Clara	792	828	986	902	885
College Park	118	67	138	71	0
Diridon	3,523	4,368	5,765	6,905	10,994
Tamien	783	1,003	1,641	1,104	1,477
Capitol	39	101	109	127	91
Blossom Hill	63	147	165	225	189
Morgan Hill	129	175	200	304	310
San Martin	45	136	163	197	215
Gilroy	128	595	644	1,075	1,032
All (Including Stations South of Tamien)	**47,066**	**57,047**	**69,151**	**83,815**	**111,427**
SF County Stations	12,253	15,270	17,357	20,590	29,035

TABLE 16: UNCALIBRATED CALTRAIN BOARDINGS BY STATION BY SCENARIO

Station	2013 Observed	2020 Model No Project	2020 Model PCEP	2040 Model No Project	2040 Model PCEP
SM County Stations	14,882	18,879	22,679	29,036	36,101
SCL County Station	19,931	22,898	29,115	34,189	46,291
Express Train Stations	37,001	42,227	50,533	61,921	77,116

Source: VTA, 2014

2.0 Calibrated Ridership Forecasts

The VTA forecasts described above take into account a wide array of regional and corridor factors influencing Caltrain ridership, including population and employment densities, auto ownership rates, demographics, transit and highway travel conditions and other factors. The VTA model does an exceptionally good job at estimating system-level Caltrain ridership and meets or exceeds industry standards for ridership accuracy within the Santa Clara and San Francisco corridor segments. However, as is true of even the best regional models, its analysis scale leaves the model relatively insensitive to fine-grained local conditions, such as transit oriented development (TOD) land use clustering, station area multi-modal circulation and local para-transit services. As a result, the VTA model estimates of station-specific boardings differ from passenger counts by more than 20% at over half of the Caltrain stations.

To address this, Fehr & Peers used "direct ridership" analytics to compare model estimates to actual ridership and access modes, and develop a calibration process which adjusts VTA Model outputs to account for these factors and to better predict Caltrain station-by-station level ridership. The analysis considered over 20 local land use and accessibility factors and identified four that capture station-level activity in a more fine-tuned manner than is possible with the regional model alone. Factors to which the VTA model is relatively insensitive are: the amount of private shuttle bus service, the concentration of population and jobs within the walkable half-mile proximity to the station, a "betweenness" measure of local travel connectivity, and differences in the model's aggregation of land use between the San Mateo and Santa Clara County segments of the Caltrain corridor.

By incorporating these four factors, the Direct Ridership Model (DRM) was able to calibrate Caltrain boarding estimates to better match actual 2013 Caltrain ridership, and to:

- Improve the ridership estimates at 18 of the 23 stations studied

- Reduce the inaccuracy in estimating overall Caltrain ridership and average station boardings by 70%
- Reduce the percent root-mean-square error (RMSE) by 24%
- Improve VTA ridership estimates at different points in time, as seen through DRM performance testing with historic data from 2005 and 2010

2.1 Future Changes in Station Area Conditions

By 2020 and 2040, changes in station area land use and access are forecast to occur, independent of the proposed Caltrain electrification project. As shown in **Figure 1**, activity density is projected to increase notably in the vicinity of every station, with some of the largest percentage increases occurring at 22nd Street, Bayshore, Hayward Park, Redwood City and Diridon. In addition, local walking and cycling connections near several stations and drive directness are expected to improve by 2020 and 2040, as indicated in **Figure 2**. Stations with key station area development access improvements include Bayshore and Lawrence. Private shuttles are predicted to increase along with employment growth in the beyond-walkable distances of stations in Mountain View, Diridon, San Francisco and others as shown in **Figure 3**.

These local factors, when considered in conjunction with the regional and corridor-level factors addressed in the VTA model through the calibration process described above, produce station-by-station ridership forecasts for 2020 and 2040 as described in the following sections.

Figure 1. Station Area Activity Density
(population plus jobs within one-half mile of the station, in 1000's)

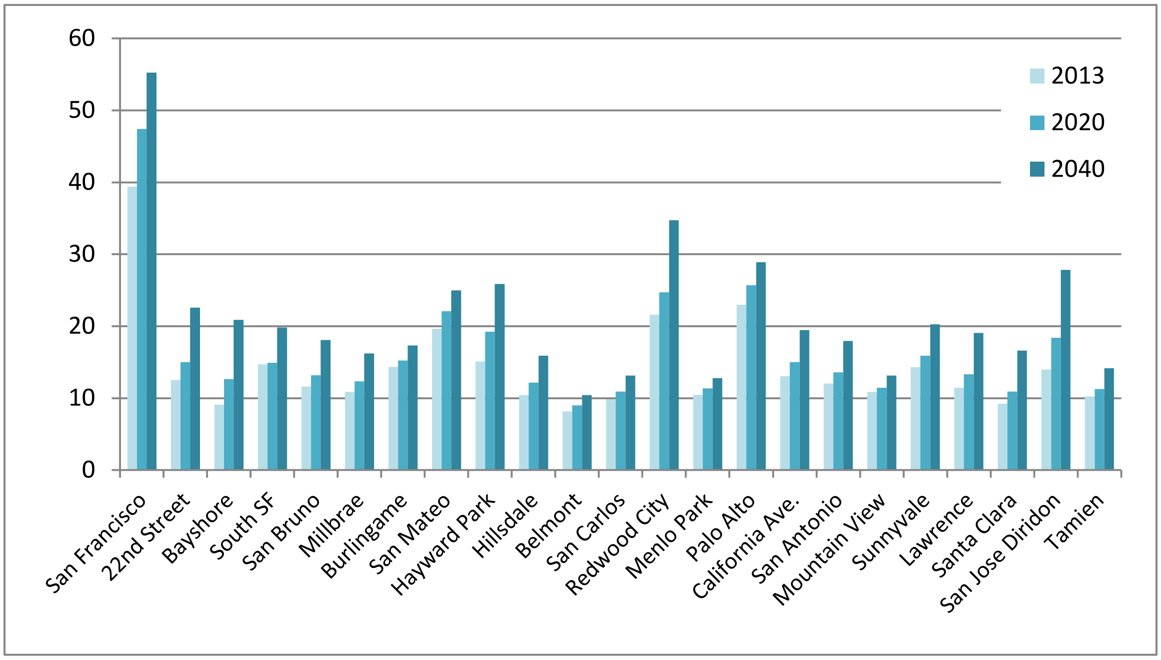


Figure 2. Local Access/Circulation Improvements
("Betweenness" - fraction of shortest paths that pass by 4 closest intersections to the station)

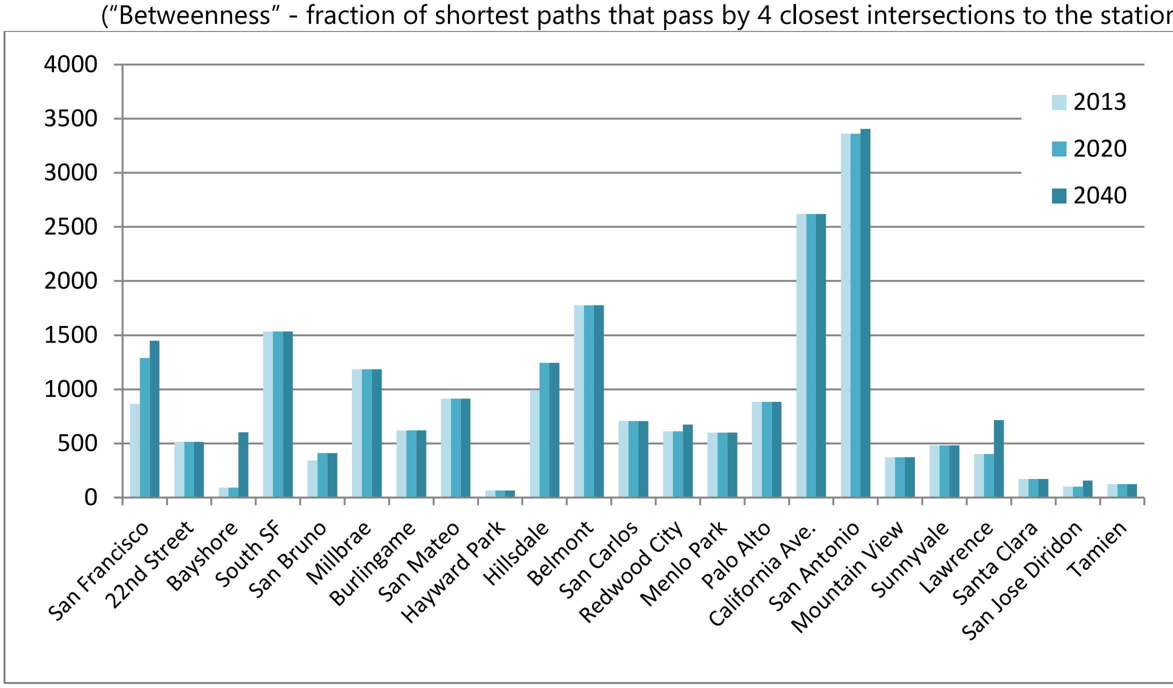
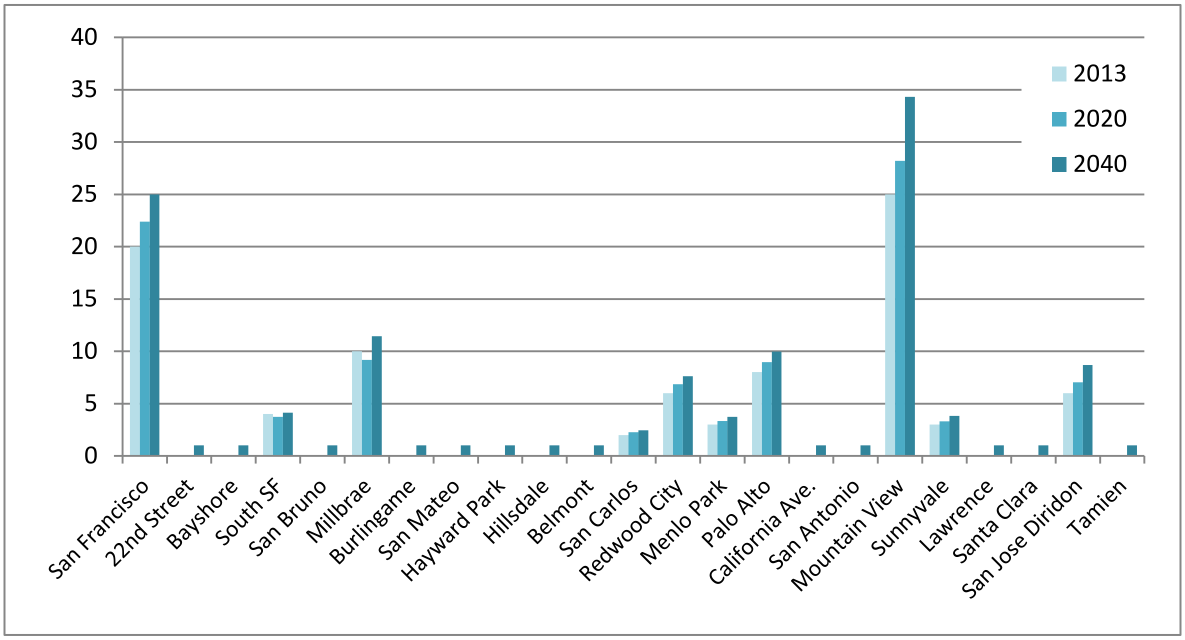


Figure 3. Private Shuttles (estimated number of employer or campus shuttles during AM period)



2.2 2020 Ridership Forecasts

The 2020 forecasts of daily ridership under No Project and PCEP Project conditions are presented in **Table 17** and **Figure 4**. Overall ridership increases by 20% in 2020 under No Project conditions, reaching almost 56,000 daily passenger trips. The change is not evenly distributed across all stations, with higher land use growth and connectivity producing ridership increases of 50% or more at 22nd Street, Bayshore, South SF and Tamien. The greatest increases in absolute terms, over 700 boardings each, occur at San Francisco, Millbrae, Palo Alto, Mountain View and Diridon.

The PCEP project increases train frequencies overall, with differences in trains-per-hour and the travel time efficiency with which certain trains reach their destinations varying by station. Overall ridership is projected to increase to almost 67,000, which is 20% higher than 2020 No Project ridership and 43% higher than 2013 system patronage. Stations with the greatest increases in ridership between 2020 No Project and 2020 Project include: Bayshore, South San Francisco, Hayward Park and Tamien, with increases ranging from 46% to 116%. Compared with 2020 No Project, small decreases in ridership are projected for Burlingame, Menlo Park and California Ave due to minor reductions in train frequency relative to neighboring stations and shifting of some riders to stations with relatively higher service levels. San Francisco, Millbrae, Palo Alto, Mountain View and Diridon will all experience increases of more than 1,100 daily riders relative to 2020 No Project.

TABLE 17. CALIBRATED CALTRAIN RIDERSHIP FORECASTS 2020 AND 2040 (NO PROJECT AND WITH PROJECT)

Station	Existing Conditions	2020 No Project	2020 Project	2040 No Project	2040 Project
Transbay Center	N/A	N/A	N/A	N/A	8,530
4th & King*	10,786	13,004	14,335	16,563	15,231
22nd Street	1,312	1,953	2,311	2,857	3,294
Bayshore	195	442	726	1,042	1,698
South SF	361	546	799	1,000	1,199
San Bruno	437	476	497	955	1,201
Millbrae	3,255	3,969	5,129	6,500	8,958
Broadway	0	0	386	0	443
Burlingame	792	888	762	1,316	1,438
San Mateo	1,571	1,739	1,913	2,528	3,275
Hayward Park	331	494	1,074	1,511	1,416
Hillsdale	2,317	2,744	3,368	4,039	5,998
Belmont	509	513	754	816	1,094
San Carlos	1,138	1,373	1,439	1,890	1,903
Redwood City	2,619	2,968	3,177	5,173	5,668
Atherton	0	0	277	0	433
Menlo Park	1,526	1,583	1,516	2,175	2,139
Palo Alto	5,469	6,377	7,914	9,821	13,538
California Ave.	1,294	1,412	1,376	1,986	1,498
San Antonio	675	748	844	1,107	1,284
Mountain View	3,876	4,581	5,915	6,696	9,567
Sunnyvale	2,274	2,715	3,280	3,482	4,625
Lawrence	700	917	1,161	1,407	1,749
Santa Clara	822	894	1,086	948	931
San Jose Diridon	3,489	4,266	5,596	6,642	10,602
Tamien**	807	1,225	2,098	1,363	1,881
Total	**46,560**	**55,830**	**67,730**	**81,820**	**109,590**

***** Numbers may not match totals due to rounding. No service increases are proposed at the College Park Station and ridership at this station is very low at present (118 boardings/day). While College Park boardings are included in overall system ridership estimates, no analysis of localized traffic around this station was conducted given the low level of boardings and lack of proposed service increases.

******Excludes ridership south of Tamien Station.

2.3 2040 Ridership Forecasts

Table 17 and **Figure 5** present the ridership forecasts for 2040 both with and without the PCEP Electrification project. Daily patronage is projected to reach almost 82,000 in 2040 without the proposed project and nearly 110,000 with the PCEP (including the Transbay Center station), increases over 2013 levels of 76% and 115% respectively.

Figure 4. 2020 Caltrain Ridership Forecasts (No Project and with Project)

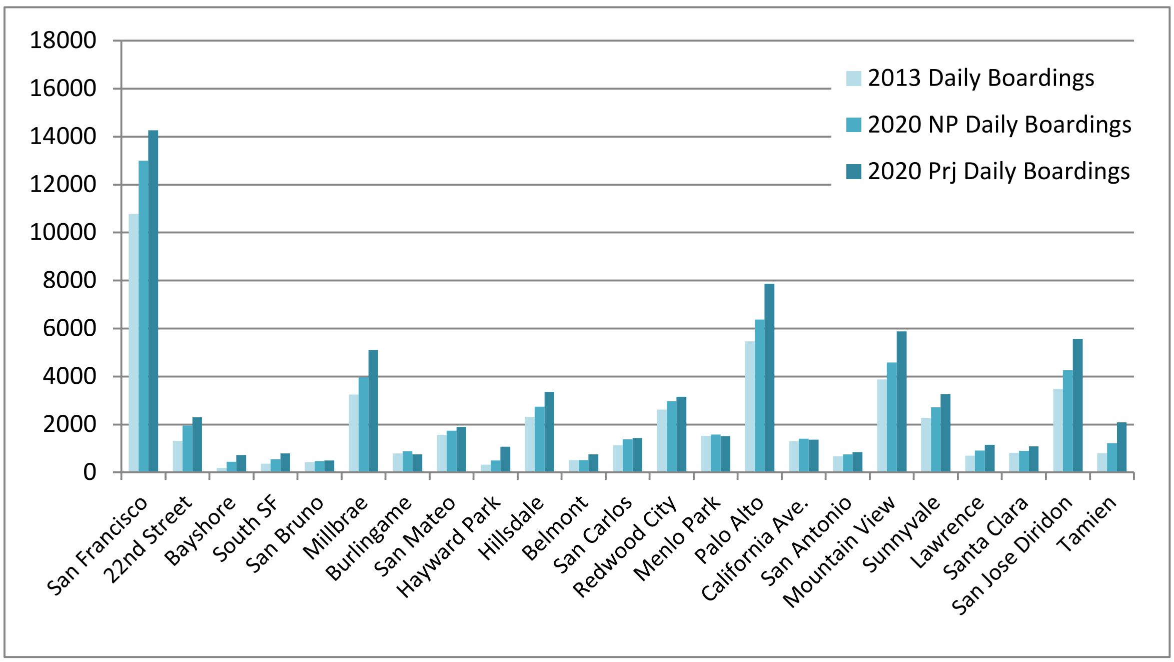
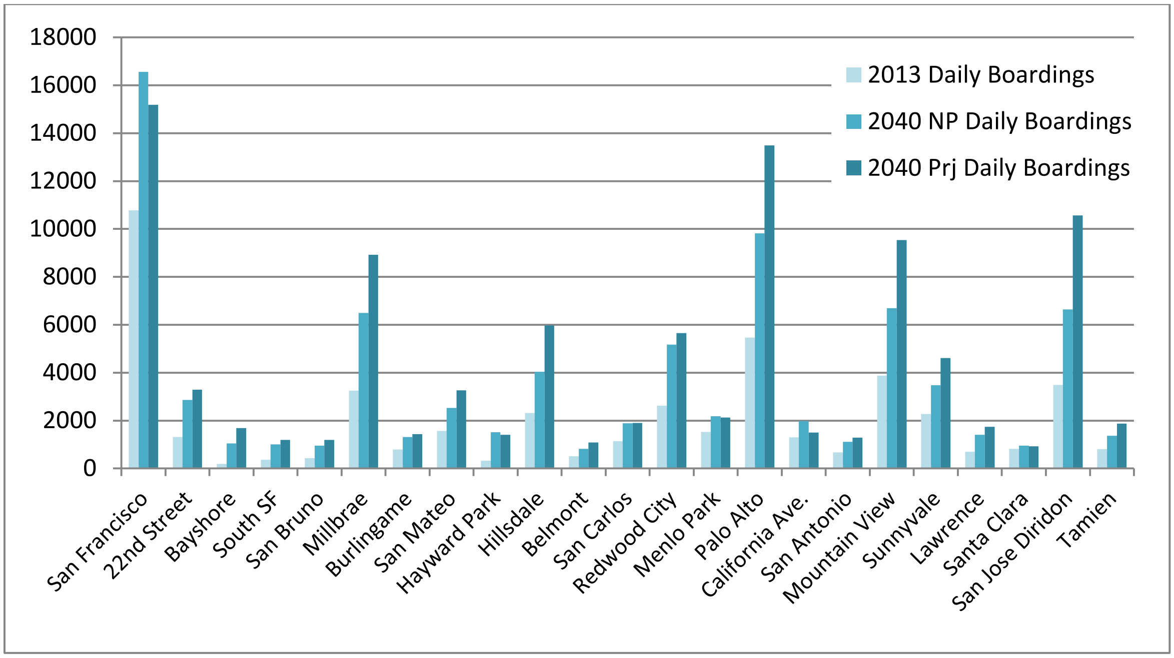


Figure 5. 2040 Caltrain Ridership Forecasts (No Project and with Project)



Under No Project conditions, corridor population and employment growth accompanied by changes to other transit connections and increases in highway congestion will increase Caltrain ridership by 47% between 2020 and 2040. Stations experiencing the greatest effects will be Bayshore, South San Francisco, San Bruno, and Hayward Park, all with increases of more than 75% over the 20 year period. In percentage terms, 4th and King will be one of the lowest growth stations, reflecting a redistribution of the trip origins and destinations to shorter intra-Peninsula travel over the period. San Francisco, Millbrae, Redwood City, Palo Alto, Mountain View and Diridon will all experience increases of more than 2,000 daily riders compared with the 2020 No Project scenario.

The addition of the PCEP project will raise 2040 ridership by 32% over 2040 No Project conditions; 2040 Project ridership will be 62% higher than 2020 Project ridership. As a partial result of PCEP service redistribution, stations where, in 2040, the PCEP will add the greatest amount of ridership compared with No Project conditions will be Bayshore, Hillsdale, Mountain View and Diridon, each with increases of at least 40%. Total ridership generated near downtown San Francisco, combining 4th/King with the new Transbay Terminal station, will also be greater than 40% higher in 2040 with PCEP than without. Millbrae, Palo Alto, Mountain View and Diridon will all experience increases of more than 2400 daily riders compared with the 2040 No Project scenario.

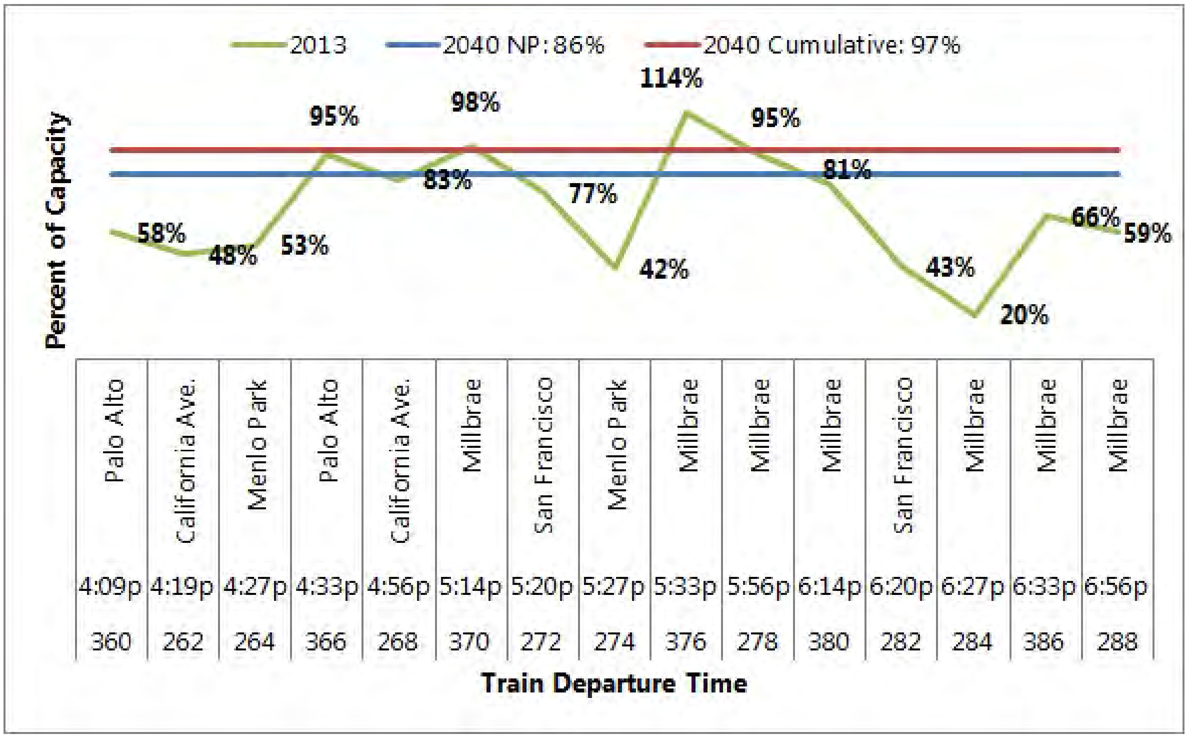
2.4 System Capacity Assessment

In 2040, Caltrain ridership will approach the system's capacity during peak periods. However, careful examination of how demand will be likely to shift over that time period leads to a conclusion that demand will reach but not exceed peak capacity. The primary shifts are:

- Trips will become shorter, with an increase in ridership within the Peninsula that is greater than the increase in riders that traverse the point of maximum line loading heading into San Francisco. The distribution of boardings and alightings will allow that, compared with today, seat occupancy will turnover more often as the trains travel the full corridor, for example serving both a rider between Tamien and Mountain View, another rider travelling between Palo Alto and Millbrae, and perhaps a third between Millbrae and San Francisco.
- Riders will shift their travel schedules within the peak period to trains with sufficient capacity, avoiding trains that, even today, are loaded to near capacity. **Figure 6** illustrates the shift to maximum utilization of peak capacity from a condition in 2013 where one peak train is overcapacity and three are at or near capacity to a 2040 No Project and Project condition where all peak period trains operate at 86% and 97% of capacity, respectively.
- About 5% of riders will shift to outside the peak period entirely, a trend that's already apparent.
- The number of standees per train will increase to about 30 standees per car at the maximum load point, lasting for a maximum of about 20 minutes based on estimated turnover rates.

This combination of peak spreading, trip shortening, turnover rates and a higher percentage of standees will allow Caltrain to accommodate more riders per line mile than in 2013 and just meet the projected 2040 demand.

Figure 6. Comparison of 2013 and 2040 Maximum Capacity Utilization – PM Peak Southbound



2.5 Peak Ridership by Station

Daily and peak period ridership estimates produced by the DRM calibrated VTA model and adjustment process described above resulted in the forecasts of peak period ridership forecasts presented in **Figures 7 and 8.**

In 2020 with No Project, changes in development and station access and increases in highway congestion are projected to increase peak period ridership by about 34% systemwide. The growth would not be evenly distributed among stations, with ridership expected to be more than double 2013 levels at Bayshore, South San Francisco and Menlo Park. Other stations at which peak period ridership growth is projected to be especially high (50% to 100%) by 2020 without the Project are 22nd Street, San Mateo, Hayward Park, Belmont, San Carlos, Redwood City, California Ave and San Antonio. In terms of numbers of riders, the greatest growth is projected for 4th/King, 22nd Street, Hillsdale, Redwood City and Menlo Park, with increases of more than 500 peak period boardings each.

Figure 7. 2020 Caltrain 5-9AM Peak Period Ridership Forecasts (No Project and with PCEP Electrification Project)

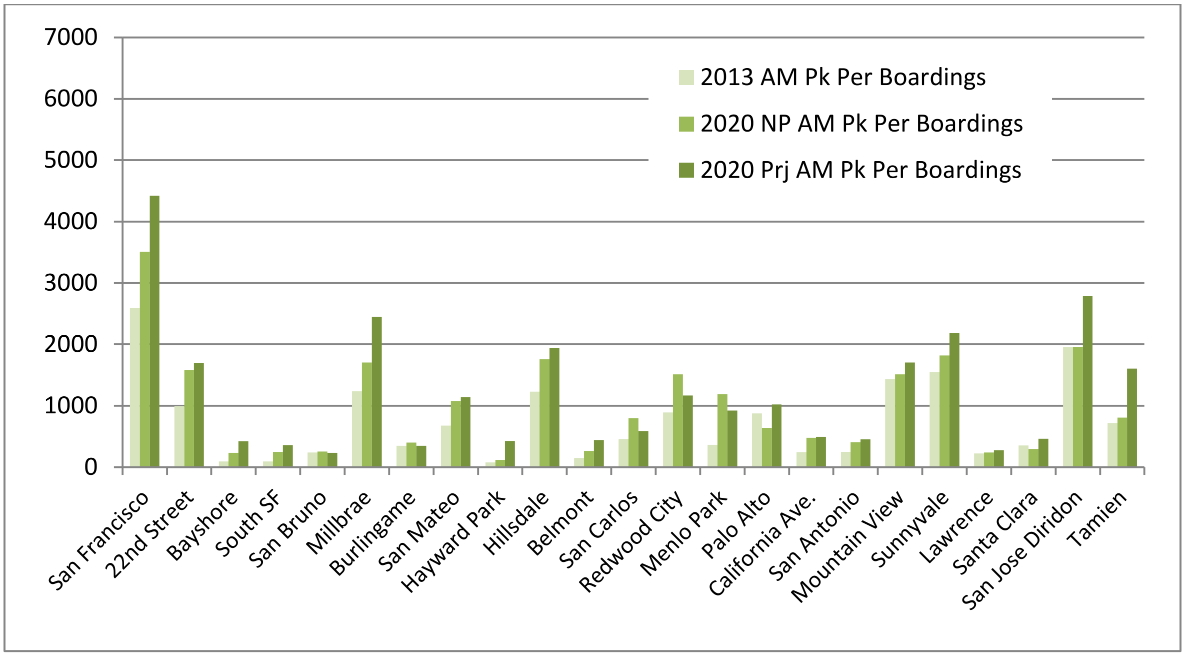
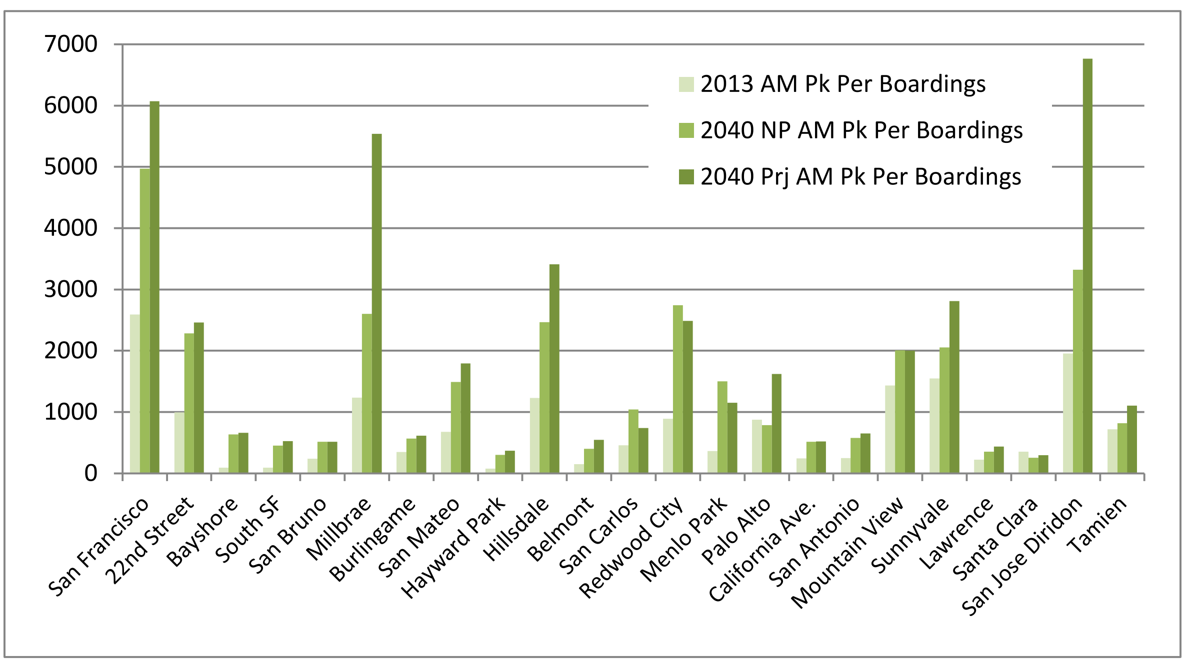


Figure 8. 2040 Caltrain 5-9AM Peak Period Ridership Forecasts (No Project and with PCEP Electrification Project)



The PCEP Project will increase peak period ridership by another 21% system-wide in 2020. The increases will not be equally distributed, with the greatest percentage increases projected at Bayshore, Hayward Park, Hillsdale, Palo Alto, Santa Clara and Tamien. This will relate, in part, to changes in the distribution of train service among the stations. Bayshore and Hayward Park will experience an increase in train frequency much greater than the average PCEP system-wide increase. Stations with the greatest absolute increases in peak period boardings will be at San Francisco, Millbrae, Diridon and Tamien, with over 700 each.

In 2040 without the PCEP project, systemwide peak period demand is projected to be about 43% higher than the 2020 No Project level. As in 2020, the percentage increases in ridership are projected to be at the stations with some of the lowest existing ridership: Bayshore, South San Francisco and Hayward Park. Stations with greatest increases in the numbers of peak period riders will be: San Francisco, Millbrae, Redwood City and Diridon.

Compared with 2040 No Project, the PCEP will increase 2040 ridership by 32%. The greatest absolute increases will be in San Francisco, Millbrae, Hillsdale, Palo Alto and Diridon, with increases of 800 to 3400 boardings over 2040 No Project. Millbrae, Palo Alto and Diridon will also experience the greatest percentage increases, more than doubling their 2040 No Project peak period demand.

The single highest ridership generation hour at each station is determined based on surveys of existing ridership peaking at each station. Comparing the single peak hour to the 5-9AM peak period, the peak-hour percentages average about 38% of the four-hour period. The highest peak-hour concentrations occur at Sunnyvale, Lawrence, and Santa Clara, at over 50% of their peak period demand.

The peak hour ridership for 2013 and the 2020 and 2040 forecasts are presented in Figures 9 and 10. The peak hour forecasts follow a similar pattern to the peak period forecasts in Figures 7 and 8, with the greatest percentage increases most often occurring at stations with the lowest existing ridership levels, and the highest absolute increases in ridership at some of the existing highest volume stations, such as San Francisco, 22nd Street, Millbrae, Hillsdale, Redwood City and Menlo Park under No Project Conditions. Under conditions with the PCEP project, the greatest increases are projected at San Francisco, 22nd Street, Millbrae, Hillsdale, Redwood City, Palo Alto, Sunnyvale and Diridon. The 2040 ridership is lower than 2020 at Santa Clara and Tamien due in part to shifts in train frequency between the two years that make adjacent stations (Lawrence and Diridon) comparatively more attractive. Each adjacent station sees a large proportional increase.

Figure 9. 2020 and 2040 No Project Caltrain Peak Hour Ridership Forecasts

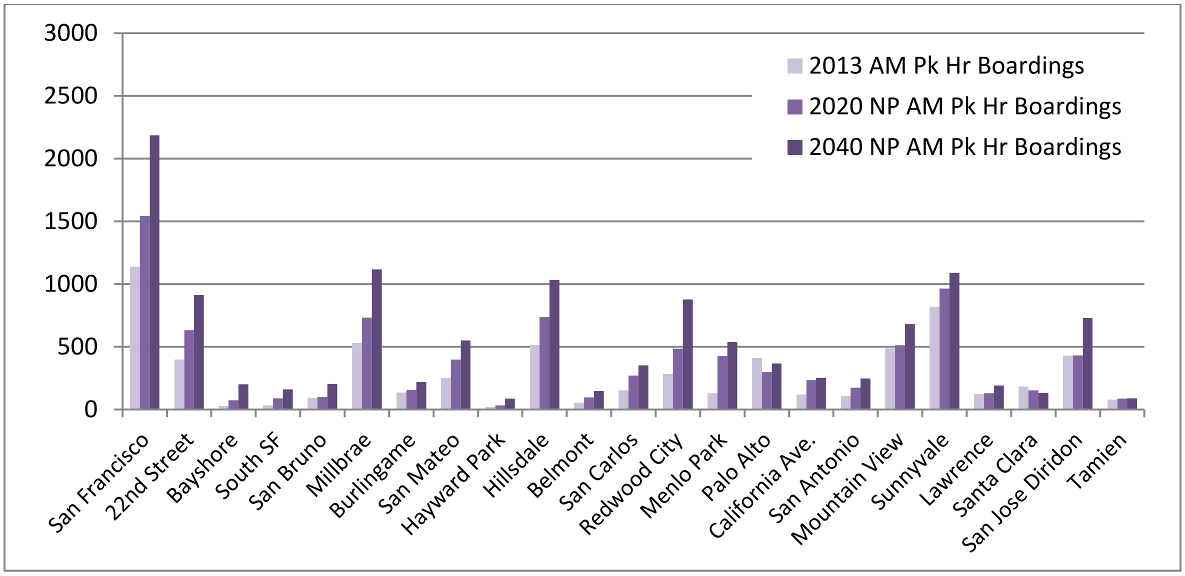
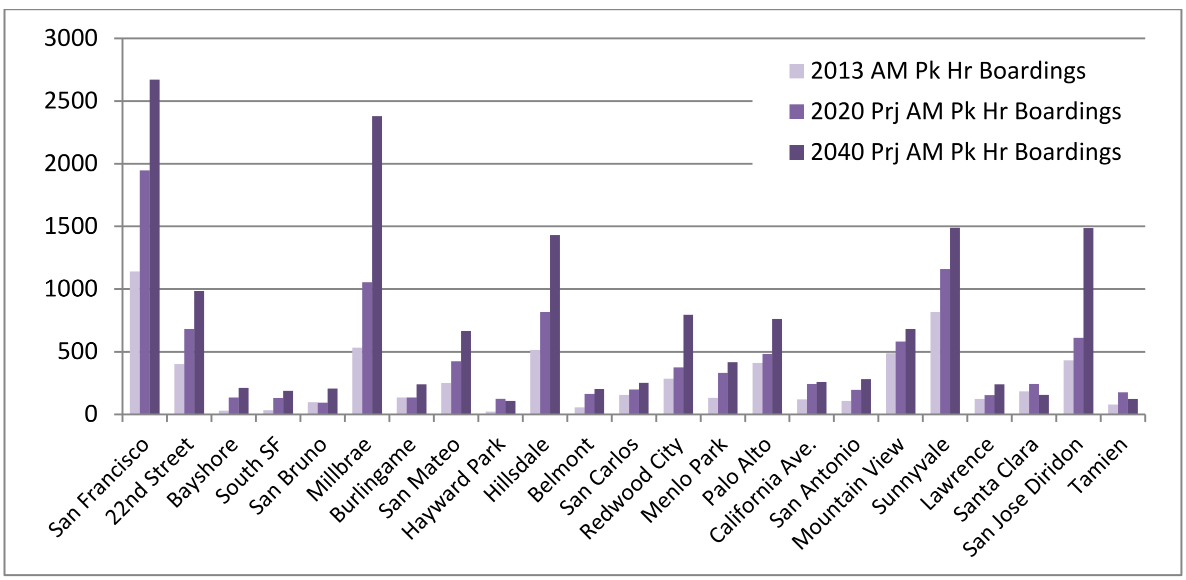


Figure 10. 2020 and 2040 No Project Caltrain Peak Hour Ridership Forecasts



3.0 Access and Egress Forecasts

Fehr & Peers developed models to forecast modes of access and modes of egress at Caltrain stations, using 2013 passenger surveys of the actual proportions of riders accessing and egressing by auto (park-ride, kiss-ride), transit, walking and bicycling. The analysis found the following factors to be directly associated with actual access and egress mode shares: parking supply and price, frequency of feeder bus, rail, and private shuttle service to station, street network intersection density, length of bike facilities in the station area, local population and employment density, and Caltrain service frequencies. The resulting Direct Ridership Model (DRM) for mode-of-access is more than 50 percent more accurate than the VTA model for all access modes. Individually, the DRM access/egress model is more than 55 percent more accurate for park-ride, and more than 45 percent more accurate for kiss-ride auto mode shares, key metrics to be used in determining the traffic and parking impacts associated with Caltrain ridership. The mode-of-egress model is more than 50 percent more accurate than the VTA model for all egress modes.

3.1 Future Changes in Station Area Access Accommodations

Figure 2 above presented the variation in one of the key access/egress factors, Activity Density, over the forecast horizon. Figures 11 through 12 present the projected changes in other key factors influencing modes of station access in 2020 and 2040.

In Figure 11, the decline in Project train frequency between 2020 and 2040 is a consequence of a reduction in daily trains serving 22nd Street, Bayshore, South San Francisco and Tamien. In San Francisco, the reduction in train frequency at 4th/King is offset by an increase in train service to Transbay Center, which also affects the number of riders needing to access the terminus station by local transit versus walking from financial district destinations.

Intersection density, as shown in Figure 12 is projected to remain generally static over the forecast horizon with the exceptions of Bayshore, where a major redevelopment plan is envisioned, and San Bruno, where the station is due to be relocated.

The AM Transit Factor (Figure 13), is a metric that incorporates the number of buses and BART trains serving the station during the AM period. Stations expected to exhibit notable increases in transit connectivity by 2040 include Millbrae, and Diridon and Santa Clara due to the South Bay BART extension. Local transit service to the 4th/King station is expected to reduce by 2040 when Caltrain. is extended all the way to Transbay Center and the financial district and Market Street BART connections.

Figure 11. 2020 and 2040 Caltrain Frequency Factor by Station
(Daily trains stopping at station daily plus daily bullet trains stopping at the station in AM)

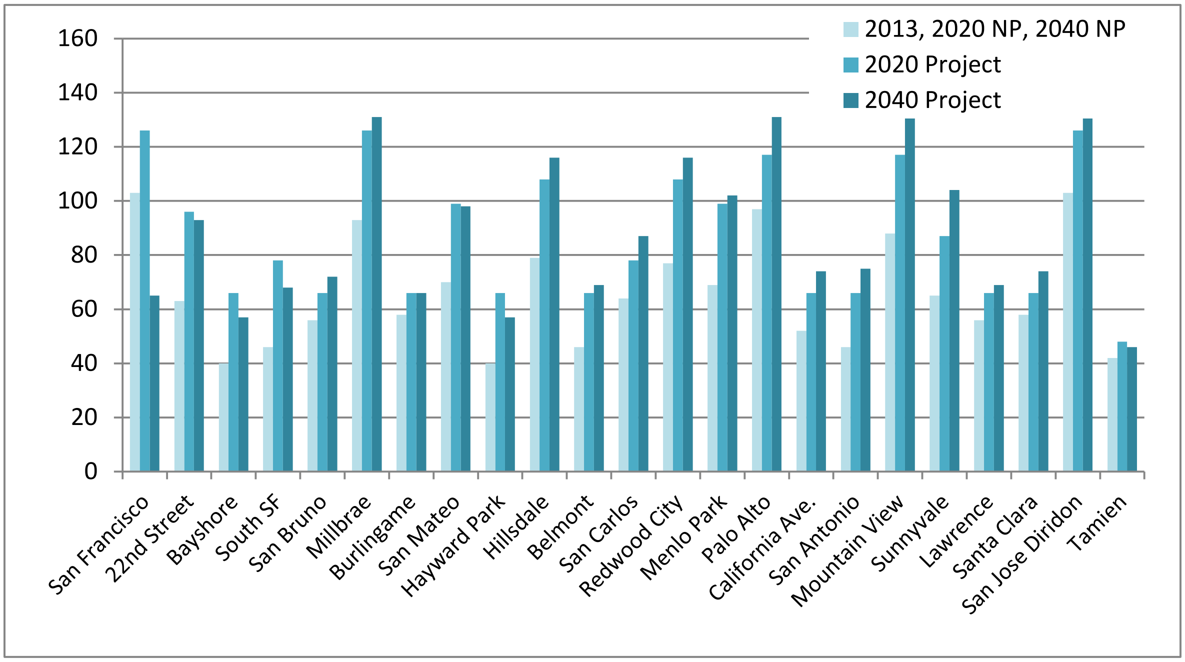


Figure 12. 2020 and 2040 Intersection Density (intersections within one-half mile of the station)

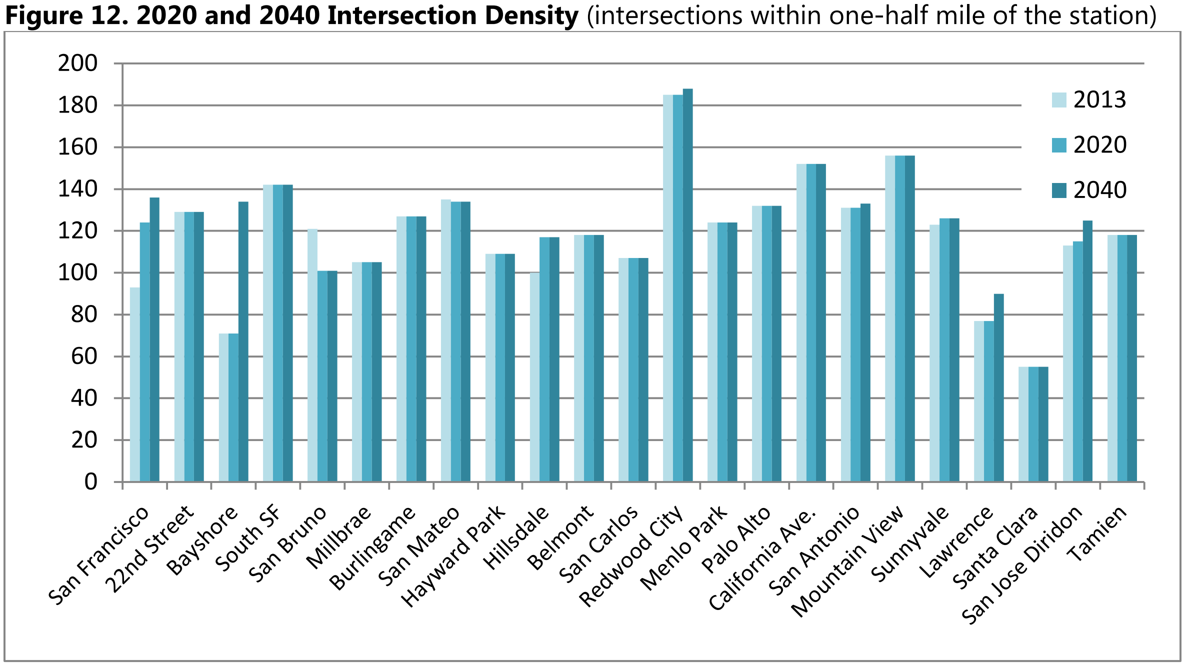


Figure 13. 2020 and 2040 AM Transit Factor (number of buses and BART trains serving station)

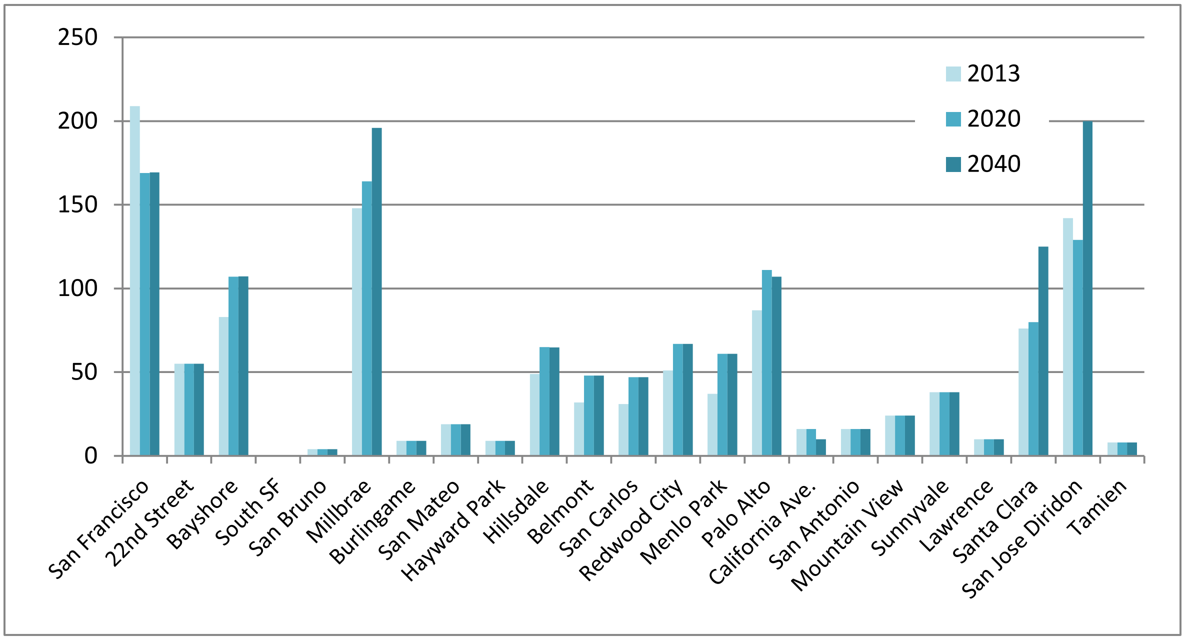
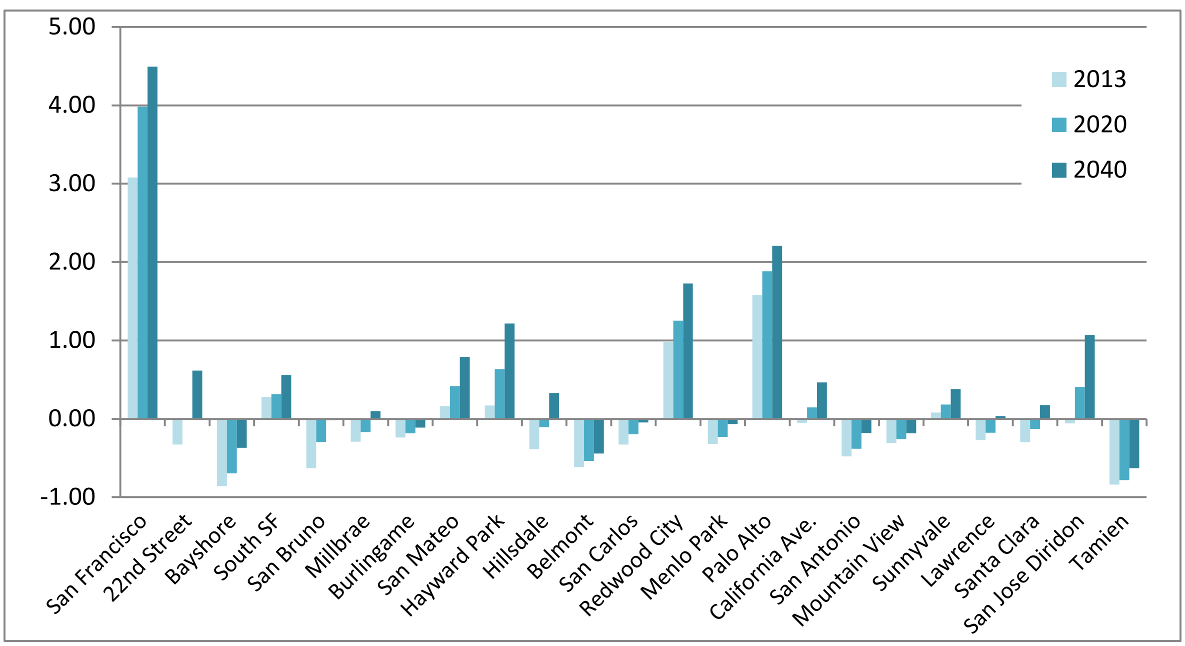


Figure 14. 2020 and 2040 Bikeway Density Factor (factor based on population and jobs within one-half mile of station and Class I, II, and III bicycle facilities within 1 mile of station)



Bikeway Density Factor, Figure 14, is an index that accounts for the density of population and jobs within one-half mile of the station and the completeness of the bicycle network (Class I, II, and III bicycle facilities) within 1 mile. Most station areas will see progressive improvement in the metric, with the biggest proportional increases anticipated at 22nd Street, Hayward Park, California Ave and Diridon.

3.2 Station Modes of Access Forecasts

No Project

Independent of the PCEP electrification project, modes used to reach Caltrain stations in the AM peak period are projected to shift as indicated in Figure 15. Due to the region's planed focus growth at transit oriented development areas, most stations are expected to progress toward higher proportions of walk and bike access. The projection is for lower proportions of, though generally not lower absolute amounts of, park-ride and kiss-ride access. Exceptions to the pattern are Diridon and Santa Clara in 2040, where the planned BART South Bay extension will dramatically increase the proportion of those arriving at Caltrain via transit. Millbrae is also projected to experience a higher proportion of access via transit in 2040 due to area transit service frequency improvements.

With PCEP Project

As shown in Figure 16, access mode choice undergoes a different transition in the PCEP project case than under future No Project conditions. In the PCEP case, walking is projected to decrease proportionally by 2020, while auto access is projected to increase as a proportion of the total. This is partly due to shifts among the stations in train service frequencies and destination travel times drawing some riders to stations that might not be the nearest ones to their point of trip origination. The effect is most noticeable at stations in northern San Mateo County and San Francisco. The trajectory is projected to reverse itself by 2040 as the effects of new station-area development begin to take effect. At many stations, the proportion of trips accessing Caltrain by auto (park-ride or kiss-ride) is projected to be similar of lower in 2040 than in 2013. Exceptions, where driving access is projected to be higher in 2040, are: San Mateo, Hillsdale, Belmont, San Carlos, Menlo Park, Palo Alto, San Antonio, Mountain View and Sunnyvale. As in the No Project case, 2040 Project access is projected to be much highly oriented toward transit at BART service stations Diridon, Santa Clara and Millbrae.

Figure 15. 2020 and 2040 No Project Modes of Station Access (AM Peak)

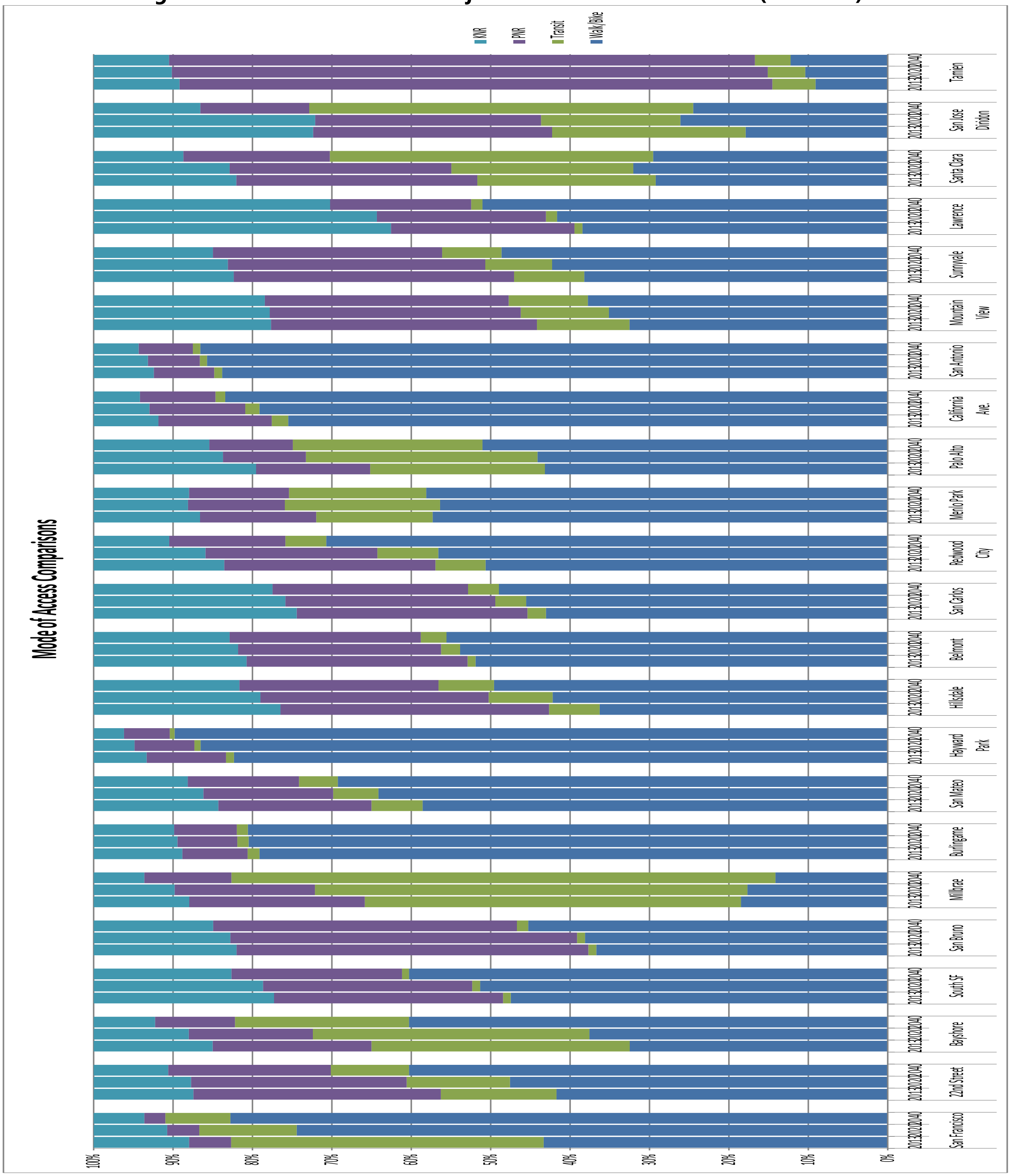
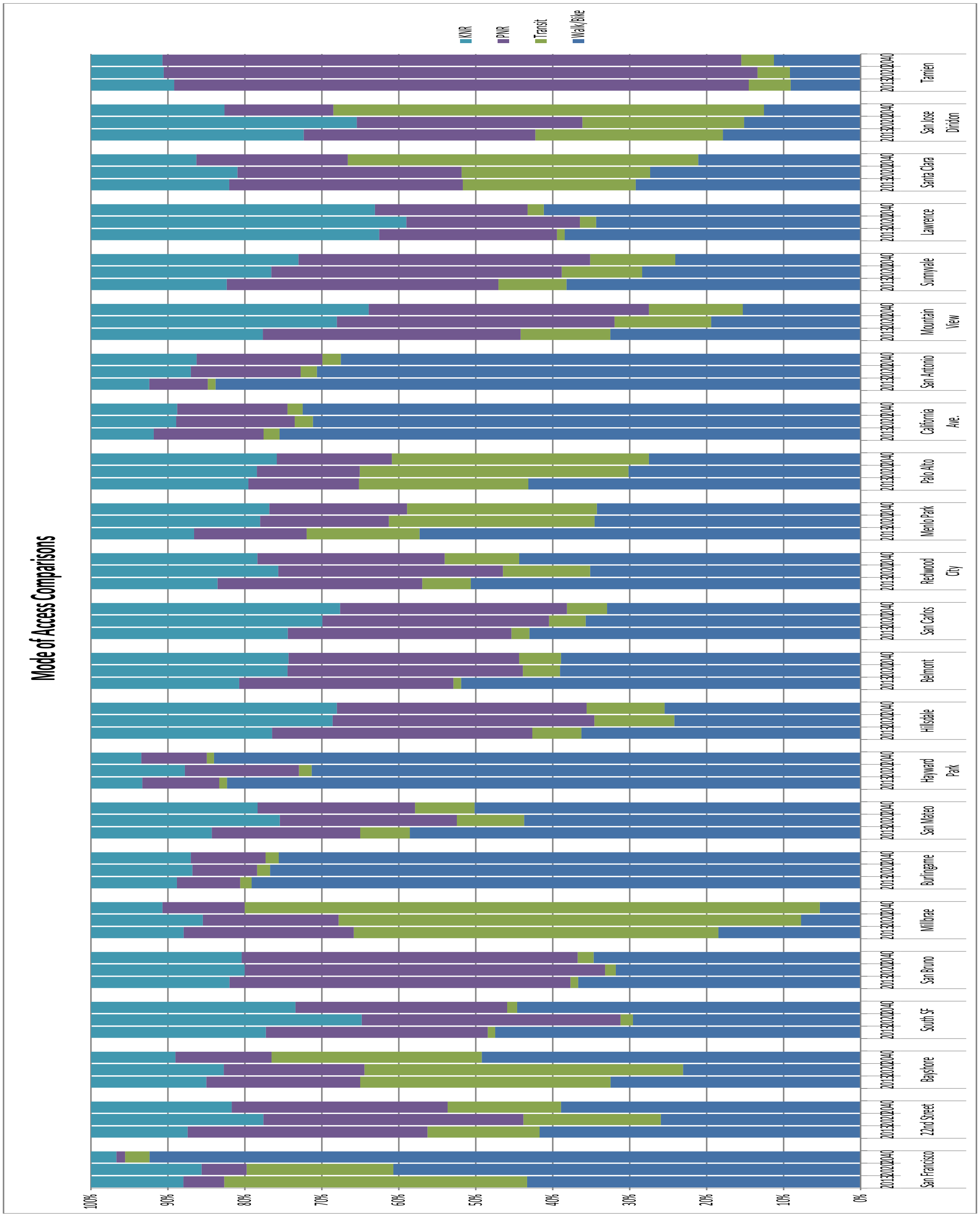


Figure 16. 2020 and 2040 Project Modes of Station Access (AM Peak)



3.3 Station Modes of Egress Forecasts

No Project

Under No Project conditions, station AM peak period egress modes are projected to follow a similar pattern as access modes discussed above. In Figure 17, most stations show a progression toward higher proportions walking and less driving in 2020 and 2040, with transit egress taking over as a dominant mode at BART-service stations by 2040.

PCEP Project

Station egress mode shares under PCEP Project conditions also exhibit this trend. Unlike PCEP Project access modes, which shift toward drive access modes in 2020 before turning toward reduced driving and increased walking in 2040, AM peak egress modes are not as affected by travelers selecting more distant stations with higher service levels. Egress modes steadily progress toward less driving, as a proportion, and AM egress mode shares are less than 18% driving at all stations in all cases and less than 10% at all but six stations.

Figure 17. 2020 and 2040 No Project Modes of Station Egress (AM Peak)

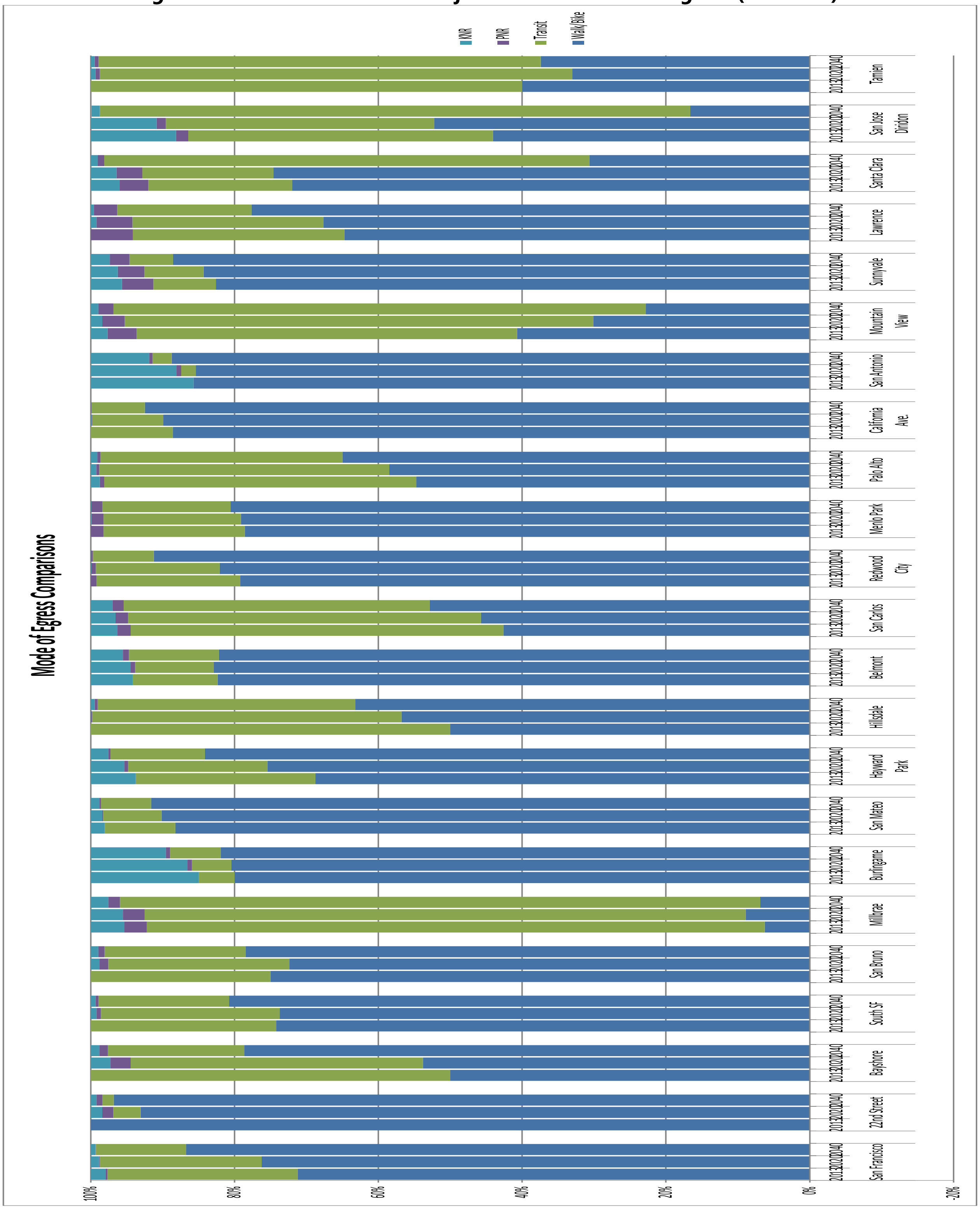
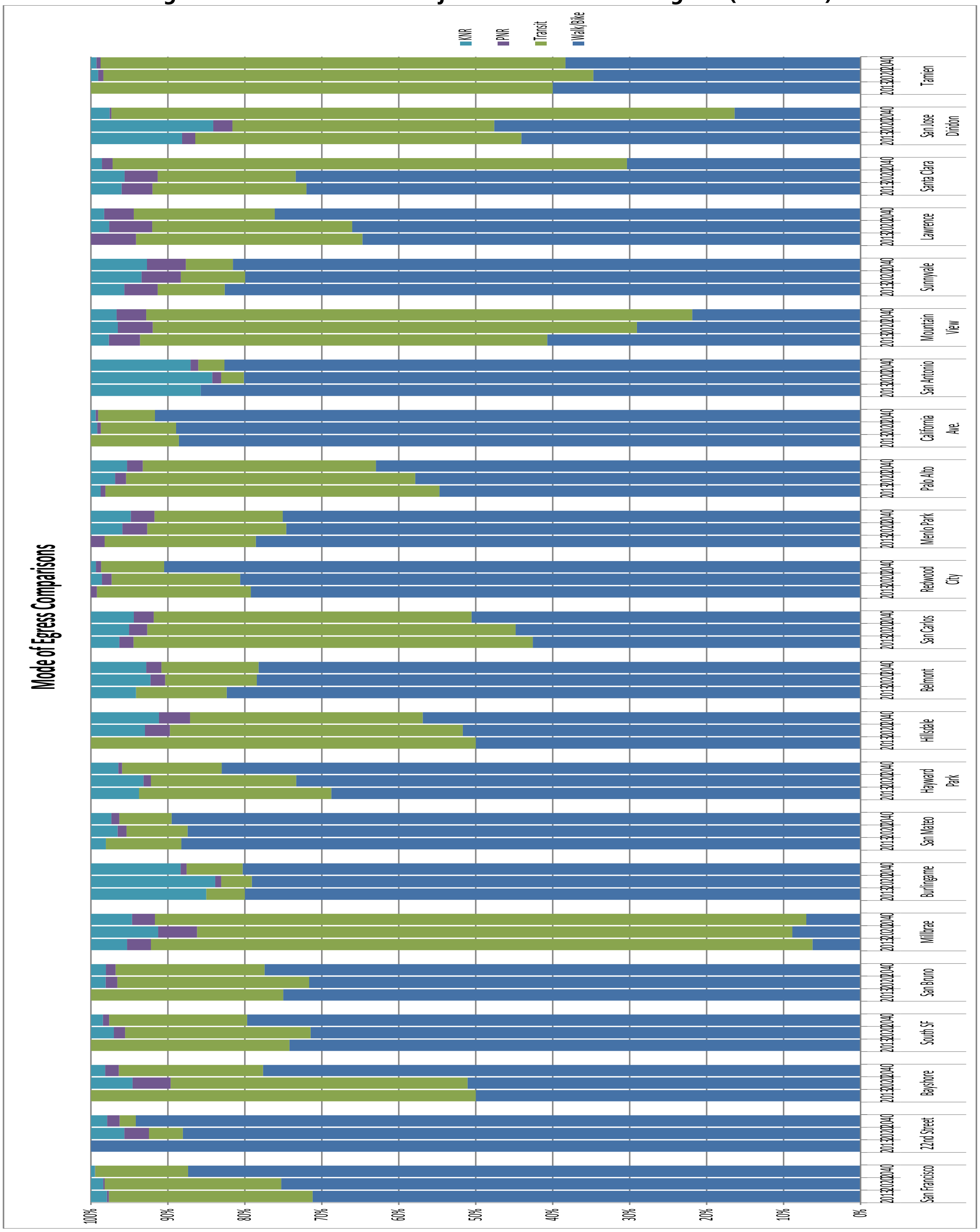


Figure 18. 2020 and 2040 Project Modes of Station Egress (AM Peak)



3.4 Peak Hour Vehicle Access/Egress Demand

The VTA model estimates both daily and peak period ridership per station. The ratio of AM peak period (5-9AM) ridership to daily ridership per station from the VTA model, per scenario, were applied to the calibrated model forecasts for each scenario in order to estimate AM peak period boardings. The same was done for AM peak period alightings. In order to estimate peak hour (8-9AM) boardings the ratio of AM peak hour boardings to AM peak period boardings from 2013 was applied to the AM peak period forecasts per station, per scenario. The same was done for AM peak period alightings. The park and ride (PNR) and kiss and ride (KNR) access mode shares from the AM mode of access model were then applied to the AM peak hour boardings forecasts in order to estimate AM peak hour PNR and KNR arrivals. The park and ride (PNR) and kiss and ride (KNR) egress mode shares from the AM mode of egress model were then applied to the AM peak hour alightings forecasts in order to estimate AM peak hour PNR and KNR departures. An average vehicle occupancy rate of 1.1 was applied to these values in order to forecast vehicle access and egress demand per station and scenario. **Table 18** summarizes the vehicle trips generated by Caltrain PNR and KNR during the AM peak hour (8-9AM) for 2020 No Project and **Table 19** summarizes the values for 2020 Project.

TABLE 18. AM PEAK HOUR VEHICLE TRIPS FOR 2020 NO PROJECT

Station	2020 No Project PNR Arrivals (8-9AM)	2020 No Project PNR Departures (8-9AM)	2020 No Project KNR Vehicles (8-9AM)	2020 No Project Inbound Trips (8-9AM)	2020 No Project Outbound Trips (8-9AM)	2020 No Project Total Trips (8-9AM)
4th & King	57	4	175	232	179	411
22nd Street	156	1	71	227	72	299
Bayshore	11	0	8	19	9	28
South SF	22	0	18	40	18	58
San Bruno	40	0	16	56	17	73
Millbrae	118	17	94	212	111	322
Burlingame	11	1	26	36	26	63
San Mateo	59	0	53	112	53	165
Hayward Park	2	1	7	9	8	17
Hillsdale	193	0	141	334	141	475
Belmont	23	0	18	41	18	58
San Carlos	65	3	66	131	69	201
Redwood City	95	2	62	158	65	222
Menlo Park	30	2	30	60	32	92
Palo Alto	34	8	68	102	76	178
California Ave.	26	0	15	41	16	57
San Antonio	10	0	16	26	16	42
Mountain View	148	38	123	271	161	431
Sunnyvale	284	8	156	440	163	603
Lawrence	25	12	45	70	57	127
Santa Clara	39	6	30	69	36	104
San Jose Diridon	112	10	177	289	187	476
Tamien	254	0	33	287	33	320
Total	**1,814**	**113**	**1,448**	**3,262**	**1,561**	**4,823**

TABLE 19. AM PEAK HOUR VEHICLE TRIPS FOR 2020 PROJECT

Station	2020 Project PNR Arrivals (8-9AM)	2020 Project PNR Departures (8-9AM)	2020 Project KNR Vehicles (8-9AM)	2020 Project Inbound Trips (8-9AM)	2020 Project Outbound Trips (8-9AM)	2020 Project Total Trips (8-9AM)
4th & King	104	7	318	422	325	747
22nd Street	210	4	144	354	148	502
Bayshore	22	1	22	44	23	67
South SF	40	2	45	85	47	132
San Bruno	40	1	18	58	19	77
Millbrae	170	35	201	371	236	607
Broadway	10	0	9	19	9	28
Burlingame	10	0	26	36	26	62
San Mateo	89	2	101	190	103	293
Hayward Park	17	2	28	45	30	75
Hillsdale	254	14	265	519	279	798
Belmont	46	1	40	86	41	127
San Carlos	54	7	70	124	77	201
Redwood City	100	7	91	191	98	289
Atherton	21	0	23	44	23	67
Menlo Park	40	5	58	98	63	161
Palo Alto	59	33	168	227	201	428
California Ave.	34	2	27	61	29	90
San Antonio	25	1	31	56	32	88
Mountain View	191	77	229	420	306	726
Sunnyvale	400	13	264	664	277	941
Lawrence	31	21	66	97	87	184
Santa Clara	64	7	49	113	56	169
San Jose Diridon	164	22	335	499	357	856
Tamien	521	0	64	585	64	649
Total	**2,716**	**264**	**2,692**	**5,408**	**2,956**	**8,364**

Following a similar process, the transit access mode shares from the AM mode of access model were applied to the AM peak hour boardings forecasts in order to estimate the number of Caltrain passengers arriving to each station by transit during the AM peak hour. The transit egress mode shares from the AM mode of egress model were applied to the AM peak hour alightings forecasts in order to estimate the number of Caltrain passengers departing from each station by transit during the AM peak hour. **Table 20** summarizes the transit trips generated by Caltrain arrivals and departures during the AM peak hour (8-9AM) for 2020 No Project and 2020 Project.

TABLE 20. AM PEAK HOUR TRANSIT TRIPS FOR 2020 NO PROJECT AND 2020 PROJECT

Station	2020 No Project Transit Arrivals (8-9AM)	2020 No Project Transit Departures (8-9AM)	2020 No Project Total Transit Trips (8-9AM)	2020 Project Transit Arrivals (8-9AM)	2020 Project Transit Departures (8-9AM)	2020 Project Total Transit Trips (8-9AM)
4th & King	190	968	1158	373	989	1362
22nd Street	82	2	84	122	5	127
Bayshore	26	4	30	56	9	65
South SF	1	16	17	2	28	30
San Bruno	1	9	10	1	10	11
Millbrae	400	523	923	636	592	1228
Broadway	0	0	0	1	3	4
Burlingame	2	5	7	2	3	5
San Mateo	23	15	38	37	17	54
Hayward Park	0	24	24	2	42	44
Hillsdale	59	132	191	85	184	269
Belmont	2	3	5	8	4	12
San Carlos	11	105	116	10	160	170
Redwood City	37	71	108	43	105	148
Atherton	0	0	0	7	1	8
Menlo Park	53	28	81	70	29	99
Palo Alto	105	826	931	169	954	1123
California Ave.	4	43	47	6	40	46
San Antonio	2	1	3	4	2	6
Mountain View	57	863	920	73	1177	1250
Sunnyvale	81	19	100	122	23	145
Lawrence	2	73	75	3	106	109
Santa Clara	35	33	68	59	34	93
San Jose Diridon	76	303	379	129	333	462
Tamien	18	11	29	31	11	42
Total	**1,267**	**4,077**	**5,344**	**2,051**	**4,861**	**6,912**

Table 21 summarizes the vehicle trips generated by Caltrain PNR and KNR during the AM peak hour (8-9AM) for 2040 No Project and Table 22 summarizes the values for 2040 Project.

TABLE 21. AM PEAK HOUR VEHICLE TRIPS FOR 2040 NO PROJECT

Station	2040 No Project PNR Arrivals (8-9AM)	2040 No Project PNR Departures (8-9AM)	2040 No Project KNR Vehicles (8-9AM)	2040 No Project Inbound Trips (8-9AM)	2040 No Project Outbound Trips (8-9AM)	2040 No Project Total Trips (8-9AM)
4th & King	53	0	174	227	174	401
22nd Street	170	1	79	249	80	329
Bayshore	19	0	15	34	15	49
South SF	32	0	27	59	27	86
San Bruno	72	1	29	101	30	131
Millbrae	112	20	85	197	105	302
Burlingame	16	1	33	49	34	83
San Mateo	70	0	62	132	62	194
Hayward Park	5	0	12	17	12	29
Hillsdale	236	0	177	413	177	590
Belmont	32	0	25	57	25	82
San Carlos	79	6	81	160	87	247
Redwood City	117	0	76	193	76	269
Menlo Park	43	2	41	84	43	127
Palo Alto	53	0	102	155	102	257
California Ave.	22	0	13	35	13	48
San Antonio	15	0	18	33	18	51
Mountain View	191	37	152	343	189	532
Sunnyvale	286	11	159	445	170	615
Lawrence	31	11	52	83	63	146
Santa Clara	22	2	15	37	17	54
San Jose Diridon	91	0	97	188	97	285
Tamien	252	0	33	285	33	318
Total	**2,019**	**92**	**1,557**	**3,576**	**1,649**	**5,225**

TABLE 22. AM PEAK HOUR VEHICLE TRIPS FOR 2040 PROJECT

Station	2040 Project PNR Arrivals (8-9AM)	2040 Project PNR Departures (8-9AM)	2040 Project KNR Vehicles (8-9AM)	2040 Project Inbound Trips (8-9AM)	2040 Project Outbound Trips (8-9AM)	2040 Project Total Trips (8-9AM)
4th & King	28	0	120	148	120	268
22nd Street	252	3	168	420	171	591
Bayshore	24	1	22	46	23	69
South SF	48	1	48	96	49	145
San Bruno	82	1	38	120	39	159
Millbrae	232	24	242	474	266	740
Broadway	10	0	8	18	8	26
Burlingame	21	1	46	67	47	114
San Mateo	124	4	143	267	147	414
Hayward Park	8	0	19	27	19	46
Hillsdale	424	32	489	913	521	1434
Belmont	55	1	51	106	52	158
San Carlos	68	12	98	166	110	276
Redwood City	177	8	165	342	173	515
Atherton	33	0	37	70	37	107
Menlo Park	60	7	90	150	97	247
Palo Alto	104	79	365	469	444	913
California Ave.	33	0	30	63	30	93
San Antonio	42	1	46	88	47	135
Mountain View	226	127	319	545	446	991
Sunnyvale	515	24	400	915	424	1339
Lawrence	43	20	91	134	111	245
Santa Clara	28	1	21	49	22	71
San Jose Diridon	192	0	252	444	252	696
Tamien	349	0	43	392	43	435
Total	**3,178**	**347**	**3,351**	**6,529**	**3,698**	**10,227**

Table 23 summarizes the transit trips generated by Caltrain arrivals and departures during the AM peak hour (8-9AM) for 2040 No Project and 2040 Project.

TABLE 23. AM PEAK HOUR TRANSIT TRIPS FOR 2040 NO PROJECT AND 2040 PROJECT

Station	2040 No Project Transit Arrivals (8-9AM)	2040 No Project Transit Departures (8-9AM)	2040 No Project Total Transit Trips (8-9AM)	2040 Project Transit Arrivals (8-9AM)	2040 Project Transit Departures (8-9AM)	2040 Project Total Transit Trips (8-9AM)
4th & King	179	672	851	85	524	609
22nd Street	90	2	92	146	4	150
Bayshore	45	5	50	58	6	64
South SF	1	24	25	2	19	21
San Bruno	3	14	17	4	16	20
Millbrae	766	981	1747	1784	746	2530
Broadway	0	0	0	1	2	3
Burlingame	3	10	13	4	11	15
San Mateo	27	22	49	52	31	83
Hayward Park	1	63	64	1	44	45
Hillsdale	72	170	242	145	263	408
Belmont	5	6	11	11	9	20
San Carlos	14	135	149	13	180	193
Redwood City	45	53	98	77	74	151
Atherton	0	0	0	11	1	12
Menlo Park	65	37	102	91	46	137
Palo Alto	132	1073	1205	255	1305	1560
California Ave.	3	46	49	5	25	30
San Antonio	2	2	4	7	3	10
Mountain View	68	1486	1554	83	2480	2563
Sunnyvale	81	23	104	165	32	197
Lawrence	3	73	76	5	101	106
Santa Clara	54	115	169	71	101	172
San Jose Diridon	353	743	1096	836	755	1591
Tamien	17	7	24	22	15	37
Total	**2,029**	**5,762**	**7,791**	**3,934**	**6,793**	**10,727**

3.5 Peak Parking Accumulation

In order to forecast parking demand, first, forecasts for daily boardings per station per scenario were generated by the calibrated ridership model. The ratio of boardings occurring before noon to daily boardings from 2013 was applied to the daily boardings forecasts in order to get forecasts for boardings occurring before noon by station and scenario. The park and ride access mode share from the AM mode of access model was then applied to the forecasts of boardings occurring before noon in order to forecast the number of Caltrans riders arriving to the station and parking before noon, by station and scenario. An average vehicle occupancy rate of 1.1 was applied to these values in order to forecast vehicle parking demand per station and scenario.

As confirmed by the intercept surveys, not all Caltrain park and riders park in Caltrain lots; some park on-street or in non-Caltrain lots. For most stations, however, the majority of PNR passengers parked in a Caltrain lot. Therefore it was assumed that, generally, PNR demand generated would park in a Caltrain lot if space was available. However, for seven stations (Bayshore, San Bruno, Millbrae, Hayward Park, San Carlos, Menlo Park, and Lawrence) the intercept survey found that at least a third of PNR demand parked on street or in non-Caltrain parking lots. Therefore, for those seven stations, the proportion of PNR demand parking in a Caltrain lot was assumed to be the same as the proportion recorded from the intercept surveys.

Tables 24 –27 summarize the parking demand for 2020 No Project, 2020 Project, 2040 No Project, and 2040 Project, respectively. Caltrain parking lot utilization for each scenario is compared to existing Caltrain parking lot utilization. Parking surplus or deficit of the Caltrain lot is also listed. Parking demand beyond the capacity of the Caltrain lot can be served either on-street or in non-Caltrain lots and garages. The table also lists the excess parking demand, which is the demand beyond the estimated Caltrain lot and on-street parking supply in the station area. The on-street parking supply in the station area was estimated as the number of on-street parking spaces within ¼ mile of the station that are not metered and are not located in residential parking permit areas. This excess parking demand could potentially be served in non-Caltrain parking lots or in on-street spaces further from the station.

Demand for shared BART/Caltrain parking spaces at the Millbrae Station is expected to be proportional to BART and Caltrain ridership increases, which would mean that the occupancy of the BART/Caltrain garage would increase over time due to increased park and ride activity related to each system. Assuming BART and Caltrain parking demand would increase proportional to their forecast increase in ridership, approximately half of the available parking spaces would be utilized by BART riders and half by Caltrain riders. This means that about 320 spaces would be available for each system to accommodate future increases in parking demand. This additional capacity would mean that the shared BART/Caltrain parking facility could absorb expected future increases in parking under Project and No Project scenarios.

Under 2020 No Project conditions, the Caltrain parking lots at the San Mateo, Mountain View, Sunnyvale, San Jose Diridon, and Tamien stations are expected to reach or exceed capacity and the Caltrain parking lot at the Hillsdale station would be parked near capacity. While the 4th and King and 22nd Street stations are expected to generate some PNR demand, these stations do not have Caltrain parking lots. However, at the 22nd Street station it is anticipated that there will be enough on-street parking to accommodate this parking demand. At the 4th and King station it is expected that up to 130 PNR vehicles would be able to park on-street in the immediate station area, but an excess of 35 vehicles would have to find parking elsewhere. Similarly, at the Sunnyvale station it is anticipated that on-street parking spaces in the immediate vicinity of the station would not be sufficient to satisfy overflow parking demand. The overflow parking demand at the Sunnyvale station is approximately 190 vehicles. These vehicles could potentially find parking spaces either in non-Caltrain parking lots and garages or on-street further from the station.

Under 2020 Project conditions, the Caltrain parking lots at the South San Francisco,, San Mateo, Hillsdale, Mountain View, Sunnyvale, San Jose Diridon, and Tamien stations are expected to reach or exceed capacity and the Caltrain parking lot at the Santa Clara station would be parked near capacity. Parking overflow beyond the Caltrain lot capacity and on-street parking near the station is anticipated at the 4th and King, 22nd Street, South San Francisco, Hillsdale, Mountain View, Sunnyvale, and San Jose Diridon stations. In particular, parking overflow at the Sunnyvale and Tamien stations is projected to be more than 400 vehicles each.

Under 2040 No Project conditions, the Caltrain parking lots at the South San Francisco, San Mateo, Hillsdale, Mountain View, Sunnyvale, San Jose Diridon, and Tamien stations are expected to reach or exceed capacity. Parking overflow beyond the Caltrain lot capacity and on-street parking near the station is anticipated at the 4th and King, Mountain View, and Sunnyvale stations.

Under 2040 Project conditions, the Caltrain parking lots at the South San Francisco, Millbrae, Burlingame, San Mateo, Hillsdale, Redwood City, Palo Alto, Mountain View, Sunnyvale, and Tamien stations are expected to reach or exceed capacity. Parking overflow beyond the Caltrain lot capacity and on-street parking near the station is anticipated at the 22nd Street, South San Francisco, Hillsdale, Palo Alto, Mountain View, Sunnyvale, and Tamien stations. In particular, parking overflow at the Hillsdale, Mountain View, and Sunnyvale stations is projected to be more than 400 vehicles each.

TABLE 24. 2020 NO PROJECT PARKING DEMAND

Station	Existing Caltrain Lot Utilization	Existing Caltrain Lot Parking Supply	2020 No Project Parking Demand	2020 No Project Caltrain Lot Utilization	2020 No Project Parking Surplus/ Deficit[1]	2020 No Project Excess Parking Demand[2]
4th and King	-	0	165	-	-165	35
22nd Street	-	0	447	-	-447	0
Bayshore	13%	38	37	13%	1	0
South SF	51%	74	48	65%	26	0
San Bruno	22%	201	118	29%	83	0
Millbrae	79%	170*	331	100%	179*	0
Broadway	8%	122	-	-	-	-
Burlingame	30%	69	37	53%	32	0
San Mateo	20%	42	148	100%	-106	0
Hayward Park	3%	210	10	3%	200	0
Hillsdale	86%	513	449	87%	64	0
Belmont	20%	375	53	14%	322	0
San Carlos	32%	207	158	43%	49	0
Redwood City	46%	553	273	49%	280	0
Atherton	-	96	-	-	-	-
Menlo Park	33%	155	60	19%	95	0
Palo Alto	87%	350	139	40%	211	0
California Ave.	31%	169	48	29%	121	0
San Antonio	33%	193	28	14%	165	0
Mountain View	97%	336	573	100%	-237	0
Sunnyvale	103%	391	643	100%	-252	189
Lawrence	30%	122	79	29%	43	0
Santa Clara	62%	190	125	66%	65	0
San Jose Diridon	99%	576	742	100%	-166	0
Tamien	98%	275	777	100%	-502	0
Total Excess Demand						**224**

1. Parking surplus/deficit beyond Caltrain lot. High parking surplus can be attributed to changes in land use where parking currently exists in some cases
2. Excess Park and Ride demand beyond Caltrain lots and on-street parking
* Includes additional parking available in shared BART-Caltrain parking garage at Millbrae Station.
Source: Fehr & Peers 2013.

TABLE 25. 2020 PROJECT PARKING DEMAND

Station	Existing Caltrain Lot Utilization	Existing Caltrain Lot Parking Supply	2020 Project Parking Demand	2020 Project Caltrain Lot Utilization	2020 Project Parking Surplus/ Deficit[1]	2020 Project Excess Parking Demand[2]
4th and King	-	0	254	-	-254	124
22nd Street	-	0	640	-	-640	18
Bayshore	13%	38	67	24%	-29	0
South SF	51%	74	88	100%	-14	14
San Bruno	22%	201	131	33%	70	0
Millbrae	79%	170*	426	100%	84*	0
Broadway	8%	122	-	29%	-	-
Burlingame	30%	69	35	51%	34	0
San Mateo	20%	42	228	100%	-186	0
Hayward Park	3%	210	45	14%	165	0
Hillsdale	86%	513	642	100%		33
Belmont	20%	375	93	25%	282	0
San Carlos	32%	207	183	50%	24	0
Redwood City	46%	553	379	69%	174	0
Atherton	-	96	28	29%	68	0
Menlo Park	33%	155	75	24%	80	0
Palo Alto	87%	350	200	57%	150	0
California Ave.	31%	169	58	34%	111	0
San Antonio	33%	193	66	34%	127	0
Mountain View	97%	336	828	100%	-492	136
Sunnyvale	103%	391	891	100%	-500	447
Lawrence	30%	122	104	38%	18	0
Santa Clara	62%	190	162	85%	28	0
San Jose Diridon	99%	576	1002	100%	-426	0
Tamien	98%	275	1359	100%	-1084	455
Total Excess Demand						**1,227**

1. Parking surplus/deficit beyond Caltrain lot. High parking surplus can be attributed to changes in land use where parking currently exists in some cases
2. Excess Park and Ride demand beyond non-Caltrain lots and on-street parking
* Includes additional parking available in shared BART-Caltrain parking garage at Millbrae Station.
Source: Fehr & Peers 2013.

TABLE 26. 2040 NO PROJECT PARKING DEMAND

Station	Existing Caltrain Lot Utilization	Existing Caltrain Lot Parking Supply	2040 No Project Parking Demand	2040 No Project Caltrain Lot Utilization	2040 No Project Parking Surplus/ Deficit[1]	2040 No Project Excess Parking Demand[2]
4th and King	-	0	169	-	-169	39
22nd Street	-	0	514	-	-514	0
Bayshore	13%	38	54	19%	-16	0
South SF	51%	74	75	100%	-1	1
San Bruno	22%	201	215	54%	-14	0
Millbrae	79%	170 *	332	100%	178*	0
Broadway	8%	122	-	-	-	-
Burlingame	30%	69	55	79%	14	0
San Mateo	20%	42	190	100%	-148	0
Hayward Park	3%	210	28	9%	182	0
Hillsdale	86%	513	615	100%	-102	0
Belmont	20%	375	82	22%	293	0
San Carlos	32%	207	210	57%	-3	0
Redwood City	46%	553	331	60%	222	0
Atherton	-	96	-	-	-	-
Menlo Park	33%	155	82	27%	73	0
Palo Alto	87%	350	232	66%	118	0
California Ave.	31%	169	52	31%	117	0
San Antonio	33%	193	47	24%	146	0
Mountain View	97%	336	811	100%	-475	119
Sunnyvale	103%	391	750	100%	-359	296
Lawrence	30%	122	105	38%	17	0
Santa Clara	62%	190	33	17%	157	0
San Jose Diridon	99%	576	239	42%	337	0
Tamien	98%	275	853	100%	-578	0
Total Excess Demand						**455**

1. Parking surplus/deficit beyond Caltrain lot. High parking surplus can be attributed to changes in land use where parking currently exists in some cases
2. Excess Park and Ride demand beyond non-Caltrain lots and on-street parking
* Includes additional parking available in shared BART-Caltrain parking garage at Millbrae Station.
Source: Fehr & Peers 2013.

TABLE 27. 2040 PROJECT PARKING DEMAND

Station	Existing Caltrain Lot Utilization	Existing Caltrain Lot Parking Supply	2040 Project Parking Demand	2040 Project Caltrain Lot Utilization	2040 Project Parking Surplus/ Deficit[1]	2040 Project Excess Parking Demand[2]
4th and King	-	0	77	-	-77	0
22nd Street	-	0	779	-	-779	157
Bayshore	13%	38	114	41%	-76	0
South SF	51%	74	113	100%	-39	39
San Bruno	22%	201	304	76%	-103	0
Millbrae	79%	170*	455	100%	55*	0
Broadway	8%	122	35	29%	87	0
Burlingame	30%	69	74	100%	-5	0
San Mateo	20%	42	359	100%	-317	0
Hayward Park	3%	210	37	12%	173	0
Hillsdale	86%	513	1112	100%	-599	503
Belmont	20%	375	135	36%	240	0
San Carlos	32%	207	243	66%	-36	0
Redwood City	46%	553	588	100%	-35	0
Atherton	-	96	44	46%	52	0
Menlo Park	33%	155	118	38%	37	0
Palo Alto	87%	350	393	100%	-43	43
California Ave.	31%	169	59	35%	110	0
San Antonio	33%	193	115	59%	78	0
Mountain View	97%	336	1379	100%	-1043	687
Sunnyvale	103%	391	1291	100%	-900	847
Lawrence	30%	122	143	53%	-21	0
Santa Clara	62%	190	32	17%	158	0
San Jose Diridon	99%	576	380	66%	196	0
Tamien	98%	275	1205	100%	-930	301
Total Excess Demand						**2,577**

1. Parking surplus/deficit beyond Caltrain lot. High parking surplus can be attributed to changes in land use where parking currently exists in some cases
2. Excess Park and Ride demand beyond non-Caltrain lots and on-street parking
* Includes additional parking available in shared BART-Caltrain parking garage at Millbrae Station.
Source: Fehr & Peers 2013.

4.0 Summary Conclusions

4.1 System ridership growth

Population and employment in the Caltrain corridor are projected to grow by about 7% and 13% respectively by 2020. By 2040 both population and employment are projected to exceed 2013 levels by about 28%. Plans and policies favoring transit oriented development are expected to concentrate high proportions of that growth within the vicinity of Caltrain stations by 2040. The growth in population and employment within one half mile of Caltrain stations is projected to be 49% between 2013 and 2040. In addition, increases in corridor congestion and parking and automobile operating costs are expected to shift travel mode choice to greater emphasis on Caltrain. As a result, Caltrain ridership to increase 20% by 2020 and by 76% by 2040 independent of the PCEP project. Daily boardings at Millbrae, Redwood City and Diridon would approximately double as indicated below.

TABLE 28. CALTRAIN RIDERSHIP UNDER NO PROJECT CONDITIONS 2020 AND 2040

Highest Ridership Stations	2013 Existing Ridership	2020 No Project Ridership	2020 Increase Over 2013	2040 No Project Ridership	2040 Increase Over 2013
4th & King	10,786	13,004	21%	16,563	54%
Millbrae	3,255	3,969	22%	6,500	100%
Redwood City	2,619	2,968	13%	5,173	98%
Palo Alto	5,469	6,377	17%	9,821	80%
Mountain View	3,876	4,581	18%	6,696	73%
San Jose Diridon	3,489	4,266	22%	6,642	90%
Total	**46,555**	**55,826**	20%	**81,817**	76%

The Caltrain PCEP service improvements, including extending the line to the San Francisco Transbay Terminal by 2040, would amplify the No Project growth forecasts as shown below. System ridership would be 43% higher in 2020 with PCEP than existing levels. In 2040 with the project, system ridership would be 132% higher than current levels, with Diridon 2040 station ridership more than triple 2013 levels.

TABLE 29. CALTRAIN RIDERSHIP UNDER PCEP PROJECT CONDITIONS 2020 AND 2040

Highest Ridership Stations	2013 Existing Ridership	2020 Project Ridership	2020 Increase Over 2013	2040 Project Ridership	2040 Increase Over 2013
4^{th} & King	10,786	14,335	33%	15,231	41%
Millbrae	3,255	5,129	58%	8,958	175%
Redwood City	2,619	3,177	21%	5,668	116%
Palo Alto	5,469	7,914	45%	13,538	148%
Mountain View	3,876	5,915	53%	9,567	147%
San Jose Diridon	3,489	5,596	60%	10,602	204%
Total	**46,555**	**67,733**	**45%**	**109,590**	**135%**

4.2 Station Access Mode Growth

Systemwide, Caltrain access will become more oriented toward transit, walking and biking by 2020 and 2040. This will be partly a result of direct BART connections at Diridon and Sunnyvale and other transit access improvements such as Transbay Terminal, and a focus of new population and employment in the corridor into transit-oriented development sites near Caltrain. Under No Project conditions, the percentage of access trips arriving by car (whether park-ride or kiss-ride) will progressively decline from 2013 to 2020 and 2040. The same will be true for modes of station egress, with the exception of a few stations in northern San Mateo County where small amounts of drive egress (less than 5% of total riders) will arise due to the patterns of development growth service by the stations.

Under PCEP conditions, however, driving will increase by 2020 as some passengers seek stations that offer the most frequent and/or fastest Caltrain service, even if those stations aren't the closest ones to their points of origination. Station egress will continue to be primarily by transit, shuttles, walking and bicycling; only seven stations will generate more than 10% of their AM peak period egress travel by automobile: Diridon, Sunnyvale, San Antonio, Hillsdale, Burlingame, Millbrae and Bayshore.

4.3 Parking Demand in 2020 and 2040

Due to the region's planned focused growth in transit-oriented development areas the proportion of passengers who drive to Caltrain is expected to decrease at some stations even though ridership in all future scenarios is expected to increase. In 2020 scenarios, parking supply remains the same in both No

Project and Project scenarios and parking demand increases. The increase is greater in the Project scenario due to increased ridership. The majority of parking deficits will be absorbed by on-street parking and and/or non-Caltrain lots where available. Stations with a large parking surplus and high existing utilization, such as Palo Alto, will tend to have more walk, bike or transit access in future scenarios.

The 2020 Project scenario predicts a greater increase in ridership that creates increased parking demand. Seven stations in the Project scenario exceed Caltrain and Non-Caltrain parking supply. The 2040 Project Scenario predicts a greater increase in ridership that contributes to most parking deficits. This ridership increase creates increased parking demand however, at some stations the increased demand is offset by future mode of access changes. Seven stations in the Project scenario exceed Caltrain and Non-Caltrain parking supply, five of which will exceed the supply by more than 100 spaces.

FEHR & PEERS

ATTACHMENT E

Date: November 22, 2013 (Revised September 2014)

To: Caltrain Electrification EIR Project Team

From: Ian Barnes and Matt Haynes, Fehr & Peers

Subject: Existing Conditions VISSIM and SimTraffic Models Calibration and Validation

SJ13-1440

Introduction

Fehr & Peers developed traffic microsimulation models that will be used to analyze the environment impacts of the proposed Caltrain Electrification project. The study area for the microsimulation models included ~~82~~ 90 intersections[1] along the Caltrain line in San Francisco, San Mateo, and Santa Clara Counties. Additional analysis was conducted at eight intersections, resulting in 90 study intersections:

- Intersection # 83 – Broadway / Rollins Road (Burlingame)
- Intersection # 84 – Rollins Road / Cadillac Way (Burlingame)
- Intersection # 85 – Bayswater Avenue/California Drive (Burlingame)
- Intersection # 86 – Encinal Avenue/El Camino Real (Menlo Park)
- Intersection # 87 – Encinal Avenue/Middlefield Road (Atherton)
- Intersection # 88 – Laurel Street /Oak Grove Avenue (Menlo Park)
- Intersection # 89 – Laurel Street/Glenwood Avenue (Menlo Park) - unsignalized
- Intersection # 90 – Laurel Street/Encinal Avenue (Menlo Park) - unsignalized

Most of these intersections (~~64~~ 70) were modeled using the Synchro/SimTraffic software package. The remaining ~~18~~ 20 intersections were modeled using the VISSIM software package which has the ability to account for more complex intersection operations. VISSIM was used at intersections where there are high levels of congestion, frequent transit service, high automobile volumes, high pedestrian or bicycle volumes, or special traffic signal systems (such as transit signal priority).

[1] The intersection of Broadway and US 1010 Southbound Ramps (#84a) in Burlingame was added to the list of intersections as a result of the US 101/Broadway Interchange Reconstruction project, however this intersection does not exist under Existing Conditions, bringing the total number of intersections modeled for future conditions to 91. Intersection 84a was analyzed using the VISSIM software package.

Table 1 lists the study intersections, the jurisdiction the intersection is located in and the analysis software package.

The remainder of this memorandum describes the development of the microsimulation models for existing conditions, including the model calibration and validation processes. The model development process includes three basic components: (1) network coding, (2) model calibration and (3) model validation. This memorandum also summarizes key existing conditions analysis results produced by the model.

TABLE 1
STUDY INTERSECTIONS

Int. ID	Intersection	Jurisdiction[1]	Modeling Tool
1	4th Street/King Street	SF	VISSIM
2	4th Street/Townsend Street	SF	VISSIM
3	Mission Bay Drive/7th Street	SF	SimTraffic
4	Mission Bay Drive/Berry Street	SF	SimTraffic
5	7th Street/16th Street	SF	VISSIM
6	16th Street/Owens Street	SF	VISSIM
7	22nd Street/Pennsylvania Street	SF	SimTraffic
8	22nd Street/Indiana Street	SF	SimTraffic
9	Tunnel Avenue/Blanken Avenue	SF	SimTraffic
10	Linden Ave/ Dollar Avenue	SSF	SimTraffic
11	East Grand Avenue/Dubuque Way	SSF	SimTraffic
12	S Linden Avenue/San Mateo Avenue	SSF	SimTraffic
13	Scott Street/Herman Street	SB	SimTraffic
14	Scott Street/Montgomery Avenue	SB	SimTraffic
15	San Mateo Ave/San Bruno Avenue East	SB	SimTraffic
16	El Camino Real/Millbrae Avenue	MB	SimTraffic
17	Millbrae Avenue/Rollins Road	MB	SimTraffic
18	California Drive/Broadway	BG	VISSIM
19	Carolan Avenue/Broadway	BG	VISSIM
20	California Drive/Oak Grove Avenue	BG	SimTraffic
21	Carolan Avenue/Oak Grove Avenue	BG	SimTraffic

TABLE 1
STUDY INTERSECTIONS

Int. ID	Intersection	Jurisdiction[1]	Modeling Tool
22	California Drive/North Lane	BG	SimTraffic
23	Carolan Avenue/North Lane	BG	SimTraffic
24	Anita Road/Peninsula Avenue	BG	SimTraffic
25	Woodside Way/Villa Terrace	SM	SimTraffic
26	North San Mateo Drive/Villa Terrace	SM	SimTraffic
27	Railroad Avenue/1st Avenue	SM	SimTraffic
28	S B St and 1st Ave	SM	SimTraffic
29	9th Ave and S Railroad Ave	SM	SimTraffic
30	S B St and 9th Ave	SM	SimTraffic
31	Transit Center Wy and 1st Ave	SM	SimTraffic
32	Concar Dr and SR 92 WB Ramps	SM	SimTraffic
33	S Delaware St and E 25th Ave	SM	SimTraffic
34	E 25th Ave and El Camino Real	SM	SimTraffic
35	31st Ave and El Camino Real	SM	SimTraffic
36	E Hillsdale Blvd and El Camino Real	SM	SimTraffic
37	E Hillsdale Blvd and Curtiss St	SM	SimTraffic
38	Peninsula Avenue/Arundel Rd/Woodside Wy	SM	SimTraffic
39	El Camino Real and Ralston Ave	BL	SimTraffic
40	El Camino Real and San Carlos Ave	SC	SimTraffic
41	Maple Street/Main Street	RC	SimTraffic
42	Main Street/Beech Street	RC	SimTraffic

TABLE 1
STUDY INTERSECTIONS

Int. ID	Intersection	Jurisdiction[1]	Modeling Tool
43	Main Street/Middlefield Road	RC	SimTraffic
44	Broadway and California	RC	SimTraffic
45	El Camino Real and Whipple Ave	RC	VISSIM
46	Arguello St and Brewster Ave	RC	SimTraffic
47	El Camino Real and Broadway	RC	SimTraffic
48	Arguello St and Marshall St	RC	SimTraffic
49	El Camino Real and James Ave	RC	SimTraffic
50	El Camino Real and Fair Oaks Ln	AT	SimTraffic
51	El Camino Real and Watkins Ave	AT	SimTraffic
52	Fair Oaks Lane/Middlefield Road	AT	SimTraffic
53	Watkins Avenue/Middlefield Road	AT	SimTraffic
54	Glenwood Avenue/Middlefield Road	AT	SimTraffic
55	El Camino Real and Glenwood Ave	MP	SimTraffic
56	El Camino Real and Oak Grove Ave	MP	SimTraffic
57	El Camino Real and Santa Cruz Ave	MP	SimTraffic
58	Merrill St and Santa Cruz Ave	MP	SimTraffic
59	Ravenswood Ave/Alma St	MP	VISSIM
60	El Camino Real and Ravenswood Ave	MP	VISSIM
61	Ravenswood Avenue/Laurel Street	MP	SimTraffic
62	Alma Street/Palo Alto Avenue	PA	VISSIM
63	Meadow Drive/Alma Street	PA	VISSIM

TABLE 1
STUDY INTERSECTIONS

Int. ID	Intersection	Jurisdiction[1]	Modeling Tool
64	El Camino Real/Alma/Sand Hill Road	PA	VISSIM
65	High St and University Ave	PA	SimTraffic
66	Alma St and Churchill Ave	PA	VISSIM
67	W Meadow Dr and Park Blvd	PA	VISSIM
68	Alma St and Charleston Rd	PA	VISSIM
69	Showers Dr And Pacchetti Way	MV	SimTraffic
70	Central Expressway and N Rengstorff Ave	MV	VISSIM
71	Central Expressway and Moffett/Castro	MV	VISSIM
72	W Evelyn Ave and Hope St	MV	SimTraffic
73	Rengstorff Avenue/California Street	MV	SimTraffic
74	Castro Street/Villa Street	MV	SimTraffic
75	W Evelyn Ave and S Mary Ave	SV	VISSIM
76	W Evelyn Ave and Frances St	SV	SimTraffic
77	Kifer Rd and Lawrence Expressway	SCC	SimTraffic
78	Reed Ave-Monroe St and Lawrence Expy	SCC	SimTraffic
79	El Camino Real and Railroad Ave	SC	SimTraffic
80	W Santa Clara St and Cahill St	SJ	SimTraffic
81	S Montgomery St and W San Fernando St	SJ	SimTraffic
82	Lick Ave and W Alma Ave	SJ	SimTraffic
83	Broadway / Rollins Road	BL	VISSIM
84	Rollins Road / Cadillac Way	BL	VISSIM

TABLE 1
STUDY INTERSECTIONS

Int. ID	Intersection	Jurisdiction[1]	Modeling Tool
85	Bayswater Avenue/California Drive	BL	SimTraffic
86	Encinal Avenue/El Camino Real	MP	SimTraffic
87	Encinal Avenue/Middlefield Road	AT	SimTraffic
88	Laurel Street /Oak Grove Avenue	MP	SimTraffic
89	Laurel Street/Glenwood Avenue	MP	SimTraffic
90	Laurel Street / Encinal Avenue	MP	SimTraffic

Notes:
1. Jurisdictions:

SF	San Francisco	SM	San Mateo	MV	Mountain View
SSF	South San Francisco	BL	Belmont	SV	Sunnyvale
SB	San Bruno	SC	San Carlos	SC	Santa Clara
MB	Millbrae	RC	Redwood City	SCC	Santa Clara County
BG	Burlingame	AT	Atherton	SJ	San Jose
MP	Menlo Park	PA	Palo Alto		

Source: Fehr & Peers, November 2013 (Updated September 2014) (TIA)

Note: This Table replaces Table 1 from Attachment E to the Draft EIR

Model Development Process

The VISSIM and SimTraffic models were constructed by digitizing the roadway networks using aerial photography as the background. The number of lanes and the location of lane additions, turn pockets and lane drops were confirmed by field observations. Additional detail, such as speed limits and vehicle turning speeds, was incorporated into the networks to better reflect observed field conditions. At signalized intersections, traffic signal timing plans (i.e., phasings, green times, transit signal priority, railroad preemption, etc.) were entered into the Synchro/SimTraffic and VISSIM models to reflect current conditions.

The SimTraffic and VISSIM models were validated to existing conditions using criteria suggested by the California Department of Transportation (Caltrans), the Federal Highway Administration (FHWA), and additional criteria developed by Fehr & Peers. A number of iterations were required to successively adjust the default SimTraffic and VISSIM parameters for geometrics and driver behavior until the model was validated to observed conditions. Validation criteria and results are presented later in this memorandum.

Once the model was successfully calibrated and validated, it was used to generate measures of corridor performance such as vehicle and transit average speeds, vehicle hours of delay and other performance measures consistent with the Highway Capacity Manual (HCM) (Transportation Research Board, 2000) such as intersection delay and level of service.

Because micro-simulation models like SimTraffic and VISSIM rely on the random arrival of vehicles, multiple runs are needed to provide a reasonable level of statistical accuracy and validity. The models were run twenty times (each using a different random seed number), and then the ten most typical runs were selected and averaged to determine model results. The selection of ten typical runs is designed to remove outliers from the process.

Model Network Coding

Development of the street network and automobiles, trains, bicyclists, and pedestrians that comprise the SimTraffic and VISSIM models required the input of geometric, traffic control and traffic flow data, each of which is described in this section. An overview of the micro-simulation model development process is described below.

Geometric Data

Roadway geometric data (traffic lanes, turn pockets, bus lanes, bus stop locations, etc.) were gathered using aerial photographs and field observations. Lane configurations were initially taken from aerial photographs and were then confirmed or revised based on field observations.

Traffic Control Data

Various City and County agencies provided signal timing plans for the traffic signals in the study area. The signal timing settings include vehicle and pedestrian signal phases and railroad preemption for several intersections. The posted speed limits for streets in the study area were collected during field observations. Maximum vehicle speeds in the model are consistent with posted speed limits, although random speed variability is assigned to each vehicle, causing them to drive above or below the speed limit, to mimic prevailing driver behavior.

Traffic Flow Data

Vehicle Volumes

Fehr & Peers collected or was provided with intersection AM peak period (7:00 to 9:00 AM) and PM peak period (4:00 to 6:00 PM) vehicular turning movement counts at the study intersections. For each model file, the peak one hour of flow in the AM and PM were used as the analysis period. The volumes from this data were then balanced between intersections using the Synchro program. Balancing is the adjustment of turning movement volumes to reduce unexpected changes in through-volumes between adjacent intersections. Where balancing was performed, the volumes were balanced to the higher volume to provide for a conservative analysis.

For Intersections #83 through 90, volumes were developed using counts from July 2014. In order to account for seasonal variations in traffic volumes, counts were also conducted at the intersections of Broadway/California Drive and El Camino Real/Glenwood Avenue in July 2014. These data were used to develop factors for adjusting the July 2014 counts for the additional intersections. Generally, summer volumes are lower than volumes throughout the remainder of the year, so the factors developed as part of this process factored the July 2014 volumes higher. A seasonal adjustment factor between 102 and 109 percent was applied, depending on the location.

Pedestrian and Bicycle Volumes

For VISSIM models, pedestrian and bicycle volumes were directly modeled through use of pedestrian crossing counts and bicycle turning movement counts. For SimTraffic models, pedestrian counts were used where available; in situations where counts were not available, pedestrian crossing volumes were assumed to range from 10-50 pedestrians per hour, depending on proximity to major pedestrian travel generators (Caltrain stations, schools, etc.).

Transit Data

For VISSIM intersections, railroad crossing preemption and gate down events were triggered using data from the Caltrain schedule. For SimTraffic intersections, railroad crossing preemption and gate down events were triggered using random arrivals that approximate the train schedule.

Because of high bus frequencies and interactions between buses, automobiles, pedestrians and bikes, the VISSIM model covering the intersections of 4th Street/King Street and 4th Street/Townsend Street in San Francisco was coded with MUNI bus schedule data for the 10 Townsend, 30 Stockton, 45 Union-Stockton, and 47 Van Ness lines were input into the model to reflect the frequent bus movements near the San Francisco-4th Street Caltrain station. Additionally, transit frequencies for the N-Judah and T-Third light rail transit lines were input into the model to reflect at-grade rail movements through the 4th Street/King Street intersection.

Model Calibration

During calibration of a microsimulation model, individual components are adjusted to match collected and field-observed data. Once developed, calibration of a model is necessary to ensure that the model provides a visually accurate depiction of the field-observed condition and that model outputs can be trusted to inform the best possible analysis.

Adjustments to the SimTraffic and VISSIM models focus on the model components related to driver behavior including yielding right-of-way at intersections, driver performance such as aggressiveness, vehicle fleet mix, and vehicle performance. The following SimTraffic and VISSIM model parameters are subject to adjustment:

- Vehicle fleet composition (passenger cars, pickup trucks, SUVs, heavy trucks, etc.)
- Vehicle headways
- Distance between stopped vehicles (standstill distance)
- Driver behavior when changing lanes

Generally speaking, only the lane change behavior was modified to better reflect real world lane changing conditions. This involves changing setting such that vehicles start to make lane changes earlier than the default distance (approximately 650 feet). For congested conditions where late lane changes were the primary cause of congestion developing, the lane change distance was set to 1,500 feet per lane change required.

As an additional calibration step, driver yield behavior to pedestrians at right turn locations was calibrated in the VISSIM models to match observed conditions. Fleet composition, vehicle headways and standstill distance were not changed for calibration of all models.

Model Validation

During validation, the VISSIM model output is compared against field data to determine if the output is within acceptable levels. Caltrans and the FHWA suggest the following validation criteria: (*Guidelines for Applying Traffic Microsimulation Modeling Software*, California Department of Transportation, 2002; *Volume III - Guidelines for Applying Traffic Microsimulation Modeling Software*, Federal Highway Administration, 2003).

- Link volumes for more than 85 percent of cases meet the following criteria:
  - For volumes less than 700 vph, within 100 vph
  - For volumes between 700 and 2,700 vph, within 15 percent
  - For volumes greater than 2,700 vph, within 400 vph
- Link volumes for more than 85 percent of cases have a GEH[2] statistic less than 5 (a measure of how well the model replicates actual conditions)
- Sum of link volumes within 5 percent
- Sum of link volumes have a GEH statistic less than 4

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[2] GEH, which received its name from its inventor Geoffrey E. Havers, is a validation statistic that is used to interpret the correlation of two sets of traffic volumes. With respect to the validation of traffic model, the two volumes present in the GEH computation formulae are observed traffic volumes and model estimated traffic volumes.

- Average travel times within 15 percent (or one minute, if higher) of measured/reported travel times, for more than 85 percent of measured travel time paths
- Bottlenecks create visually acceptable queuing and agree with observed conditions

Fehr & Peers has developed the following additional validation criterion, which has a narrower tolerance for intersection volumes (which are aggregated link volumes) than the criteria suggested by FHWA and Caltrans.

- Peak-hour volumes for more than 85 percent of intersections within 5 percent of traffic counts

Given the isolated nature of the models, a goal was set to meet 100% of the targets (beyond the requirements of FHWA and Caltrans). **Table 2** shows how the results for the existing conditions SimTraffic and VISSIM models compare to the validation criteria thresholds recommended in the FHWA and Caltrans guidelines and intersection volume validation developed by Fehr & Peers. The results reflect the average of 10 of 20 micro-simulation model runs.

TABLE 2
VALIDATION CRITERIA THRESHOLDS COMPARISON

Criteria	Criteria Threshold	FHWA/ Caltrans Target for % Met	% Met	Pass/Fail
Link Volumes				
< 700 vph	100 vph	> 85%	100%	Pass
between 700 & 2,700 vph	15%			
> 2,700 vph	400 vph			
GEH Statistic	< 5.00	> 85%	100%	Pass
Sum of Link Volumes				
Sum of All Links	+/- 5%	-	100%	Pass
GEH Statistic	< 4.00	-	100%	Pass
Aggregated Volumes				
Intersections[1]	+/- 5%	>85%	100%	Pass
Visual Inspection				
Queuing	match observations		-	Pass

Notes: **Bold** and underline font indicates that the criteria are not met.
1. Fehr & Peers developed criterion.

Source: Fehr & Peers, 2013

Existing Conditions Results

Traffic operations results were determined using the validated AM and PM peak hour VISSIM and SimTraffic models. The intersection analysis results include a descriptive term known as level of service (LOS). LOS is a measure of traffic operating conditions, which varies from LOS A, which represents free flow conditions, with little or no delay, to LOS F, which represents congested conditions, with extremely long delays. **Table 3** below gives the LOS designations for signalized intersections, and **Table 4** gives the LOS designations for unsignalized intersections.

TABLE 3
SIGNALIZED INTERSECTION LEVEL OF SERVICE DEFINITIONS

Level of Service	Description	Average Control Delay Per Vehicle (Seconds)
A	Operations with very low delay occurring with favorable progression and/or short cycle lengths.	≤ 10.0
B	Operations with low delay occurring with good progression and/or short cycle lengths.	10.1 – 20.0
C	Operations with average delays resulting from fair progression and/or longer cycle lengths. Individual cycle failures begin to appear.	20.1 – 35.0
D	Operations with longer delays due to a combination of unfavorable progression, long cycle lengths, and high volume-to-capacity (V/C) ratios. Many vehicles stop and individual cycle failures are noticeable.	35.1 – 55.0
E	Operations with high delay values indicating poor progression, long cycle lengths, and high V/C ratios. Individual cycle failures are frequent occurrences.	55.1 – 80.0
F	Operations with delays unacceptable to most drivers occurring due to over-saturation, poor progression, or very long cycle lengths.	> 80.0

Source: *2010 Highway Capacity Manual* and Fehr & Peers, November 2013

TABLE 4
UNSIGNALIZED INTERSECTION LEVEL OF SERVICE DEFINITIONS

Level of Service	Description	Average Control Delay Per Vehicle on Worst Approach (Seconds)
A	Little or no delays	≤ 10.0
B	Short traffic delays	10.1 – 15.0
C	Average traffic delays	15.1 – 25.0
D	Long traffic delays	25.1 – 35.0
E	Very long traffic delays	35.1 – 50.0
F	Extreme traffic delays with intersection capacity exceeded	> 50.0

Source: *2010 Highway Capacity Manual* and Fehr & Peers, November 2013

For signalized intersections, delay and LOS are calculated for the whole intersection average. For unsignalized, side-street stop-controlled intersections, the delay and LOS are calculated for the average of the worst approach. For all-way stop-controlled intersections, the delay and LOS are calculated for the whole intersection average. For intersection analysis purposes, these results are compared to a LOS standard for the intersection. **Table 5** lists the intersections, software analysis package, LOS standard and calculated delay and LOS for existing conditions.

TABLE 5
EXISTING INTERSECTION DELAY AND LEVELS OF SERVICE (2013)

Int. ID	Intersection	Jurisdiction	Peak Hour	Intersection Control	Delay	LOS
			ZONE 1			
1	4th Street and King Street	SF	AM PM	Signal	56.6 84.5	E F
2	4th Street and Townsend Street	SF	AM PM	Signal	28.9 28.8	C C
3	Mission Bay Drive and 7th Street	SF	AM PM	Signal	8.3 12.7	A B
4	Mission Bay Drive and Berry Street	SF	AM PM	Signal	2.3 8.4	A A
5	7th Street and 16th Street	SF	AM PM	Signal	67.3 49.5	E D
6	16th Street and Owens Street	SF	AM PM	Signal	10.6 10.7	B B
7	22nd Street and Pennsylvania Street	SF	AM PM	All-way Stop	7.6 7.3	A A
8	22nd Street and Indiana Street	SF	AM PM	All-way Stop	5.3 5.4	A A
9	Tunnel Avenue and Blanken Avenue	SF	AM PM	All-way Stop	7.9 7.2	A A
10	Linden Avenue and Dollar Avenue	SSF	AM PM	Signal	15.1 48.9	B D
11	East Grand Avenue and Dubuque Way	SSF	AM PM	Signal	7.5 7.5	A A
12	S Linden Avenue and San Mateo Avenue	SSF	AM PM	Signal	6.7 7.4	A A
13	Scott Street and Herman Street	SB	AM PM	Side-Street Stop	9.8 14.0	A B
14	Scott Street and Montgomery Avenue	SB	AM PM	Side-Street Stop	4.8 5.7	A A
15	San Mateo Avenue and San Bruno Avenue	SB	AM PM	Signal	10.9 >120	B F
			ZONE 2			
16	El Camino Real and Millbrae Avenue	MB	AM PM	Signal	43.4 42.7	D D
17	Millbrae Avenue and Rollins Road	MB	AM PM	Signal	33.0 38.8	C D
18	California Drive and Broadway	BG	AM PM	Signal	80.5 58.7	F E
19	Carolan Avenue and Broadway	BG	AM PM	Signal	16.6 42.1	B D
20	California Drive and Oak Grove Avenue	BG	AM PM	Signal	34.3 24.2	C C
21	Carolan Avenue and Oak Grove Avenue	BG	AM PM	Side-Street Stop	>120 92.1	F F

TABLE 5
EXISTING INTERSECTION DELAY AND LEVELS OF SERVICE (2013)

Int. ID	Intersection	Jurisdiction	Peak Hour	Intersection Control	Delay	LOS
22	California Drive and North Lane	BG	AM PM	Side-Street Stop	14.7 11.4	B B
23	Carolan Avenue and North Lane	BG	AM PM	Side-Street Stop	23.0 17.8	C C
24	Anita Road and Peninsula Avenue	BG	AM PM	Side-Street Stop	15.6 >120	C F
25	Woodside Way and Villa Terrace	SM	AM PM	Side-Street Stop	5.1 4.7	A A
26	North San Mateo Drive and Villa Terrace	SM	AM PM	Side-Street Stop	11.7 12.8	B B
27	Railroad Avenue and 1st Avenue	SM	AM PM	Side-Street Stop	10.4 19.0	B C
28	S B Street and 1st Avenue	SM	AM PM	Signal	22.6 30.5	C C
29	9th Avenue and S Railroad Avenue	SM	AM PM	Side-Street Stop	34.7 21.4	D C
30	S B Street and 9th Avenue	SM	AM PM	Signal	15.0 14.4	B B
31	Transit Center Way and 1st Avenue	SM	AM PM	Uncontrolled	5.1 26.7	A D
32	Concar Drive and SR 92 Westbound Ramps	SM	AM PM	Signal	6.0 6.1	A A
33	S Delaware Street and E 25th Avenue	SM	AM PM	Signal	19.1 20.6	B C
34	E 25th Avenue and El Camino Real	SM	AM PM	Signal	32.0 80.6	C F
35	31st Avenue and El Camino Real	SM	AM PM	Signal	19.2 68.7	B E
36	E Hillsdale Boulevard and El Camino Real	SM	AM PM	Signal	43.7 67.1	D E
37	E Hillsdale Blvd. and Curtiss Street	SM	AM PM	Signal	12.0 14.7	B B
38	Peninsula Avenue and Arundel Road and Woodside Way	SM	AM PM	Side-Street Stop	14.3 >120	B F
39	El Camino Real and Ralston Avenue	BL	AM PM	Signal	>120 85.4	F F
40	El Camino Real and San Carlos Avenue	SC	AM PM	Signal	25.6 47.1	C D
41	Maple Street and Main Street	RC	AM PM	Side-Street Stop	10.9 14.3	B B
42	Main Street and Beech Street	RC	AM PM	Side-Street Stop	5.2 8.6	A A
43	Main Street and Middlefield Road	RC	AM PM	Signal	12.5 20.1	B C

TABLE 5
EXISTING INTERSECTION DELAY AND LEVELS OF SERVICE (2013)

Int. ID	Intersection	Jurisdiction	Peak Hour	Intersection Control	Delay	LOS
44	Broadway Street and California Street	RC	AM PM	Signal	60.0 >120	F F
45	El Camino Real and Whipple Avenue	RC	AM PM	Signal	74.7 48.3	E D
46	Arguello Street and Brewster Avenue	RC	AM PM	Signal	14.7 39.4	B D
47	El Camino Real and Broadway Street	RC	AM PM	Signal	27.5 45.5	C D
48	Arguello Street and Marshall Street	RC	AM PM	Signal	15.1 48.7	B D
49	El Camino Real and James Avenue	RC	AM PM	Signal	26.2 33.7	C C
	ZONE 3					
50	El Camino Real and Fair Oaks Lane	AT	AM PM	Signal	33.6 27.6	C C
51	El Camino Real and Watkins Avenue	AT	AM PM	Side-street stop	34.5 48.1	D E
52	Fair Oaks Lane and Middlefield Road	AT	AM PM	Side-Street Stop	>120 41.3	F E
53	Watkins Avenue and Middlefield Road	AT	AM PM	Side-Street Stop	31.6 28.3	D D
54	Glenwood Avenue and Middlefield Road	AT	AM PM	Side-Street Stop	49.2 >120	E F
55	El Camino Real and Glenwood Avenue	MP	AM PM	Signal	34.1 29.6	C C
56	El Camino Real and Oak Grove Avenue	MP	AM PM	Signal	17.9 30.9	B C
57	El Camino Real and Santa Cruz Avenue	MP	AM PM	Signal	9.1 12.5	A B
58	Merrill St and Santa Cruz Avenue	MP	AM PM	All-way Stop	7.3 8.9	A A
59	Ravenswood Avenue and Alma Street	MP	AM PM	Side-Street Stop	24.4 17.1	C C
60	El Camino Real and Ravenswood Avenue	MP	AM PM	Signal	39.3 119.0	D F
61	Ravenswood Avenue and Laurel Street	MP	AM PM	Signal	31.0 26.3	C C
62	Alma Street and Palo Alto Avenue	PA	AM PM	Side-Street Stop	11.2 14.6	B B
63	Meadow Drive and Alma Street	PA	AM PM	Signal	72.6 62.0	E E
64	El Camino Real and Alma Street and Sand Hill Road	PA	AM PM	Signal	60.7 49.1	E D
65	High Street and University Avenue	PA	AM PM	Signal	12.6 14.1	B B

TABLE 5
EXISTING INTERSECTION DELAY AND LEVELS OF SERVICE (2013)

Int. ID	Intersection	Jurisdiction	Peak Hour	Intersection Control	Delay	LOS
66	Alma Street and Churchill Avenue	PA	AM PM	Signal	66.0 64.0	E E
67	W Meadow Drive and Park Blvd.	PA	AM PM	Side-Street Stop	>120 29.3	F D
68	Alma Street and Charleston Road	PA	AM PM	Signal	63.5 80.5	E F
69	Showers Drive and Pacchetti Way	MV	AM PM	Signal	4.5 3.7	A A
70	Central Expressway and N Rengstorff Avenue	SCC	AM PM	Signal	75.5 90.9	E F
71	Central Expressway and Moffett Boulevard and Castro Street	SCC	AM PM	Signal	76.3 66.5	E E
72	W Evelyn Avenue and Hope Street	MV	AM PM	Signal	3.0 4.0	A A
73	Rengstorff Avenue and California Street	MV	AM PM	Signal	50.3 55.6	D E
74	Castro Street and Villa Street	MV	AM PM	Signal	11.8 21.2	B C
75	W Evelyn Avenue and S Mary Avenue	SV	AM PM	Signal	62.4 61.5	E E
76	W Evelyn Avenue and Frances Street	SV	AM PM	Signal	16.1 23.4	B C
			ZONE 4			
77	Kifer Road and Lawrence Expressway	SCC	AM PM	Signal	96.6 >120	F F
78	Reed Avenue and Lawrence Expressway	SCC	AM PM	Signal	97.3 93.7	F F
79	El Camino Real and Railroad Avenue	SCL	AM PM	Signal	26.6 21.3	C C
80	W Santa Clara Street and Cahill Street	SJ	AM PM	Signal	10.4 12.7	B B
81	S Montgomery Street and W San Fernando Street	SJ	AM PM	Signal	7.9 9.6	A A
82	Lick Avenue and W Alma Avenue	SJ	AM PM	Signal	15.8 20.8	B C
83	Broadway and Rollins Road	BG	AM PM	Signal	46.2 95.6	D F
84	Rollins Road and Cadillac Way	BG	AM PM	Signal	89.1 48.3	F D
85	Bayswater Avenue and California Drive	BG	AM PM	Signal	9.1 8.7	A A
86	Encinal Avenue and El Camino Real	MP	AM PM	Signal	25.5 30.9	C C

TABLE 5
EXISTING INTERSECTION DELAY AND LEVELS OF SERVICE (2013)

Int. ID	Intersection	Jurisdiction	Peak Hour	Intersection Control	Delay	LOS
87	Encinal Avenue and Middlefield Road	AT	AM PM	Signal	19.3 12.7	B B
88	Laurel Street and Oak Grove Avenue	MP	AM PM	Signal	9.7 8.6	A A
89	Laurel Street and Glenwood Avenue	MP	AM PM	All-way Stop	6.6 5.9	A A
90	Laurel Street and Encinal Avenue	MP	AM PM	All-way Stop	5.7 9.5	A A

Notes:
1. Jurisdictions:
SF San Francisco
SSF South San Francisco
SB San Bruno
MB Millbrae
BG Burlingame
SM San Mateo
BL Belmont
SC San Carlos
RC Redwood City
AT Atherton
MP Menlo Park
PA Palo Alto
MV Mountain View
SV Sunnyvale
SCL Santa Clara
SCC Santa Clara County
SJ San Jose

LOS designation per *2010 Highway Capacity Manual*

Source: Fehr & Peers, 2013 (Updated September 2014)

Note: This Table replaces Table 5 from Attachment E the Draft EIR (TIA)

AM = morning peak hour, PM = afternoon peak hour
LOS designation as per 2010 Highway Capacity Manual

Delay measured in seconds.

These results are incorporated into the EIR for the Proposed Project. The resulting Existing Conditions models will be used as the basis for the Year 2020 and Year 2040 scenarios for No Project and Project conditions.