BUSINESS PLAN TECHNICAL MEMORANDA

A supplement to the Caltrain Business Plan
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Caltrain

Service Planning Memo

Prepared for:

Caltrain

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1. INTRODUCTION

1.1 PURPOSE

This memo describes the service planning methodology for Caltrain Business Plan including market context, goals, technical analysis process, and outcomes. It describes an illustrative set of all-day service plans for the Baseline, Moderate, and High Growth Scenarios. Each service plan includes hours of service, frequency, peak and off peak and service types.

METHODOLOGY

The service planning process analyzes potential 2040 service patterns and related infrastructure needs for the Moderate Growth Scenario and High Growth Scenario. Illustrative service plans presented in this memorandum are based on realistic technical parameters related to train and systems performance; however, this planning-level analysis is deterministic and does not consider operational perturbations. A rail simulation analysis will evaluate the reliability of each service plan.

The service planning process involved an interagency stakeholder engagement process spanning operators, cities, and community input. Service plans were developed by an interagency working group of Caltrain and high speed rail (HSR) staff, with involvement by staff from the City/County of San Francisco, City of San Jose, Capitol Corridor, Altamont Commuter Express (ACE) on terminal analyses. The goals, concepts, evaluation, and illustrative service plan were presented at City Staff Coordination Group (CSCG) and Local Policy Maker Group (LPMG) meetings, along with the Caltrain Board of Directors.

FINDINGS

Caltrain's existing service structure is becoming increasingly mismatched with market demand. Caltrain operates a complex schedule oriented towards peak commuter periods; riders typically plan their travel around a handful of trains, and experience long and irregular wait times if they do not plan ahead. Existing ridership is highly concentrated at a few stations with the highest service levels, fastest travel times, and convenient access to population and employment hubs. There is considerable latent demand for more frequent service during peak and off-peak periods. Over the next two decades, the Caltrain corridor is expected to see considerable growth, and major regional transit investments will open new markets to Caltrain. On its current path, ridership demand is expected to exceed a comfortable level of crowding during peak hours after the completion of the Downtown Extension (DTX) around 2029.

Two illustrative service plans were developed to demonstrate how Caltrain could meet the changing needs of the corridor. The Moderate Growth service plan would operate eight trains per hour, per direction during peak periods split between Local and Regional Express service. The High Growth service plan would operate 12 trains per hour, per direction during peak periods, with four Local trains and eight Regional Express trains. In comparison to the Baseline Growth service plan (six trains per hour, per direction), the Moderate and High Growth service plans provide faster travel times and higher frequency service to more stations. All service plans assume four high speed rail (HSR) trains per hour, per direction north of Diridon Station, and eight trains per hour, per direction south of Diridon Station.

Improvement plans underway at Caltrain's terminals are able to accommodate service expansions with some refinements. In the Baseline and Moderate Growth service plans, Salesforce Transit Center (STC) could serve all trains, while in the High Growth service plan, four trains per hour, per direction would continue to use 4th & King Station. The Moderate and High Growth service plans are compatible with the reconstruction of Diridon Station, but would require additional turn tracks at Tamien and Blossom Hill stations in San Jose.

APPLICATIONS IN THE BUSINESS PLAN

Illustrative service plans function as a key input to the Integrated Business Model, including components such as ridership forecasts, and capital and operating cost estimates. Service outcomes also inform the evaluation of growth scenarios.

DEFINITIONS & ABBREVIATIONS

This document refers to several service patterns in describing existing and potential future Caltrain service:

- **Local** service makes all stops in the territory in which it operates. A local train can operate for the entire length of the service territory or within an "inner zone" — the closest group of stations nearest to the major terminal.
- ***Regional Express*** service stops at select major stations only and generally operates across the full service territory. Caltrain's Baby Bullet service operates as a regional express between San Francisco and San Jose.
- **Skip-Stop** service is a hybrid between local and express service which operates more than one pattern of service at close headways. Skip stop trains alternate stops to increase the average speed of trains and reduce the number of station stops. The pattern allows for faster trip times for local service versus all-stop trains and ability to deliver more total seats with constrained infrastructure.
- ***Zone Express*** service stops at a group of stations in succession within a zone and then operates as a non-stop express train the rest of the way to its major city destination. Zone express trains generally operate during weekday peak periods inbound in the morning peak and outbound in the evening peak. The number of zones offering zone-express service depends upon the length of the service territory and the volume of demand.
- ***Intercity Express*** service provides express service between major station hubs. HSR service would function as an intercity express for trips between San Francisco, Millbrae, San Jose, and Gilroy.

Each of these service patterns presents advantages and disadvantages. Many European and Asian railroads operate a combination of local and regional express services to serve long high-volume transit corridors while maintaining strong local connectivity and legibility. However, scheduling of local and express becomes challenging on a two-track corridor like Caltrain due to a differential in run times. Most American commuter railroads on the East Coast operate a Zone Express service to enable express service to a single major central business district, matching available seats to market demand. However, Zone Express lacks good internal connectivity and is less suited to polycentric and bidirectional markets like the Caltrain corridor. Agencies rarely operate skip stop service at a large scale since many local station pairs are not served with direct service and some station pairs are not served at all. A skip-stop based service plan may be confusing for non-regular users of the system, especially in case of service

Table 1: Definitions & Abbreviations

ACE	Altamont Corridor Express
Baseline Growth Scenario	All service and infrastructure improvements currently in planning or reasonably foreseeable based on current policy commitments
Blended Service	Shared operations between Caltrain and HSR on a mostly two track corridor
Crowding-constrained ridership	The total forecasted ridership that may be comfortably served after considering seated and standing room on trains given train lengths and service levels.
DTX	The Downtown Extension of Caltrain to the Salesforce Transit Center
EMU	Electric Multiple Unit
High Growth Scenario	2040 service expansions to 16 trains per hour, per direction, including 12 Caltrains and 4 high speed trains
HSR	High-Speed Rail
Moderate Growth Scenario	2040 service expansions to 12 trains per hour, per direction, including 8 Caltrains and 4 high speed trains
PCEP	Peninsula Electrification Project (also known as Caltrain Electrification)
Ridership demand	The total forecasted ridership in response to a train service plan given a set of land use and transportation parameters
STC	Salesforce Transit Center
VTA	Valley Transportation Authority

2. EXISTING SERVICE CONTEXT

This section reviews existing and future market demand along the Caltrain corridor and implications for the service planning process. For more information on existing and future ridership patterns, see the Market Analysis and Ridership Forecasts Memorandum.

2.1 EXISTING SERVICE PLANS

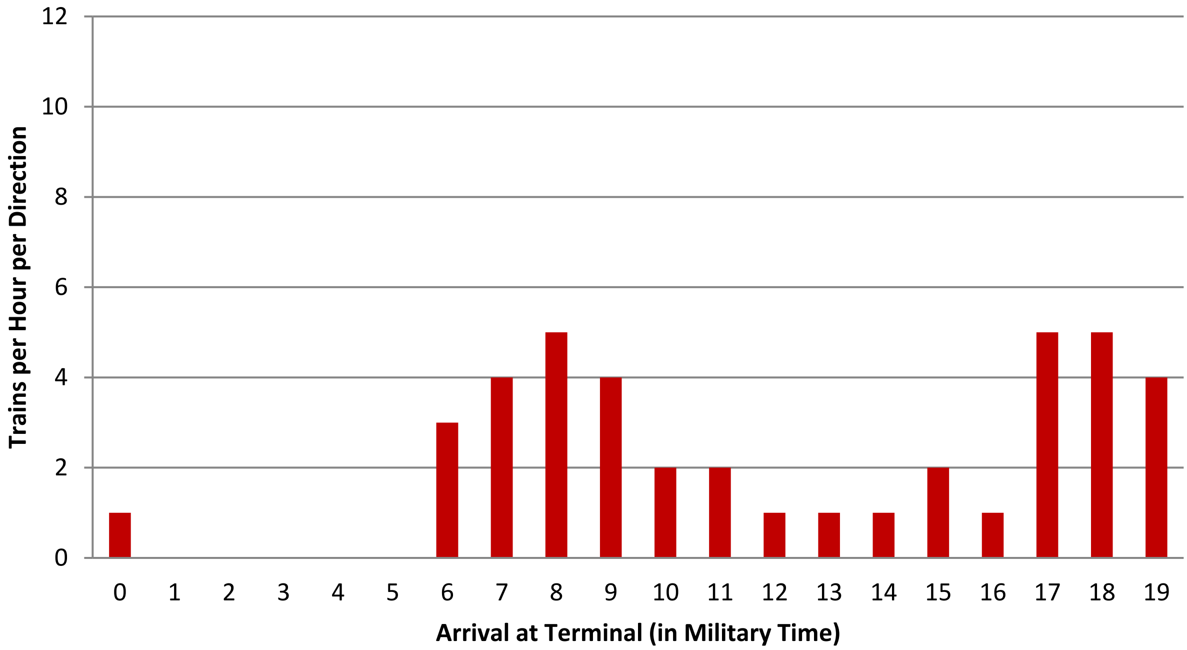
Caltrain's existing passenger service is oriented towards peak commuter periods. Caltrain's revenue operating hours are from 4:30 AM (first outbound departure from San Jose) through 1:30 AM (last inbound arrival into San Francisco). Peak service periods are approximately 6:30 AM – 9:30 AM in the morning and 4:30 PM - 7:30 PM in the evening. Caltrain operates up to five trains per hour, per direction between San Jose and San Francisco (4th & King) during these peak periods and hourly service in the off-peak periods. Figure 1 depicts the existing Caltrain timetable, while Figure 2 illustrates systemwide service levels by time of day.

As shown in Figure 1, Caltrain's current schedule is rather complex. Service pattern types vary by time of day with a mix of local, zone express, skip stop and regional express (Baby Bullets). Peak period travel times between 4th & King and Diridon Stations vary from around 62 to 95 minutes. Riders typically plan their travel around a handful of trains, and experience long and irregular wait times if they do not plan ahead. Service patterns also vary by peak direction (northbound AM and southbound PM) versus reverse-peak direction (southbound AM and northbound PM). For example, Sunnyvale receives four trains per hour in the peak direction and one train per hour in the reverse peak direction. As a result, the system can be complicated to navigate for both seasoned and occasional riders, and service is infrequent at most stations.

FIGURE 1: EXISTING AM PEAK DIRECTION TIMETABLE

Zone	Northbound Train No.	101	103	305	207	309	211	313	215	217	319	221	323	225	227	329	231	233	135	237	139	143
6	Gilroy									6:06a		6:26a			7:06a							
6	San Martin									6:15a		6:37a			7:15a							
6	Morgan Hill									6:21a		6:43a			7:21a							
5	Blossom Hill									6:36a		6:58a			7:36a							
5	Capitol									6:42a		7:04a			7:42a							
4	Tamien	–	4:55a	–	5:51a	5:56a	–	–	–	6:50a	6:56a	7:15a	–	–	7:53a	7:59a	–	8:26a	–	9:37a	–	–
4	San Jose Diridon	4:28a	5:03a	5:45a	5:59a	6:04a	6:23a	6:49a	6:54a	6:59a	7:04a	7:23a	7:49a	7:54a	7:59a	8:04a	8:23a	8:39a	9:13a	9:50a	10:13a	11:13a
4	College Park	–	–	–	–	–	–	–	–	–	–	–	–	–	8:03a	–	–	–	–	–	–	–
4	Santa Clara	4:33a	5:08a	–	6:06a	–	6:28a	–	–	7:06a	–	7:28a	–	–	8:08a	–	8:28a	8:44a	9:18a	9:55a	10:18a	11:18a
4	Lawrence	4:39a	5:13a	–	6:12a		–	–	–	7:12a		7:33a	–	–	8:15a		–	8:50a	9:24a	10:00a	10:24a	11:24a
3	Sunnyvale	4:43a	5:18a	–	6:20a	6:14a	6:36a	–	7:06a	7:20a	7:14a	7:38a	–	8:06a	8:22a	8:14a	8:36a	8:55a	9:29a	10:05a	10:28a	11:28a
3	Mountain View	4:48a	5:23a	6:00a	6:25a	–	6:42a	7:04a	7:11a	7:25a	–	7:44a	8:04a	8:11a	8:28a	–	8:42a	9:00a	9:34a	10:10a	10:33a	11:33a
3	San Antonio	4:52a	5:27a	–	6:29a	–	–	–	–	7:29a	–	–	–	–	8:32a	–	–	9:04a	9:38a	10:14a	10:37a	11:37a
3	California Ave	4:57a	5:31a	–	6:34a	–	6:48a	–	7:17a	7:34a	–	7:49a	–	8:17a	8:36a	–	–	9:09a	9:42a	10:18a	10:42a	11:41a
3	Palo Alto	5:01a	5:36a	6:08a	6:38a	6:26a	–	7:12a	7:21a	7:38a	7:26a	–	8:12a	8:21a	8:41a	8:27a	–	9:14a	9:47a	10:23a	10:47a	11:46a
3	Menlo Park	5:04a	5:39a	–	6:41a	–	6:54a	–	–	7:41a	–	7:54a	–	–	8:44a	–	8:51a	9:17a	9:50a	10:26a	10:50a	11:49a
2	Redwood City	5:10a	5:44a	–	6:47a	6:32a	6:59a	–	–	7:47a	7:32a	8:00a	–	–	8:51a	8:34a	8:57a	9:24a	9:57a	10:32a	10:55a	11:55a
2	San Carlos	5:15a	5:49a	–	–	–	7:04a	–	7:29a	–	–	8:05a	–	8:29a	–	–	9:02a	9:28a	10:01a	10:37a	10:59a	11:59a
2	Belmont	5:18a	5:52a	–	–	–	7:07a	–	–	–	–	8:08a	–	–	–	–	9:05a	9:32a	10:05a	10:40a	11:03a	12:03p
2	Hillsdale	5:22a	5:56a	6:18a	6:54a	–	7:11a	7:23a	7:34a	7:54a	–	8:12a	8:24a	8:34a	8:59a	–	9:09a	9:35a	10:08a	10:44a	11:06a	12:06p
2	Hayward Park	5:25a	5:59a	–	–	–	7:14a	–	–	–	–	8:15a	–	–	–	–	9:12a	–	10:11a	–	11:09a	12:09p
2	San Mateo	5:28a	6:03a	–	–	6:43a	7:18a	–	7:38a	–	7:43a	8:19a	–	8:38a	–	8:44a	9:15a	9:40a	10:14a	10:49a	11:12a	12:12p
2	Burlingame	5:32a	6:06a	–	–	–	7:21a	–	7:43a	–	–	8:22a	–	8:43a	–	–	9:19a	9:43a	10:17a	10:52a	11:15a	12:15p
2	Millbrae	5:36a	6:11a	6:26a	7:03a	6:51a	7:26a	7:31a	–	8:03a	7:51a	8:27a	8:33a	–	9:08a	8:52a	9:24a	9:48a	10:22a	10:57a	11:20a	12:20p
1	San Bruno	5:41a	6:16a	–	–	–	7:30a	–	7:50a	–	–	8:31a	–	8:50a	–	–	9:28a	9:53a	10:27a	11:02a	11:25a	12:25p
1	So. San Francisco	5:45a	6:20a	–	7:09a	–	7:34a	–	–	8:09a	–	8:35a	–	–	9:14a	–	9:32a	–	10:31a	–	11:29a	12:29p
1	Bayshore	5:51a	6:26a	–	–	–	7:41a+		–	–	–	8:43a+		–	–	–	9:39a	–	10:37a	–	11:35a	12:35p
1	22nd Street	5:57a	6:32a	–	–	–	7:50a+	–	–	–	–	8:51a+	–	–	–	–	9:45a	–	10:43a	–	11:41a	12:41p
1	San Francisco	6:03a	6:38a	6:47a	7:24a	7:08a	7:57a	7:51a	8:07a	8:24a	8:11a	8:58a	8:53a	9:07a	9:29a	9:11a	9:52a	10:09a	10:50a	11:17a	11:46a	12:48p

FIGURE 2: EXISTING SERVICE LEVELS BY TIME OF DAY



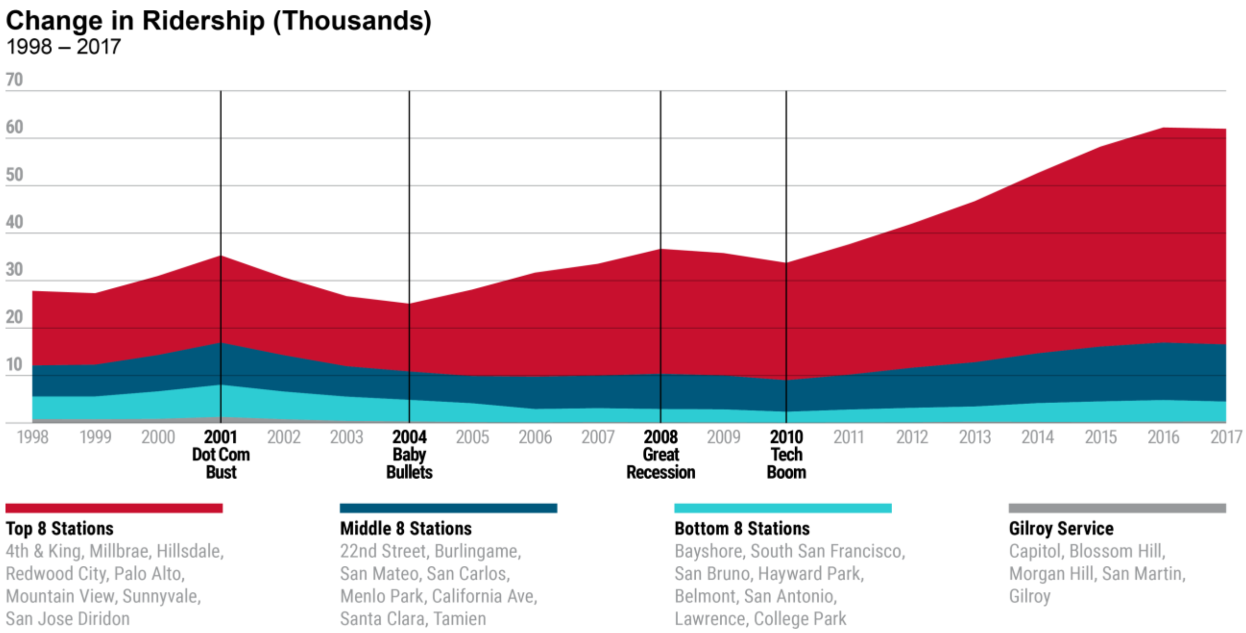
SYSTEMWIDE RIDERSHIP TRENDS

In 2017, Caltrain served over 62,000 riders on weekdays and 13,000 riders on weekends, translating to approximately 19 million passengers per year.[1] On weekdays, about 80 percent of ridership occurs during peak commuting periods when service levels are highest and regional traffic congestion is at its worst. The railroad has experienced substantial ridership growth over the past two decades – nearly tripling its ridership since the mid-1990s and doubling since the Great Recession in 2010. Caltrain's ridership growth is fueled by a combination of service improvements (e.g. the introduction of Baby Bullets in 2004), access improvements (e.g. the BART to Millbrae connection in 2003), and regional economic growth (especially employment growth in the technology sector and transit-oriented development near to stations).

Caltrain's existing ridership is highly concentrated at a few stations with the highest service levels, fastest travel times, and convenient access to population and employment hubs. Consequently, one in four Caltrain riders do not use the station closest to their origin or destination to access the train service. The busiest tier of eight stations accounts for 73 percent of Year 2017 daily boardings and 85 percent of ridership growth over the past 20 years. Travel between these major origin-destination pairs constitutes a majority of ridership in the system. Two Caltrain stations serve greater than 5,000 boardings per day (4th & King and Palo Alto). The middle tier of eight stations accounts for about 19 percent of daily boardings and the remaining 15 percent of historical growth. The bottom tier of eight stations accounts for about seven percent of daily boardings and has lost about 1,000 boardings over the past 20 years. This group includes the five stations south of Tamien that accounts for about one percent or daily boardings. **Figure 3** illustrates the change in Caltrain ridership over the past two decades.

[1] In 2018, Caltrain changed its ridership data collection methodology to count mid-week ridership instead of average daily ridership. Ridership increased from 64,000 mid-weekday boardings in 2017 to 65,000 mid-weekday boardings in 2018.

FIGURE 3: CHANGE IN RIDERSHIP, 1998-2017



2.2 ORIGIN-DESTINATION PATTERNS

Unlike traditional commuter railroads that primarily serve one peak direction, Caltrain serves a polycentric corridor with strong travel markets in both directions. During the AM peak period, 64 percent of riders travel northbound to employment hubs primarily in San Francisco, San Mateo, Redwood City, and Palo Alto. In the southbound direction, 36 percent of riders travel to employment hubs mostly in San Mateo, Redwood City, Palo Alto, Mountain View, and San Jose. On a daily basis, 55 percent of trips have an origin or destination in San Francisco; of these, about two thirds of passengers are traveling to or from Santa Clara County and one third traveling to or from San Mateo County. **Figure 4** illustrates AM peak period boardings and alightings by station.

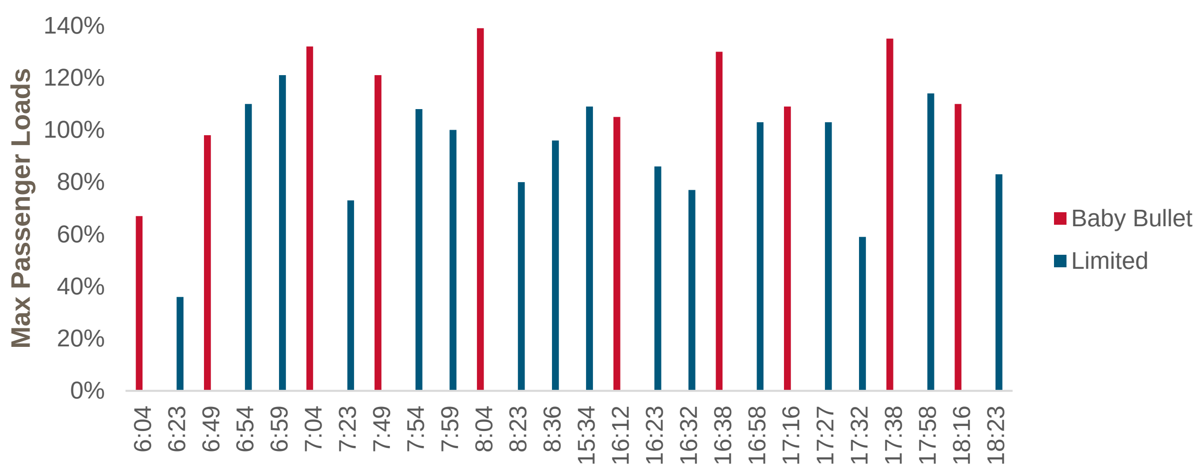
FIGURE 4: AM PEAK PERIOD BOARDINGS AND ALIGHTINGS, 2017

Red indicates boardings, blue indicates alightings

2.3 TRAIN CROWDING

Train crowding beyond seated capacity occurs in both directions. Ridership typically exceeds seated capacity on about half of peak period trains. Baby Bullet trains usually operate beyond their seated capacity (up to 140 percent above seated capacity) while Limited trains are typically near capacity (80 to 100 percent occupancy). Train crowding indicates that there may be latent demand for increased Caltrain service on the corridor amongst people who would ride if a more comfortable riding condition was achieved. **Figure 5** depicts peak period, peak direction passenger loads as a measure of train crowding.

FIGURE 5: PEAK PERIOD, PEAK DIRECTION PASSENGER LOADS, 2017

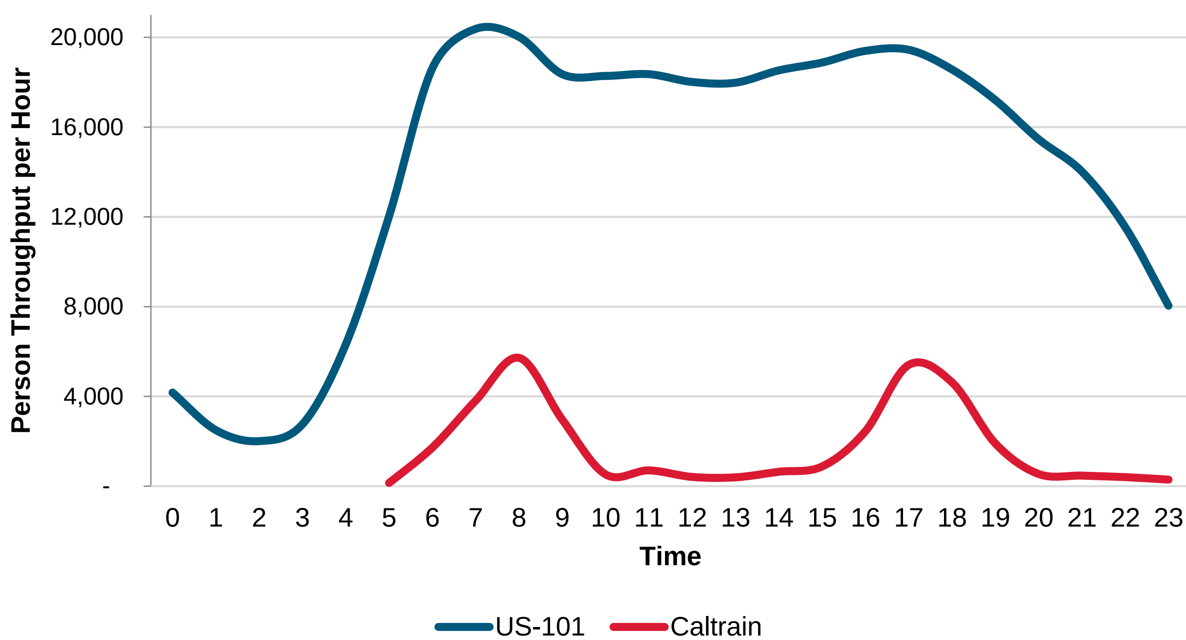


2.4 EXISTING REGIONAL TRANSPORTATION CONTEXT

Caltrain serves as the primary north-south transit connection between San Francisco and San Jose. Transfers are provided to a dozen operators, including Muni (San Francisco), BART (Millbrae), SamTrans (San Mateo County), Commute.org (San Mateo County), VTA (Santa Clara County), Highway 17 Express (Santa Cruz), County Express (San Benito County),

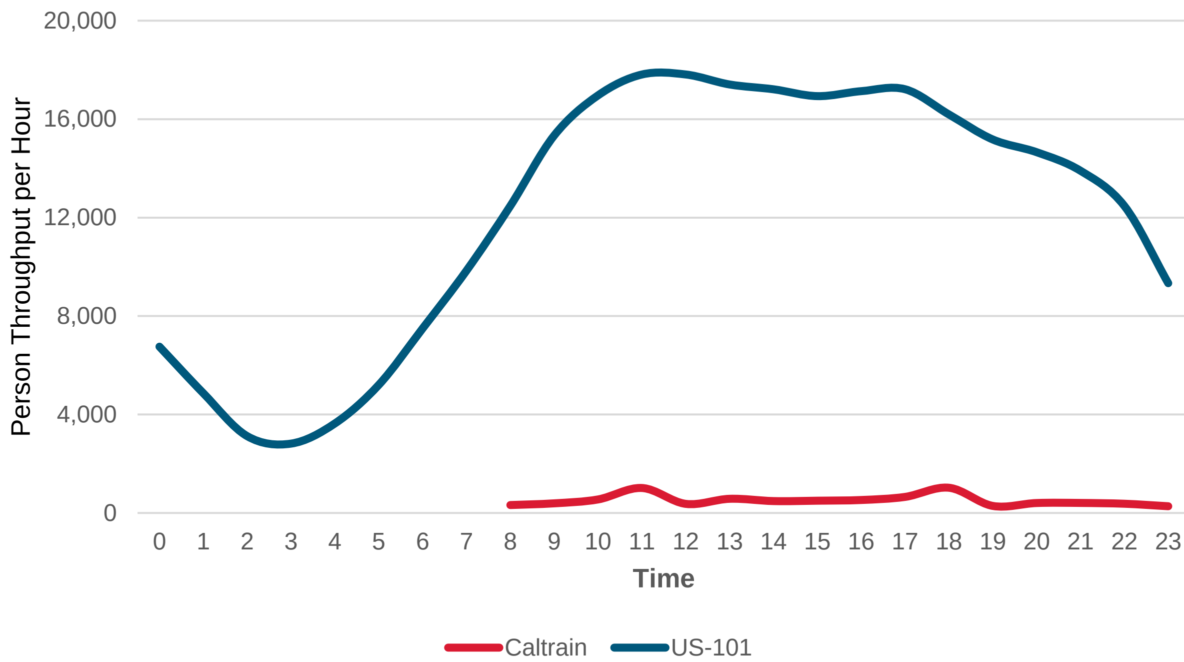
Caltrain carries a relatively small share of regional travel relative to US-101 and I-280 – the two freeway corridors that parallel the train line. During peak periods, Caltrain carries around 10 percent of all people traveling through the Mid-Peninsula (including US-101 and I-280). During off-peak and weekend periods, this mode share is around one to two percent. Whereas US-101 experiences high traffic volumes and varying levels of traffic congestion throughout the day, Caltrain experiences two distinct peak periods in the morning and evening. **Figure 14** and **Figure 7** depict weekday and weekend travel volumes along the Caltrain corridor crossing the San Francisco County line for Caltrain and US-101.[2]

FIGURE 6: WEEKDAY USAGE – US-101 VS. CALTRAIN



[2] Based on Caltrain ridership data and Caltrans PEMS traffic counts. I-280, BART, bus, and local street traffic are not shown.

FIGURE 7: WEEKEND USAGE – US-101 VS. CALTRAIN



2.5 FUTURE TRANSPORTATION CONTEXT

Major regional transit investments over the next two decades will open new markets to Caltrain, while some projects will introduce new potentially competitive options to Caltrain riders. Key projects include, but are not limited to:

- The **Central Subway** will reduce travel times between 4th & King Station and Union Square/Chinatown.
- The **US-101 Managed Lanes Project** and reintroduction of **SamTrans Express Bus Service** will expand travel choices on the Peninsula.
- **High Speed Rail (HSR)** provides a statewide intercity rail system sharing the Caltrain corridor.
- The **Downtown Extension (DTX)** closes last mile gap between 4th & King Station and Salesforce Transit Center in downtown San Francisco while providing more direct regional connections to the East Bay and North Bay via BART, buses, and ferries.
- **Dumbarton Rail** links southern Alameda County and the Peninsula, facilitating transfers to Caltrain in Redwood City.
- **Silicon Valley BART Extension** enhances regional connectivity between the East Bay and San Jose and improves access to Caltrain from eastern San Jose, while also providing another option to reach San Francisco.
- Other regional rail investments in Capitol Corridor, ACE, and rail service to Salinas envisioned in the **State Rail Plan** create a more extensive commuter and intercity rail system connecting to Caltrain.

By 2040, Caltrain will connect to a regional and statewide rail network that spans the East Bay, Central Valley, Central Coast, and Southern California. Consequently, the market for Caltrain would expand from a Peninsula- and South Bay-focus to include a more diverse array of origins and destinations.

2.6 LAND USE CONTEXT

The Caltrain corridor spans nearly 80 miles of urban, suburban, and rural environments. Today, Caltrain serves about three million people and jobs within two miles of stations, about 20 percent or 600,000 of which are within one half mile of stations. Land use densities around immediate ½ mile station areas are highest in San Francisco, but are also high in major Peninsula downtowns such as San Mateo, Redwood City, and Palo Alto. Within two mile catchment areas, land use densities are also fairly high around stations in Santa Clara County, whereas closely-spaced mid-Peninsula stations have smaller catchment areas and consequently serve less people overall. Land use density does not necessarily correlate with station ridership. Some stations like Hillsdale experience relatively high service levels and ridership with relatively low densities, while other stations like Lawrence serve a dense catchment area, but experience relatively low service and ridership levels.

Over the next two decades, the Caltrain corridor is expected to see considerable growth. Plan Bay Area forecasts and approved developments by individual cities amount to 1.2 million additional people and jobs within two miles of the corridor by 2040.[3] Immediately adjacent to stations (within ½ mile), population and employment would nearly double from 600,000 to one million people and jobs. Growth is expected to be most heavily concentrated at the northern and southern ends of the corridor, including San Francisco, northern San Mateo County, and northern/central Santa Clara County, while less development is expected in the mid-Peninsula and southern Santa Clara County. Land use growth on the Caltrain corridor is likely to drive additional demand for Caltrain service over time. **Figure 8** and **Figure 9** illustrate existing and future population and employment within one half mile and two miles of Caltrain stations.[4]

[3] Approved projects by individual cities amount to an extra 12,000 people and 115,000 jobs along the Caltrain corridor as described in Table 12 on Appendix A.

[4] Several development plans are underway on the Caltrain Corridor but were not approved prior to this analysis and therefore have been omitted from land use forecasts. This list of pending projects includes large developments in South San Francisco (Genentech Master Plan and other East of 101 and Lindenville developments), San Bruno (Bayhill Specific Plan), Menlo Park (Facebook Willow Village project), Palo Alto (Stanford General Use Permit update), Mountain View (East Whistman Specific Plan), San Jose (Google Diridon development and Downtown Plan), and Gilroy (Station Area Plan). Combined, these would result in an additional 12,000 people and 80,000 jobs along the study corridor beyond Plan Bay Area forecasts and approved land use growth. If these developments are realized, they are likely to further increase demand on the Caltrain corridor and exacerbate capacity challenges.

FIGURE 8: POPULATION AND EMPLOYMENT WITHIN ½ MILE OF STATIONS – EXISTING AND 2040

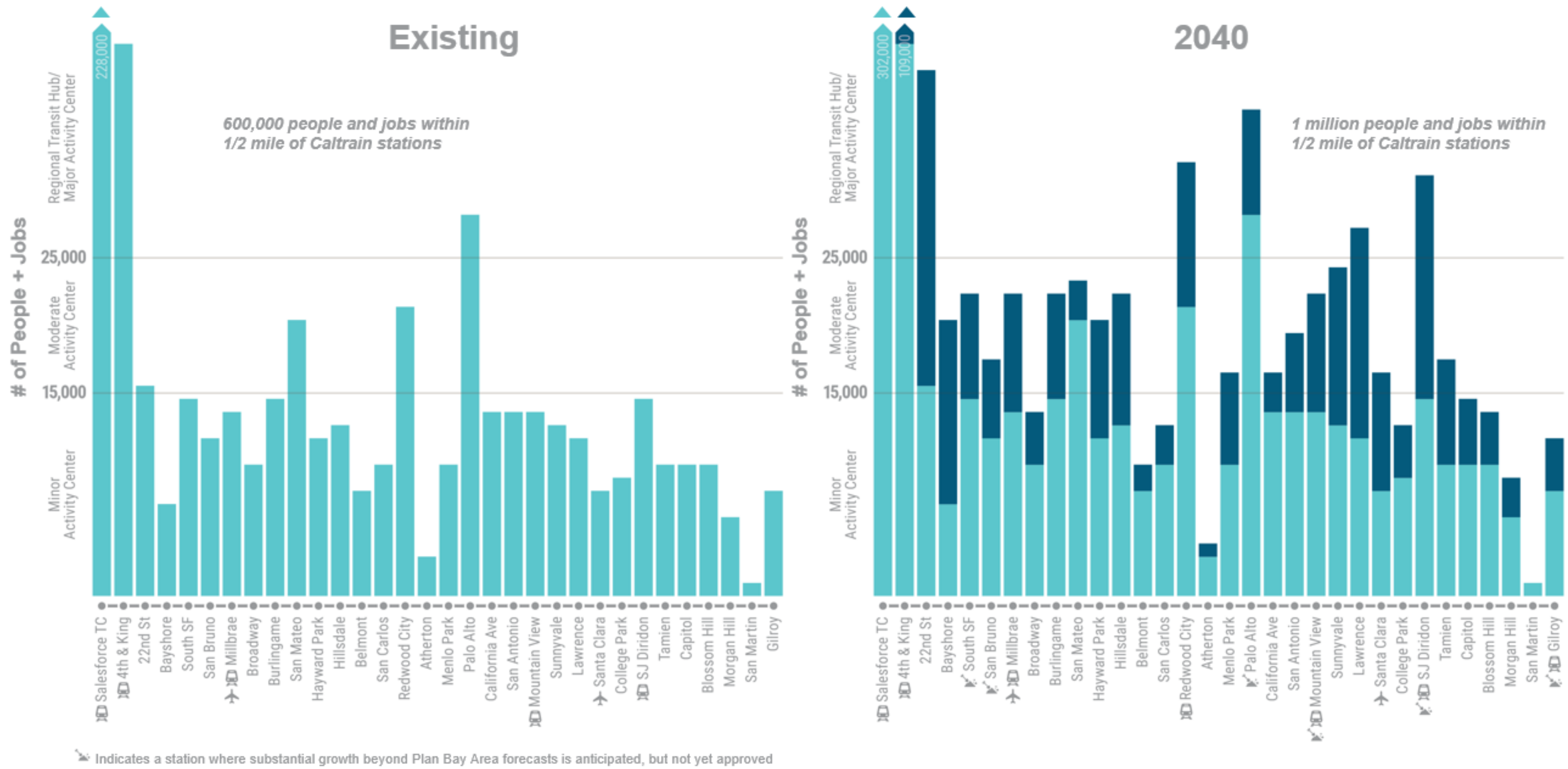
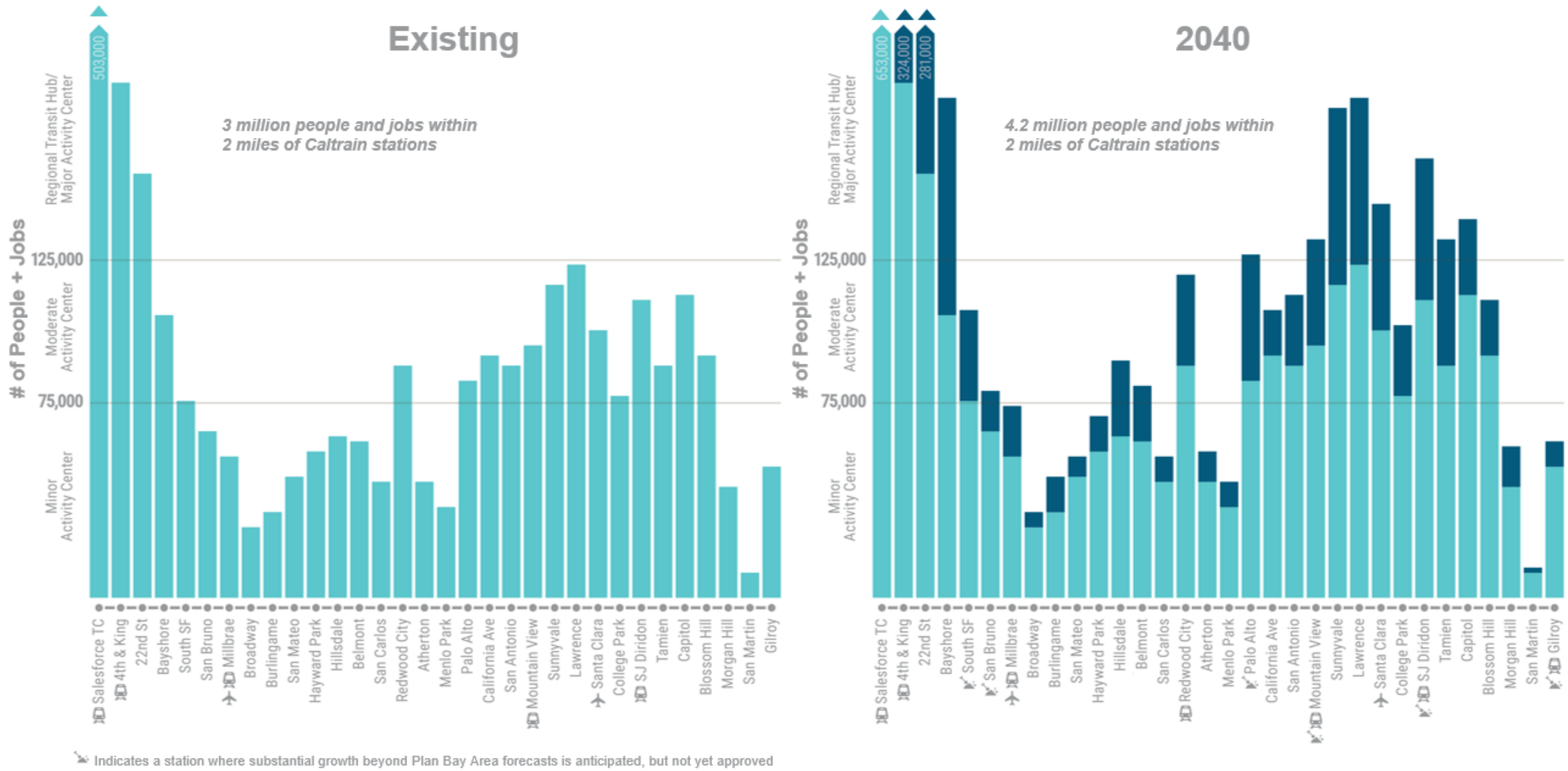


FIGURE 9: POPULATION AND EMPLOYMENT WITHIN 2 MILES OF STATIONS – EXISTING AND 2040



3. BASELINE GROWTH SERVICE PLAN

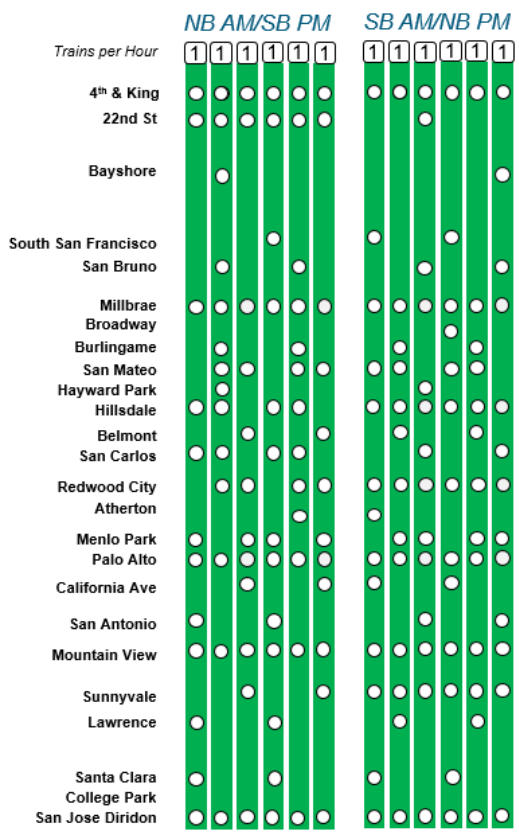
Caltrain has made several infrastructure and policy commitments to shape its service over the next two decades. These commitments include electrifying Caltrain's fleet and expanding to six trains per hour per direction during peak periods (also known as the Peninsula Corridor Electrification Project, or PCEP), blended service operations with HSR on a mostly two-track corridor (as described in the HSR Business Plan); and extending operations to the Salesforce Transit Center via DTX.

For Caltrain's Business Plan, this package of improvements is known as the *2040 Baseline Growth Scenario*. Changes to Caltrain service over time associated with the Baseline Growth Scenario are described below.

3.1 PRELIMINARY ELECTRIFICATION SERVICE PLAN (2022-2029)

The *Preliminary Electrification Service Plan* (Figure 10) provides several improvements over today's service structure. Electrification increases total peak period frequency from five trains per hour to six via seven-car electric multiple unit (EMU) trains. For some stations, this equates to up to a 100 percent increase in service, from one or two trains per hour, per direction to two or four trains per hour, per direction. Electrification also has the potential to help simplify Caltrain's operations: trains would depart San Francisco and San Jose at a clockface schedule, although stations in between would still experience variable departure and wait times. Peak period travel times between 4th & King and Diridon Stations would range from 62 to 71 minutes with a mix of skip stop and regional express services. During off-peak periods, Caltrain would operate two local trains per hour, per direction. This preliminary service plan will be further refined in a future Business Plan task.

FIGURE 10: PRELIMINARY ELECTRIFICATION SERVICE PLAN



Note: At Tamien Station, a combination of diesel and electrified service would operate. South of Tamien Station, diesel service would continue to operate.

The initial electrification of the corridor will partially include an electrified fleet. Diesel operations would continue south of Tamien with one train per hour in the peak direction during peak periods until Caltrain fully expands its EMU fleet and HSR electrifies the corridor to Gilroy by 2029.

3.2 BLENDED SERVICE PLAN (2029-2040)

The *Blended Service Plan* (Figures 11-13) adds HSR service to the Caltrain Corridor per the service plans prepared for the HSR Environmental Impact Report (EIR) and 2018 HSR Business Plan. Blended service assumptions are as follows:

- From 2029 to 2033, HSR Valley to Valley service would operate two trains per hour, per direction all day between STC, Diridon, and Gilroy stations, with service continuing to Bakersfield. While service could be provided to 4th & King on an interim basis until the completion of DTX, no service would be provided Millbrae or the proposed 4th & Townsend station. Caltrain would continue operating six trains per hour, per direction, for a total of eight trains per hour, per direction.
- From 2033 to 2040, HSR Phase One service would operate four trains per hour, per direction during the peak period between STC and Diridon stations, with two trains per hour, per direction stopping at 4th & Townsend and Millbrae. During off-peak periods, HSR would operate three trains per hour, per direction. South of Diridon, HSR would operate eight trains per hour, per direction during peak periods and four trains per hour, per direction during off-peak periods. Trains would continue to Southern California. Caltrain would continue operating six trains per hour, per direction, for a total of ten trains per hour, per direction between Diridon and STC.

The Blended Service Plan assumes several modifications to Caltrain's service plans spanning 2029 to 2040. The plan is characterized by three skip-stop patterns each operating at 30-minute headways. Most stations are served by one or two of these patterns, receiving two or four trains per hour, with a few major stations served by all three. While all stations receive semi-express service to major destination on the corridor, many origin-destination pairs require a transfer and several origin-destination pairs are not served at all. Moreover, since no new passing tracks would be provided, Caltrain and HSR would operate at irregular bunched headways, meaning that three Caltrain trains would depart over a span of 10 to 15 minutes, then two HSR trains would operate during the next 15 to 20 minutes. Caltrain would also need to operate a similar service pattern during off-peak periods since local-stop operations would not be viable. All peak period trains achieve travel times of about 62 to 65 minutes between 4th & King and Diridon Stations with a skip stop pattern. South of Tamien, the Blended Service Plan includes one train per hour in the peak direction during peak periods. Figure 11 shows the weekday peak period service plan, while Figures 12 and 13 illustrate the weekday and weekend all-day service plans.

FIGURE 11: 2029-2040 BASELINE PEAK PERIOD SERVICE PLAN

SERVICE PLAN DESCRIPTION

- Consistent with HSR and PCEP service planning processes
- Three half-hourly skip stop patterns each with similar travel times
- Bunched service results in irregular Caltrain headways; each pattern arrives over span of 10 minutes, then a 20 minute gap between trains
- Some origin-destination pairs not served at all
- South of Tamien, peak-direction skip stop service with 10 round trips per day

Trains per Hour, per Direction	Peak: 6 Caltrain + 4 HSR Off-Peak: 3 Caltrain + 3 HSR
Stopping Pattern	Skip Stop (8 Car Trains)
Travel Time, STC-Diridon	69-73 Min
New Passing Tracks	Millbrae

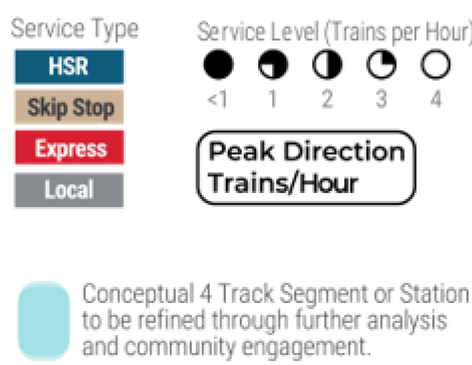


FIGURE 12: 2029-2040 BASELINE WEEKDAY SERVICE LEVELS

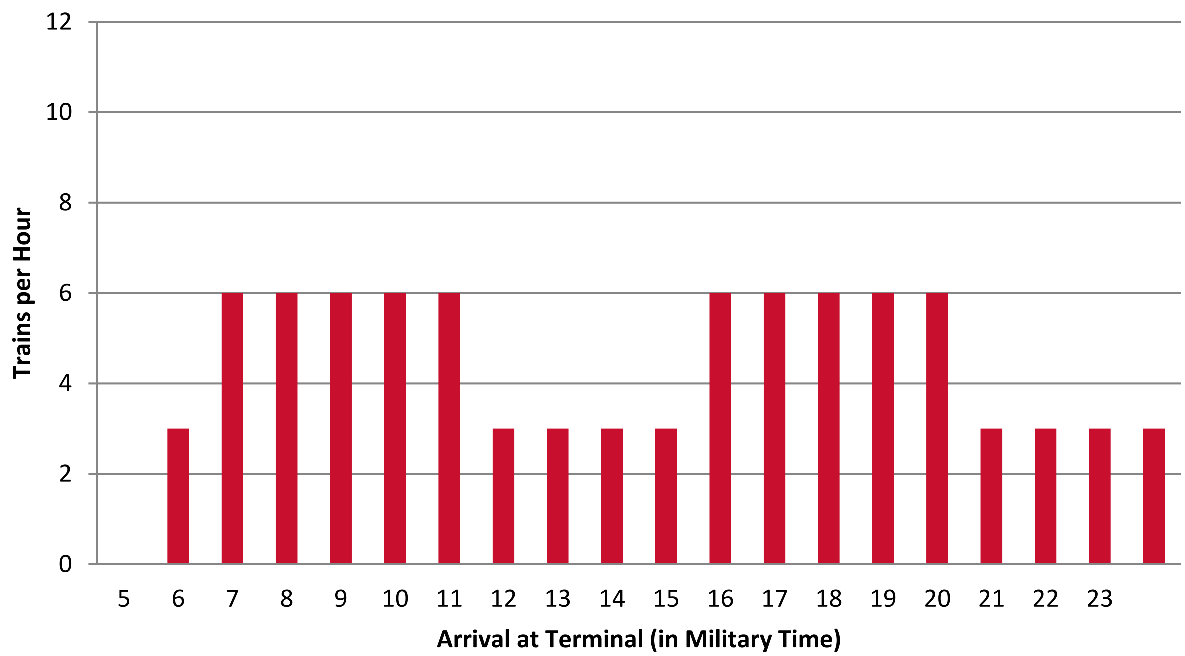
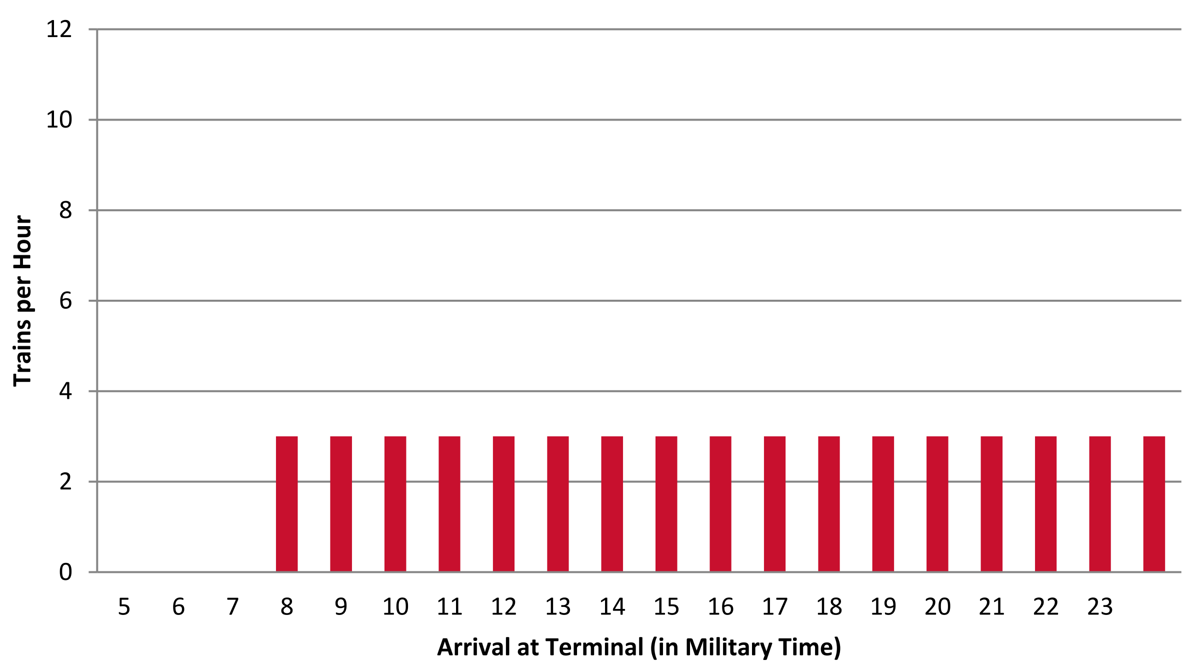


FIGURE 13: 2029-2040 BASELINE WEEKEND SERVICE LEVELS



Significant capital investment and construction/reconstruction is assumed to be needed to support the 2040 Baseline Service Plan, including but not limited to the following:

- Curve straightening and track upgrades to support up to 110 mph operation;
- New signaling system and positive train control upgrades to support 2 minute headways and 110 mph operation;
- Catenary pole placement adjustment to enable 110 mph operation;
- Some terminal and shared station modification;
- Platform lengthening and level boarding System;
- Full fleet electrification and expansion;
- Storage and maintenance expansion / reconfiguration;
- Grade separations and grade-crossing improvements; and
- General station, customer amenity and access facility improvements.

3.3 DOWNTOWN EXTENSION (APPROXIMATELY 2029)

In parallel to electrification and blended service operations with HSR, the City/County of San Francisco is leading the Downtown Extension (DTX) project to extend Caltrain to the Salesforce Transit Center (STC). The project includes a 1.2 mile tunnel and a new underground station at 4th & Townsend. The City/County is also pursuing an extended tunnel under Pennsylvania Avenue and a possible relocation of 22nd Street Station, (analyzed in the Railyards and Benefits Study). For the Business Plan, both DTX and the Pennsylvania Avenue Tunnel are assumed to be completed by 2029.

3.4 RIDERSHIP & CROWDING (2029-2040)

Although Caltrain would experience short-term crowding relief after electrification, the Business Plan ridership analysis suggests that DTX will push Baseline demand above a comfortable crowding level during peak commute hours. While six trains with eight car EMUs could comfortably carry about 6,500 passengers per hour, Caltrain could experience a maximum peak direction demand of over 8,000 passengers during the peak hour, growing to over 9,000 passengers by 2040. Consequently, the Baseline Growth scenario would not fully serve peak hour demand - falling short by 30 to 50 percent which translates to about 6,000 to 10,000 daily unserved riders. From a rider's perspective, trains would feel crowded and finding a seat would be difficult. This need for expanded throughput capacity is a primary driver of the Business Plan's service planning process.

4. SERVICE PLANNING FRAMEWORK

4.1 SERVICE PLANNING APPROACH

The Business Plan considers an expansion in service beyond the Baseline Growth Scenario for a 2040 horizon to meet growing demand for Caltrain service. For planning purposes, illustrative service plans are considered which envision Caltrain service in the year 2040. These scenarios – Moderate and High Growth – do not consider changes to service prior to 2040.

Weekday peak period service plans dictate the infrastructure and fleet needs for each service plan. From a methodology standpoint, the development of service plans focuses on the peak period, with off-peak and weekend pivoting from the peak period structure. Service plans were developed for the mainline corridor between San Francisco and San Jose, followed by a more detailed study of the implications for the north and south terminals.

4.2 SERVICE PLANNING GOALS

The Caltrain corridor serves a growing mix of local, regional, and statewide travel markets and trip purposes (**Table 2**). In developing the Moderate and High Growth Scenarios, a range of potential options, tradeoffs, and solutions were considered to accommodate the range of transportation needs within the infrastructure constraints and policy commitments of the Caltrain corridor.

In coordination with project partners and corridor stakeholders, Caltrain identified goals and performance metrics to guide the service planning process. These goals seek to optimize benefits to operations, ridership and infrastructure while minimizing adverse effects to Caltrain, HSR, and the corridor's communities.

Table 2: Service Goals and Metrics

	Goal	Metric
1. Maximize Ridership	Provide high frequency service	Number of stations served every 10 minutes or better
	Improve travel times between major markets	Average travel times plus wait times between Major Activity Centers
2. Improve Connectivity	Achieve 15-minute frequencies at most stations	Number of stations served by at least four trains per hour, per direction
	Maintain connectivity between stations	Percentage of stations directly connected by local train without a transfer
3. Enhance Convenience	Provide capacity responsive to 2040 demand	Ridership demand is comfortably accommodated within seated and standing capacity
	Provide legible service structure	Complexity of stopping pattern
4. Minimize New Infrastructure	Minimize mainline track expansions	Miles of new passing track

4.3 OPERATING PARAMETERS AND ASSUMPTIONS

Each 2040 service plan assumes:

- An electrified rail corridor from Gilroy to San Jose;
- Blended operations between Caltrain and High-Speed Rail along a mostly two-track corridor;
- All service operates with ten car EMUs (the Baseline Growth assumes eight-car EMUs); and
- An improved signal system is in place capable of delivering trains at closer headways than the existing system.

Table 3 shows the set of operational parameters used to govern the movement of trains on the system within which the service plans were developed.

Table 3: Operational Needs and Parameters

Operational Parameter	Assumption	Description
Headway	2-minute minimum corridor separation times	Time separation between two consecutive trains passing over the same section of track
Minimum Turnaround Time	HSR: 20 min Caltrain: 20 minute	Minimum time allowed for a train to turn at the terminals
Minimum Dwell Time	HSR: 2 minute Caltrain: 1 Minute at Major Stations; 0.7 minute at Minor Stations	Minimum station stop time to board and alight passengers
Rolling Stock	HSR: Generic high-Speed Trainset Caltrain: Adapted to EMU RFP train performance and 8 to 10 car train length	Description of the equipment
Speed Limit	110 mph	Allowable speed for all train service
Recovery Time	10% Distributed	Additional time added to the timetable above pure calculated run time to allow for a stable timetable.

The following elements were considered in developing service plans for the Moderate and High Growth Scenarios:

- Potential 3- or 4-track overtakes to allow for additional service (either at stations or as "running" overtakes);
- Power supply and catenary system upgrades to support higher service levels;
- Terminal modifications or expansion to accommodate increased service levels;
- Additional platform lengthening to support longer train consists;
- Further fleet expansion to allow for increased service and longer trains;
- Revised depot and maintenance strategy to accommodate increased fleet size; and
- Additional grade separations and improvements to at-grade crossings.

Service concepts were developed to incorporate various levels of growth on the Caltrain corridor: an incremental "Moderate Growth" expansion of service to 12 trains per hour, per direction (eight Caltrains plus four HSR trains), and a more substantial "High Growth" expansion of service to 16 trains per hour, per direction (12 Caltrains plus four HSR trains). This section describes the process for developing service concepts.

4.4 2040 MARKET SEGMENTATION

Service concept development was informed by two findings around 2040 market segmentation. First, Caltrain ridership will remain bidirectional and polycentric, with major population and employment hubs dispersed throughout the corridor and at either terminal. This geographic distribution illustrates the need for a corridor-wide service structure that maximizes connectivity between a range of markets. Second, demand would remain differentiated between stations, reflecting the relative size of markets at individual stations and origin-destination pairs. A "one size fits all" approach would not meet the travel needs for peak and off-peak periods.

An analysis of transportation and land use plans helped inform the changing nature of market potential between stations.[5] Stations were grouped into three typologies based on 2040 projections for population, employment, and transit connectivity: major activity centers (11 stations), moderate activity centers (13 stations), and minor activity centers (eight stations), shown in Table 4. Service concepts were developed using these typologies as a framework for assessing service needs.

Table 4: Service Typologies

Typology	Description	Transit Connectivity	2040 Land Use Characteristics	
			Population + Employment within ½ Mile	Population + Employment within 2 Miles
Major Activity Center	Serves regional population or employment center and/or transfer point to regional transit service.	HSR, BART, regional rail, light rail, bus, and/or shuttle service	>25,000	>125,000
Moderate Activity Center	Serves moderately high concentrations of people and jobs	Light rail, bus, and/or shuttle service	15,000-25,000	75,000-125,000
Minor Activity Center	Serves lower concentrations of people and jobs	Bus and/or shuttle service	<15,000	<75,000

4.5 SERVICE CONCEPT IDENTIFICATION

Moderate and High Growth service concepts with 12 and 16 trains per hour, per direction were developed and tested for each of the three types of patterns (Zone Express, Local/Regional Express and Skip-Stop). The service patterns were adapted to the Caltrain Corridor based on the relative intensity of demand illustrated in the station typologies. Seven service concepts resulted from this process, as shown in Figure 14. Each service concept includes a unique set of infrastructure requirements (generally lower for 12 train options compared to 16 train options) and exhibits strengths and weaknesses relative to the service goals. The following provides a summary description of each of the concepts developed in this stage:

Zone Express (A&B):

- Provides good coverage with all stations receiving at least four trains per hour, per direction;
- Most major activity centers receive eight trains per hour, per direction, with the exception of 22nd Street, Sunnyvale, and Lawrence;
- Transfers required to travel between moderate and minor activity centers in different zones, with a two minute transfer at Redwood City;

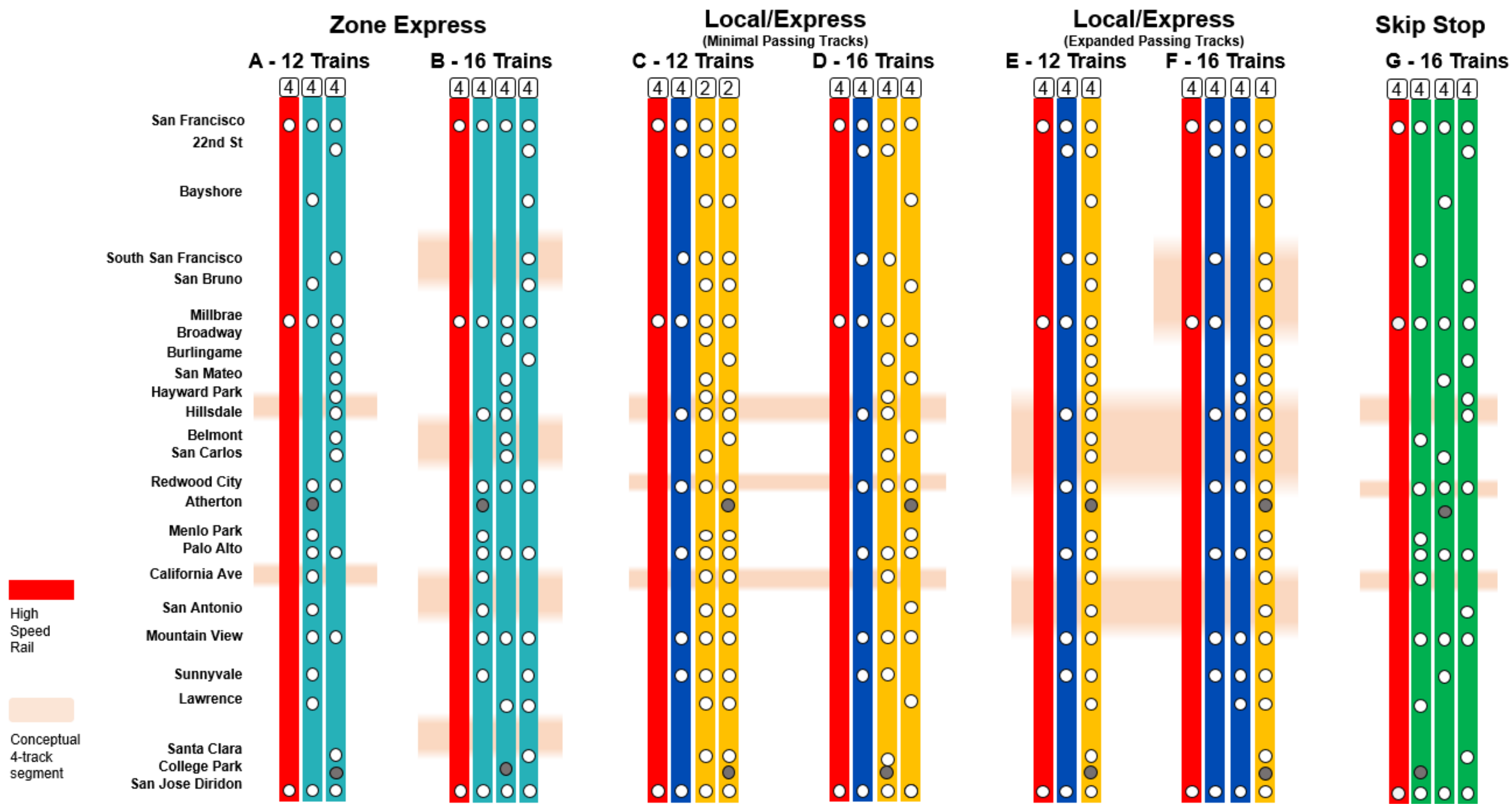
[5] Ridership forecasts were not an input to the service planning process due to the strong relationship between service characteristics and ridership at a station and origin-destination level.

- All stations receive semi-express service to major activity centers, but the lack of dedicated express train between major activity centers results in 70 minute travel time from 4th & King to Diridon – about 10 percent slower than existing Baby Bullet service;

- Some challenges with internal connectivity and legibility; and

- Substantial passing tracks needed to achieve 16 trains per hour without substantial improvement in service frequency.

FIGURE 14: INITIAL SERVICE CONCEPTS



Local/Regional Express (C, D, E, & F):

- Provides dedicated regional express train service connecting major activity centers, achieving best trip time for the most passengers (60 minutes from 4th & King to Diridon);
- Mid-Peninsula hub at Redwood City allows for cross platform transfer between local and regional express, providing seamless connectivity;
- Most local stations receive regular 15-minute local service; however, some local stations receive only 30-minute service without significant passing track infrastructure; and
- Significant passing track infrastructure required for 16 trains per hour, per direction in order to maintain connected local service.

Skip-Stop (G):

- Distributes relatively fast and frequent service across most stations;
- Relatively fewer miles of passing tracks needed to achieve 16 trains per hour;
- Does not provide differentiated products – end to end travel times are approximately 70 minutes from 4th & King to Diridon;
- Significant challenges for internal connectivity and legibility – service is difficult to understand, and many station origin-destination pairs are not served; and
- Few comparable examples in operation.

4.6 SERVICE CONCEPT EVALUATION

Through an initial screening process, three service concepts were removed from consideration:

B - Zone Express 16 Trains

- Infrastructure needs are extensive and incompatible with other service options; and
- Increased train throughput does not result in additional service at most stations.

E - Local/Regional Express 12 Trains (More Passing Tracks)

- Requires significantly more infrastructure to achieve the same throughput as other 12-train concepts; and
- Infrastructure is compatible with and builds toward Local/Regional Express 16-train concept.

G - Skip Stop 16 Trains

- Similar to D - Local/Regional Express 16 Train pattern;
- Challenging internal connectivity and service legibility; and
- Increased train throughput does not result in additional service at most stations.
- The four remaining service plans (A, C, D, and F) were evaluated against the service goals and performance metrics. Table 5 presents the evaluation, with the existing service pattern shown for reference.

Table 5: Evaluation Results

	Goal	Metric	Existing	Baseline	Minimal Passing Tracks			Expanded Passing Track
			5 TPH	6 TPH Skip Stop	A - 12 TPH Zone Express	C - 12 TPH Local/Express	D - 16 TPH Local/Express	F - 16 TPH Local/Express
1. Maximize Ridership	Provide high frequency service	Number of stations served every 10 minutes or better	0 Stations	0 Stations[6]	6 Stations	10 Stations	10 Stations	14 Stations
	Improve travel times between major markets	Average travel times plus wait times between Major Activity Centers	55 Minutes	39 Minutes	37 Minutes	34 Minutes	33 Minutes	30 Minutes
2. Improve Connectivity	Achieve four trains per hour at most stations	Number of mainline stations with less than four trains per hour	21 Stations	14 Stations	6 Stations	9 Stations	4 Stations	6 stations
	Maintain connectivity between stations	Percentage of stations directly connected by local train without a transfer	83%	84%	66%	96%	64%	99%
3. Enhance Convenience	Provide capacity responsive to 2040 demand	2040 demand served within comfortable crowding condition	No	No	No	No	Yes	Yes
	Provide legible service structure	Complexity of stopping pattern	High Complexity	High Complexity	Moderate Complexity	Moderate Complexity	High Complexity	Low Complexity
4. Minimize New Infrastructure	Minimize mainline track expansions	Miles of new passing track	-	1	4	5	5	20

[6] While the Baseline Service Plan provides six trains per hour, per direction at several stations, these trains are bunched at irregular headways due to the lack of passing tracks. Consequently, no stations receive service at regular ten minute intervals.

The evaluation yielded the findings described below:

A - Zone Express 12 TPH – removed from consideration

- Insufficient capacity to meet future demand;
- Longest average travel times; and
- Least stations with high-frequency service.

C – Local/Regional Express 12 TPH – carried forward as Moderate Growth service plan

- Insufficient capacity to meet future demand;
- Good connectivity, travel times, and frequency; and
- Legible service structure.

D – Local/Regional Express 16 TPH (Low Infrastructure) – removed from consideration

- High complexity and poor connectivity; and
- 15% of origin-destination pairs are not connected at all.

E – Local/Regional Express 16 TPH (High Infrastructure) – carried forward as High Growth service plan

- Excellent connectivity travel times, and frequency;
- Service levels sufficient to meet 2040 demand; and
- Significant level of infrastructure investment may affect feasibility.

Through this evaluation process, two variants of a Local/Regional Express concept were chosen to incorporate into the 2040 Moderate and High Growth service plans: a Moderate Growth concept with 12 trains per hour, per direction (four HSR and eight Caltrain) and less intensive infrastructure investment, and a High Growth concept with 16 trains per hour, per direction (four HSR and 12 Caltrain) and more intensive infrastructure investment.

5. ILLUSTRATIVE SERVICE PLANS

5.1 MODERATE GROWTH SERVICE PLAN

The Moderate Growth service plan (Figures 13 through 15) is characterized by two Caltrain service patterns (Local and Regional Express) along with HSR each operating at 15-minute headways (or four times per hour) during the peak period (Figure 15). As in all 2040 service plan (Baseline, Moderate and High) four high-speed trains operate between San Jose and San Francisco with two stopping at Millbrae and 4th & Townsend and two operating non-stop to STC. Both the Moderate and High Growth service plan operate on a 15 minute clockface schedule, accommodating regularly spaced trains throughout the hour and avoiding the bunching needs of the Baseline Growth service plan.

A 10 car Regional Express train operates in between the high-speed slots with eight intermediate station stops between San Francisco and San Jose with continuing service to Blossom Hill (four trains per hour, per direction) and tapered service to Gilroy (two trains per hour, per direction). This service provides regular, frequent, limited-stop service between San Jose, San Francisco and major intermediate markets such as Redwood City, Palo Alto, and Mountain View. Regional Express trains would serve most of the current and future travel demand on the corridor, which tends to be intermediate-to long-distances.

A six car Local train would complement the Regional Express serving most stops with 15 minute headways. However, to operate within the limited passing track infrastructure in the Moderate Growth service plan, some skip stop elements are necessary for the Local service. A local train can only stop twice between San Bruno and Hillsdale and between Hillsdale and Redwood City. These constraints result in infrequent half hourly local service for Broadway, Burlingame, San Mateo, Belmont and San Carlos. Additionally, Atherton, College Park, and San Martin would be served on an hourly or exception basis due to lower demand.

A key feature in the Moderate and High Growth plans is a timed transfer between Local and Regional Express trains at Redwood City. This transfer point enhances intra-corridor connectivity and provides an opportunity for crossbay transfers to a planned Dumbarton Rail service. Cross platform transfers between the Local and Regional Express services would occur for each train every fifteen minutes. For passengers riding a Local train from Menlo Park to San Francisco or from San Bruno to San Jose, a cross-platform transfer to a Regional Express Train would save approximately 10 minutes of travel time.

The Moderate Growth plan includes several locations in which faster trains overtake slower trains along the corridor. To facilitate these overtakes, approximately three miles of new four track segments and stations are needed. These infrastructure investments include a short four track main line section between Hayward Park and Hillsdale (inclusive of stations), a four track station at Redwood City, and a four track station somewhere in northern Santa Clara county (Palo Alto, California Avenue, San Antonio, or Mountain View). The Service plan as defined used California Avenue as a overtake location, but some flexibility remains to shift this north or south without fundamentally changing the nature of the plan. Tail tracks are also required just beyond the Blossom Hill station to facilitate turning two Regional Express trains at this location, achieving 15 minute headways at both Blossom Hill and Capitol stations.

During the off-peak periods and weekends, Caltrain would operate six trains per hour, per direction – four Regional Express trains and two Local trains. This approach maximizes all-day ridership demand between major markets, but scales back service to secondary ridership markets. Although most stations would receive two to six trains per hour, per direction, Mid-Peninsula stations served by skip stop Local service would receive hourly service. However, should a stronger market for off-peak and weekend service materialize, Caltrain may increase Local service accordingly.[7]

[7] While BART is able to maintain relatively frequent off-peak and weekend service by reducing train consist lengths, Caltrain's EMU fleet is less flexible due to rolling stock and location of train storage facilities. Changes to consist length have not been assumed in the service plans.

Figure 15 shows the weekday peak period service plan, while Figures 16 and 17 illustrate the weekday and weekend all-day service plans.

FIGURE 15: MODERATE GROWTH SERVICE PLAN

SERVICE PLAN DESCRIPTION

- Local and Express trains each operating at 15 minute frequencies with timed cross-platform transfer at Redwood City
- Skip stop pattern for some mid-Peninsula stations; some origin-destination pairs not served at all
- Trains serve Capitol and Blossom Hill every 15 minutes and Morgan Hill and Gilroy every 30 minutes

Trains per Hour, per Direction	Peak: 8 Caltrain + 4 HSR Off-Peak: 6 Caltrain + 3 HSR
Stopping Pattern	Local (6 Cars) Express (10 Cars)
Travel Time, STC-Diridon	67 Min (Express) 88 Min (Local)
New Passing Tracks	Millbrae, Hayward Park-Hillsdale, Redwood City, Norther Santa Clara County, Blossom Hi

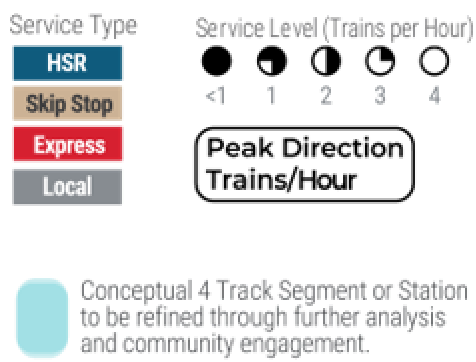


FIGURE 16: MODERATE GROWTH WEEKDAY SERVICE LEVELS BY TIME OF DAY

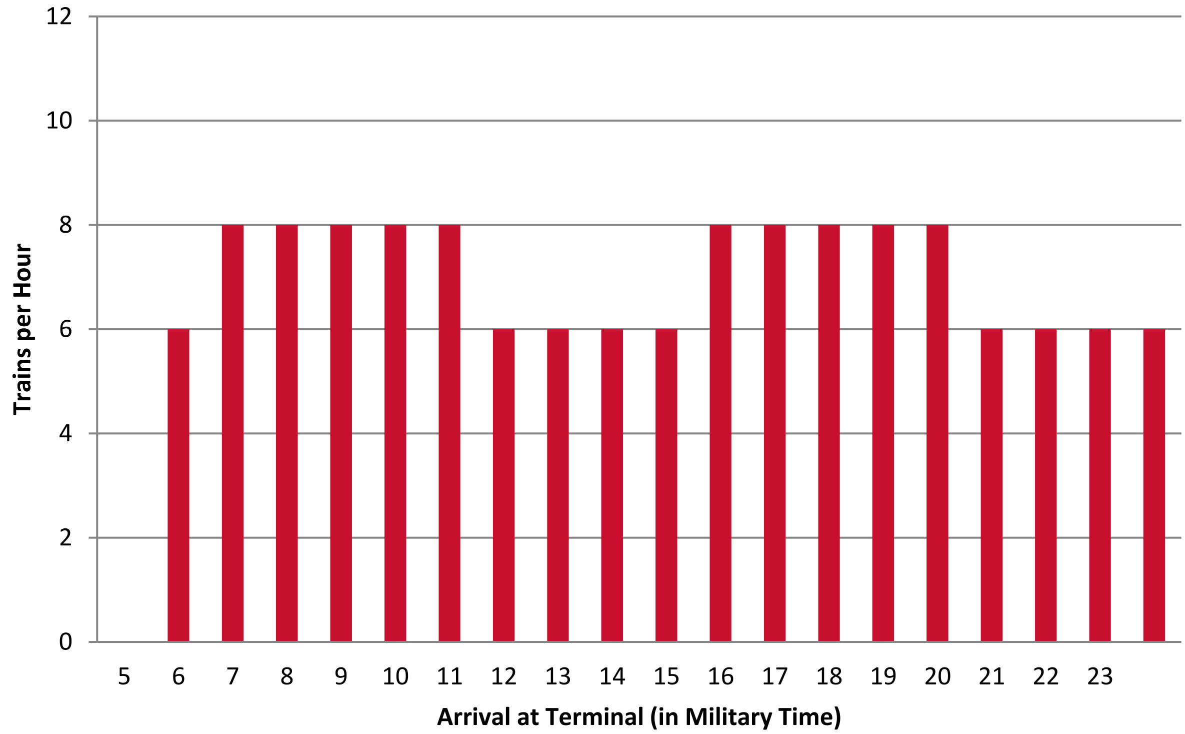
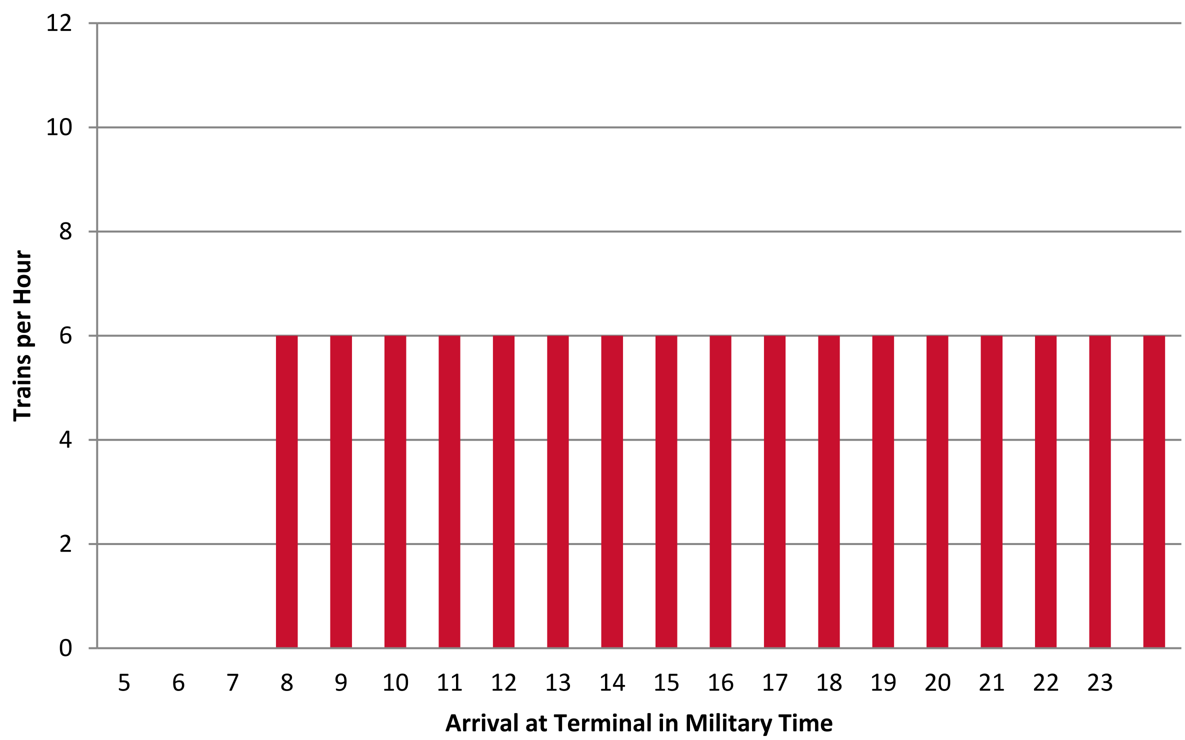


FIGURE 17: MODERATE GROWTH WEEKEND SERVICE LEVELS BY TIME OF DAY



5.2 HIGH GROWTH SERVICE PLAN

The High Growth service plan (Figures 16 through 18) shares a similar service offering as the Moderate Growth service plan, adding an extra four Regional Express trains per hour, per direction to the Moderate Growth service plan (Figure 18). The High-Speed Rail and Regional Express trains are the same in both plans. Service south of Tamien and during off-peak periods and weekends would mirror the Moderate Growth service plan.

The High Growth service plan differs from the Moderate Growth service plan in two ways. First, by adding additional passing track infrastructure, it offers a nearly complete Local stop service without the skip stop elements of the Moderate Growth service plan. Second, the additional passing track infrastructure enables a second six car Regional Express service providing additional service to secondary travel markets and additional seats to major markets.

The High Growth service plan needs approximately 15 miles of new four track segments spanning South San Francisco to Millbrae, Hayward Park to Redwood City, and California Avenue to Mountain View (or elsewhere in northern Santa Clara County between Palo Alto and Mountain View). In general, additional passing tracks enable additional service at four track stations, and there is flexibility in service levels between stations. Nonetheless, the stopping pattern of the second Regional Express service is somewhat constrained even with this infrastructure: trains cannot stop north of Burlingame.

Figure 18 shows the weekday peak period service plan, while Figures 19 and 20 illustrate the weekday and weekend all-day service plans.

FIGURE 18: HIGH GROWTH SCENARIO

SERVICE PLAN DESCRIPTION

- Local and Express A trains each operating at 15 minute frequencies with timed cross-platform transfer at Redwood City
- Express B trains operate every 15 minutes between 4th & King and Tamien
- Local trains make nearly all stops
- Trains serve Capitol and Blossom Hill every 15 minutes and Morgan Hill and Gilroy every 30 minutes

Trains per Hour, per Direction	Peak: 12 Caltrain + 4 HSR Off-Peak: 6 Caltrain + 3 HSR
Stopping Pattern (Train Cars)	Local (6 Cars) Express A (10 Cars) Express B (6 Cars)
Travel Time, STC-Diridon	67 Min (Express A) 85 Min (Local)
New Passing Tracks	South San Francisco-Millbrae, Hayward Park-Redwood City, northern Santa Clara County, Blossom Hill

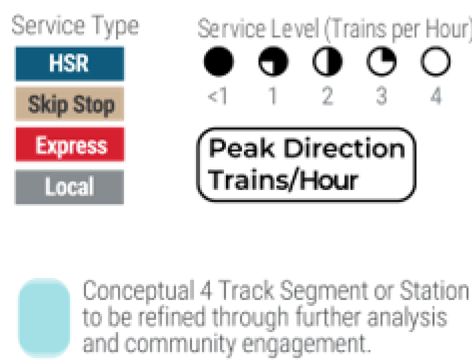


FIGURE 19: HIGH GROWTH WEEKDAY SERVICE LEVELS BY TIME OF DAY

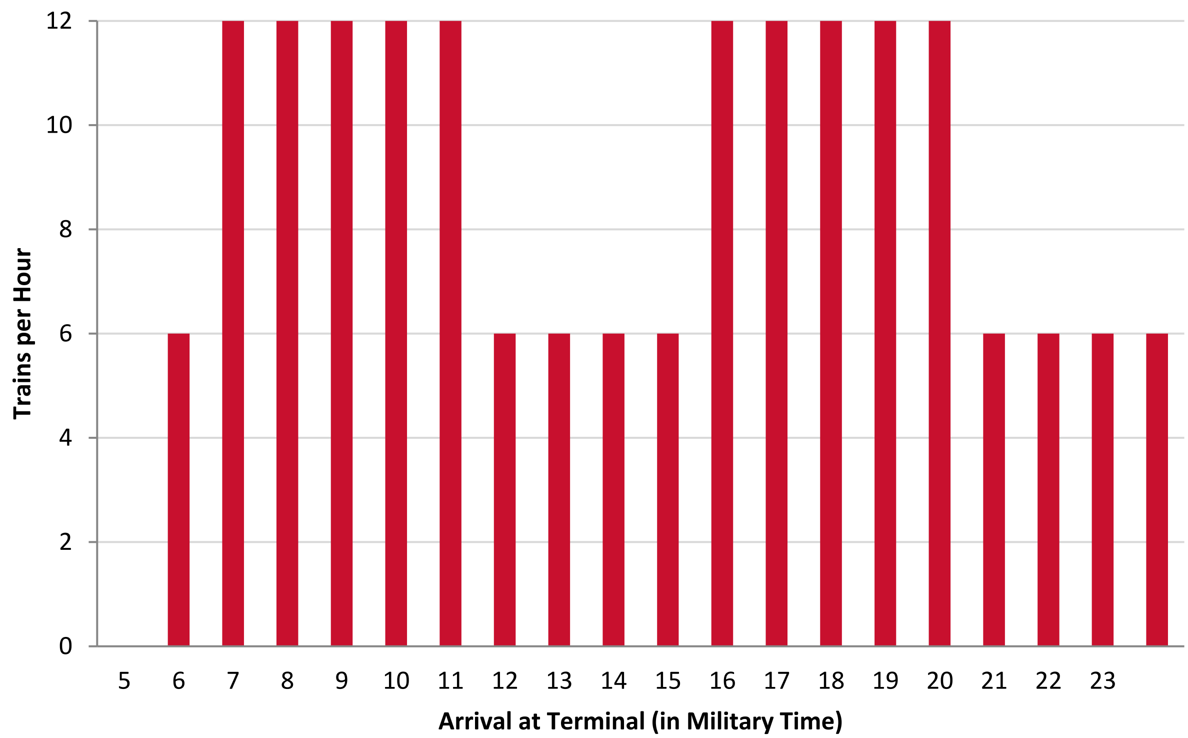
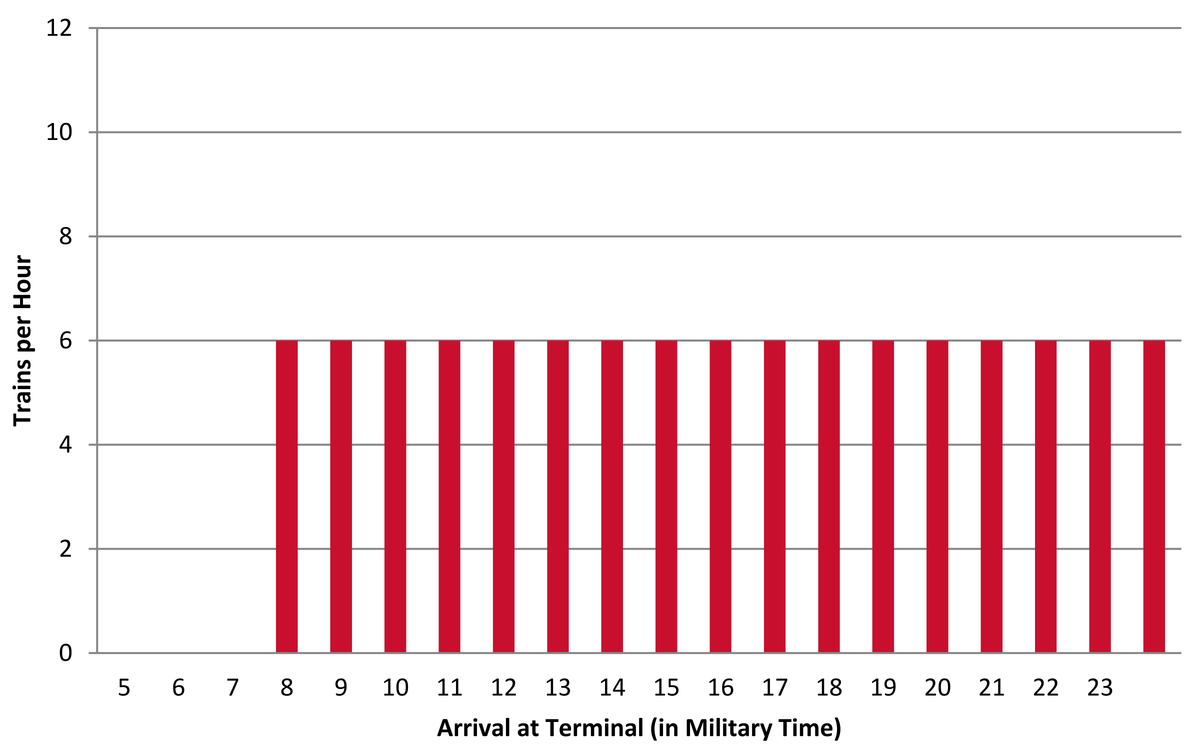


FIGURE 20: HIGH GROWTH WEEKEND SERVICE LEVELS BY TIME OF DAY



5.3 COMPARISON OF SERVICE OUTCOMES

Each service plan improves the frequency and regularity of trains between major stations relative to current service levels, as shown in Table 6. Whereas existing wait times vary widely during peak periods and span up to nearly 50 minutes, the Baseline service plan would reduce this variance to no more than 20 minutes between trains. The regularity of travel times would also improve in the Baseline to a level comparable with existing Baby Bullet trains. The Moderate and High Growth service plans would improve travel times by up to 20 percent relative to the Baseline, while wait times would be further reduced on a regular clockface schedule. The High Growth would provide the fastest overall travel times plus wait times, though the Regional Express overlay service would provide a slightly longer travel time compared to the primary Regional Express service.

Table 6: Travel Times between Major Stations

Origin	Destination	Existing		Baseline Growth (Skip Stop)		Moderate Growth (Regional Express)		High Growth (Regional Express)	
		Travel Time	Wait Time	Travel Time	Wait Time	Travel Time	Wait Time	Travel Time	Wait Time
4th & King	Palo Alto	38-42	7-47	38-41	3-18	34	15	34-39	4-11
4th & King	Redwood City	36-58	5-49	32-36	3-18	29	15	29-31	6-9
4th & King	San Jose	62-74	5-45	62-65	3-18	56	15	55-63	7-8
San Jose	Palo Alto	23-28	7-47	23-24	3-18	21	15	20	4-11
San Jose	Redwood City	29-36	5-49	28-32	3-18	26	15	25	6-9

All travel times and wait times expressed in minutes. Travel times assume the fastest times between stations and exclude Local trains if a faster train is available. Wait times are presented as a range to illustrate the minimum and maximum peak period wait times between OD pairs.

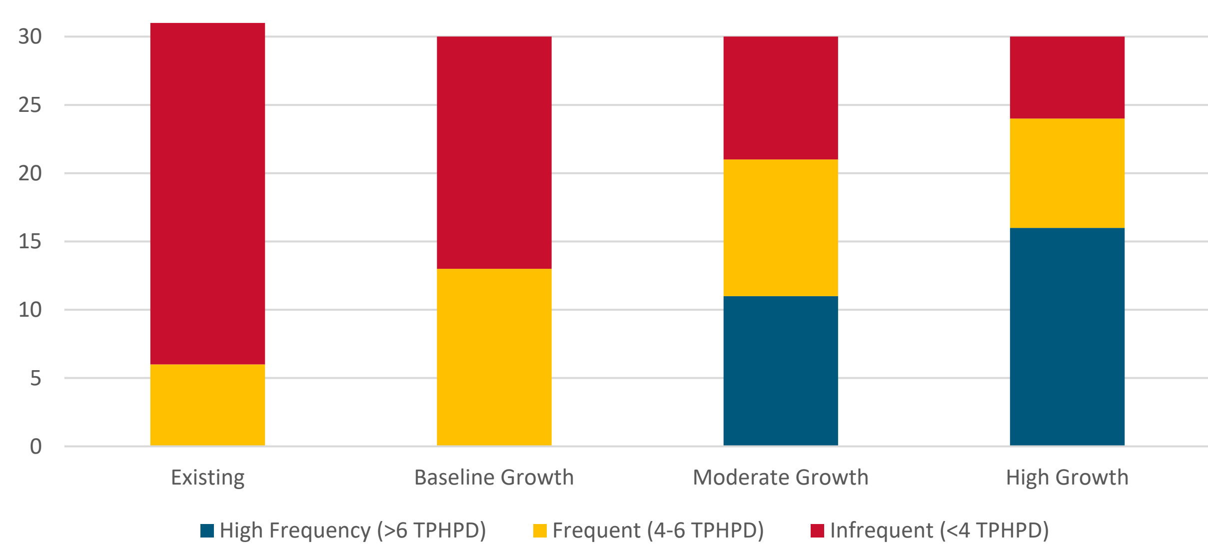
Service levels at individual stations would increase substantially between the Baseline, Moderate, and High Growth service plans relative to existing as shown in Table 6. Today, six Caltrain stations receive four or more trains per hour, per direction, while the remainder are served infrequently - mostly with one to three trains per hour, per direction. Under the Baseline Growth service plan, 13 stations receive greater than four trains per hour, per direction, while most other stations receive at least two trains per hour, per direction. The Moderate and High Growth service plans increase the number of stations receiving frequent service to 21 and 24 stations, respectively.

Table 7: Peak Period Service Levels by Station

Service Characteristics	Trains per Hour, per Direction	Frequency by Number of Stations			
		Existing	Baseline Growth	Moderate Growth	High Growth
Infrequent Service	<2	13	6	3	3
	2	6	12	7	4
	3	6	-	1	1
Frequent Service	4	4	5	9	8
	5	2	-	-	-
	6	-	8	1	-
High Frequency Service	8	-	-	11	6
	10	-	-	-	1
	12	-	-	-	9

Existing service levels are averaged for stations receiving directionally imbalanced service levels.

FIGURE 21: COMPARISON OF STATION SERVICE LEVELS



5.4 FLEET NEEDS

Based on the peak period service plans and cycle times, fleet size estimates were developed for revenue service (excluding spare train sets). As shown in Table 8, fleet needs are approximately in proportion to service levels, but vary depending on the type of service provided: the Baseline Growth service plan needs 22 train sets; Moderate Growth needs 30 train sets; and High Growth needs 42 train sets. These calculations assume full eight car train sets for Baseline Growth and a combination of six and ten car train sets for Moderate and High Growth. Variable consist lengths are not assumed due to operational challenges.

Table 8: Fleet Needs

Scenario	Number of Trains
2040 Baseline Growth Service Plan	22
2040 Moderate Growth Service Plan	30
2040 High Growth Service Plan	42

5.5 GATE DOWN TIME

Gate down time (GDT) was estimated at 41 at-grade crossing along the Caltrain corridor based on the AM peak period service plans for each growth scenario. GDT is defined as the total number of minutes that a gate is down at a crossing during the peak hour. The GDT calculation includes the following inputs:

- The average single-train GDT at each crossing during the AM peak period (derived from the 2011 train schedule analyzed in the PCEP EIR);
- The number of trains per hour per direction (existing and future); and
- The number of minutes of train overlaps based on the train schedule (existing and future).

Based on the results of the analysis, as shown in **Figure 23**, GDTs will increase at most crossings when service increases between Baseline and Moderate or High growth scenarios. **Table 9** provides a high-level GDT summary for the corridor.

The timing of gate events, direction of the train, and the GDT per event effect the total downtime. As shown in the figure, the magnitude of growth varies between crossings, because the increase in trains does not necessarily have a direct and equal impact on GDT. For instance, even with an increase in trains, there may be a reduction in GDT at select crossings due to a high number of overlapping trains.

It is important to note that the results shown are highly sensitive to two important assumptions: the single-train GDT and the train schedule. The single-train GDT is based on Caltrain event recorder data collected in November 2011 for the Caltrain Modernization Program. Any upgrades to the signaling system that have occurred since then or that are planned in the future will impact the average GDT for a single-train at a crossing. Additionally, the schedule used for this analysis is a prototypical schedule. Therefore, the results should not be used in absolute terms, but rather to understand the relative changes between the growth scenarios.

Table 9: GDT Summary by Scenario (minutes)

Scenario	Minimum	Average	Maximum
Existing	6	11	17
2040 Baseline Growth Service Plan	11	17	28
2040 Moderate Growth Service Plan	14	20	31
2040 High Growth Service Plan	18	25	39

FIGURE 22: EXISTING GATE DOWN TIME

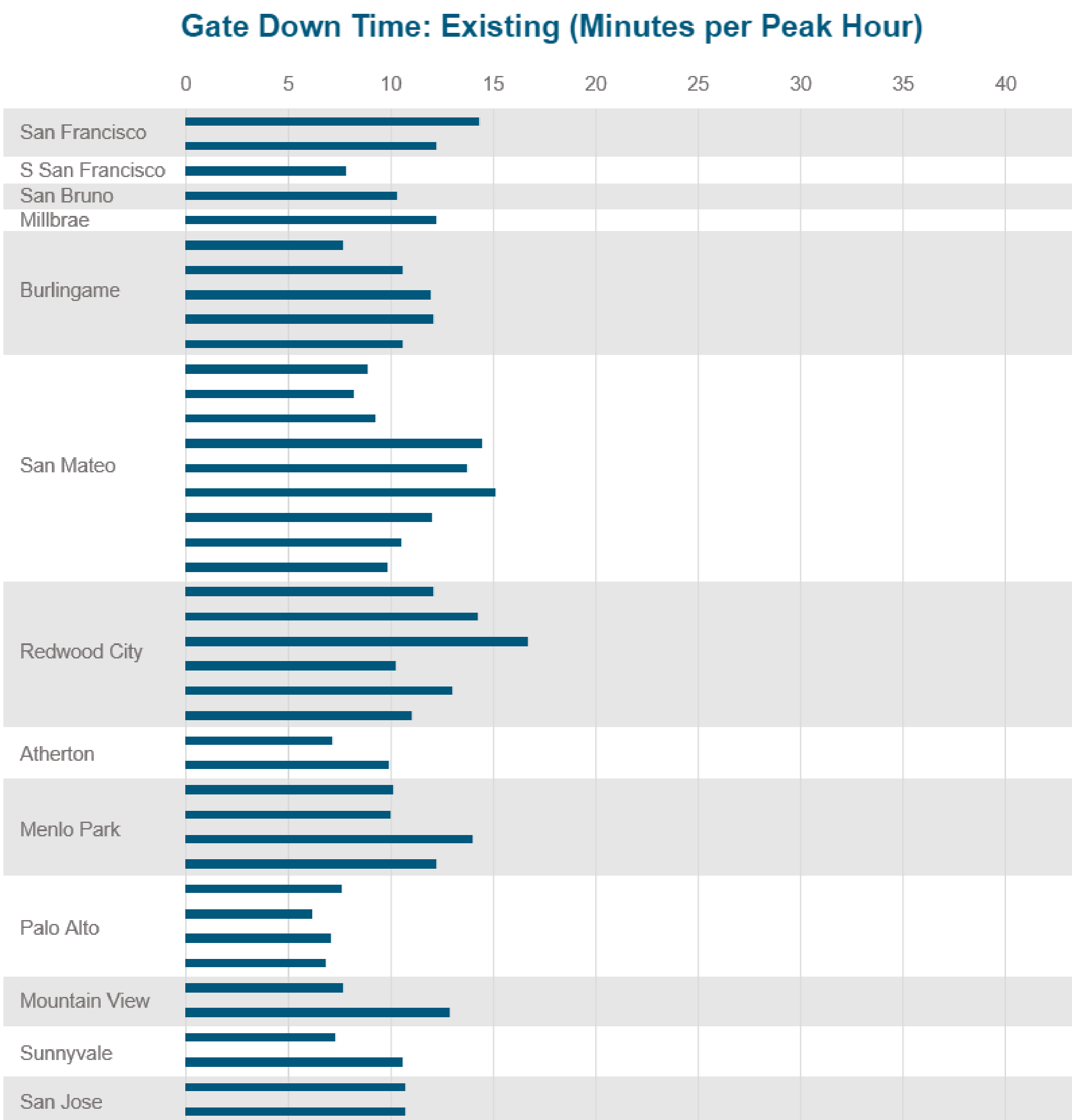
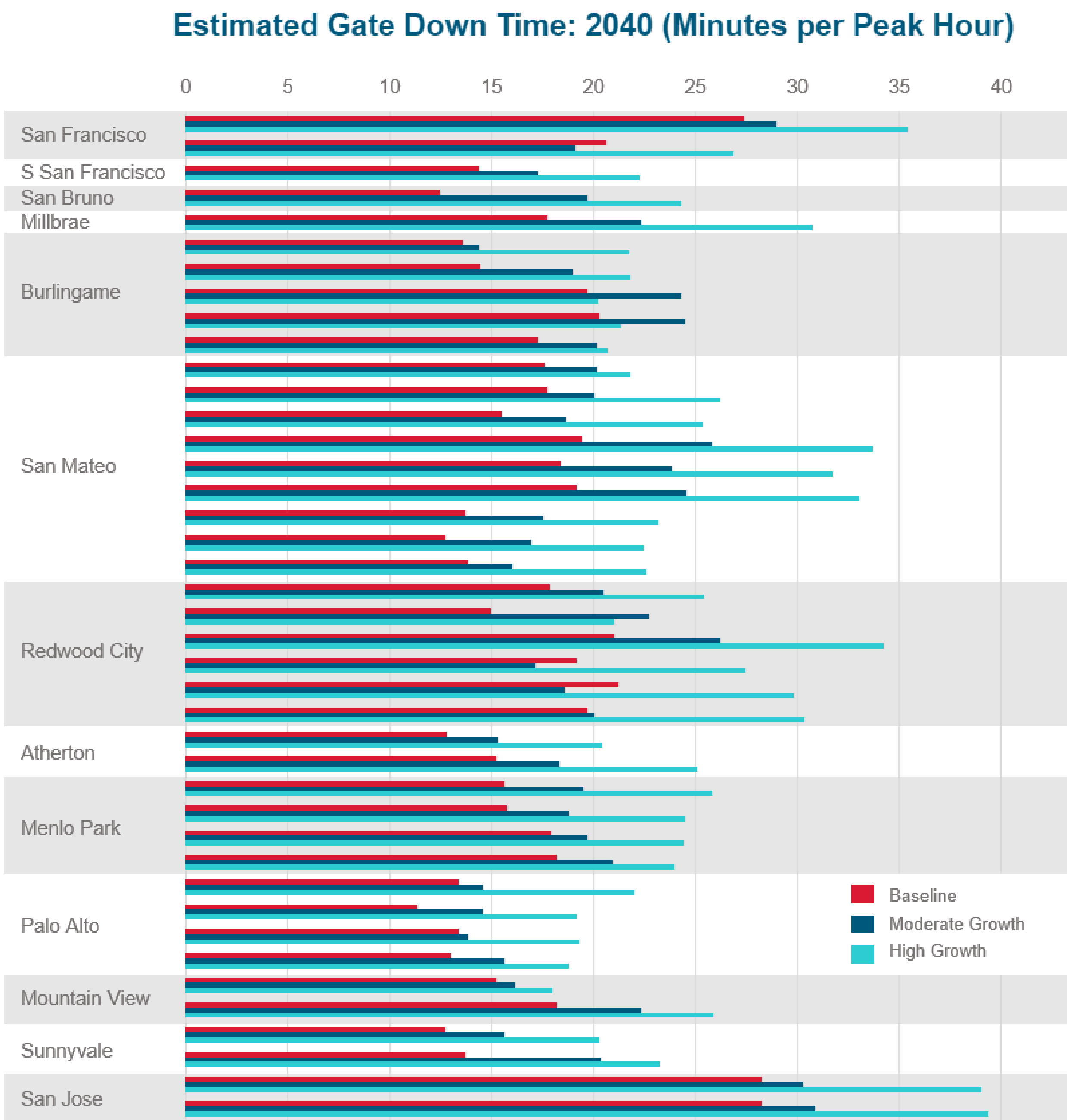


FIGURE 23: 2040 GATE DOWN TIME



6. TERMINAL PLANNING

Caltrain's north and south terminals present unique opportunities and complexities with respect to service planning. "Terminals" refer to the ends of most mainline rail service operations, including both operational needs (such as turn tracks, train storage, and maintenance facilities) and infrastructure (such as tracks, interlockings, and station platforms). This analysis defines the "North Terminal" in San Francisco as the area between Bayshore Station and STC including current terminal facilities at 4th & King, and the "South Terminal" as roughly the area between Santa Clara and Blossom Hill stations in Santa Clara County.

Not only do these areas in San Francisco and San Jose encompass Caltrain's current operations and maintenance facilities as well as high concentrations of ridership, they also present substantial opportunities for land use development and intermodal transfer hubs. In San Francisco, major plans and projects include DTX, the Pennsylvania Avenue Tunnel, the introduction of HSR service, and the redevelopment and relocation of the 4th & King railyard. In San Jose, major plans and projects include the reconstruction of Diridon Station to accommodate the introduction of HSR and BART service, relocation of Central Equipment and Maintenance Facility (CEMOF), and possible reconfigurations of Tamien and Blossom Hill stations. Planning for significant changes to Diridon station inherently affects the other operators including HSR, ACE, Amtrak, and freight. Both terminals present complex operational environments.

The service planning process included extensive coordination with partner agencies to align objectives and outcomes around terminal planning processes. The outcomes of this process includes the following:

- **Initial Operating Plans:** The development of initial, "planning level" operating plans to be used in the Business Plan for the Baseline, Moderate Growth and High Growth service plans at both the North and South Terminals. This work informs the systemwide service plans, ridership modeling, costing, business case evaluations and simulations required to advance the Business Plan process.
- **Simulation:** A rail simulation validates the operational viability of initial operating plans by dynamically simulating the Baseline, Moderate, and High Growth service plans. Simulation work is ongoing and may result in suggested operating, service and infrastructure design changes necessary to achieve reliable operations.

6.1 NORTH TERMINAL ANALYSIS

Caltrain, HSR, City/County of San Francisco, and Transbay Joint Powers Authority (TJPA) staff developed an initial framework of planning inputs for the North Terminal (Table 10). These inputs provided a basis for developing initial operating plans consistent with systemwide service plans. All planning carried out on the North Terminal assumed a base infrastructure configuration as defined in the TJPA - Preliminary Engineering Track Plans; Downtown Rail Extension, October 25, 2018 (Figure 24).

Table 10: North Terminal Planning Parameters

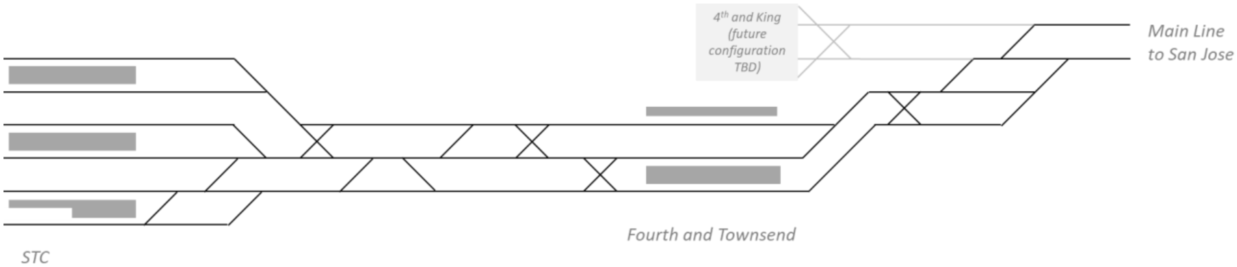
Parameter / Input	Description / Assumption
Minimum separation time - Caltrain	3 minute line headways, 2 minutes on approach to stations (3 minutes on approach to STC)
Minimum separation time - HSR	3 minute line headways, 2 minutes on approach to stations (3 minutes on approach to STC)
Minimum turnaround time - Caltrain	20 minutes (potential exploration of impacts of shorter turn time on equip & platform requirements at terminals)
Minimum turnaround time - HSR	20 minutes
Minimum dwell times at 4th & Townsend - Caltrain	1 minute
Minimum dwell times at 4th & Townsend - HSR	2 minute
Minimum dwell times at 22nd Street- Caltrain	0.7 minutes

Table 10: North Terminal Planning Parameters

Parameter / Input		Description / Assumption
Maximum Train Length - Caltrain		8 Cars - 10 Cars (853')
Maximum Train Length - HSR		205 Meters (656') (double train set 410 meters (1312')
Event-based dwells at 4th & Townsend- Caltrain		Not analyzed in base scenario development
Event-based dwells at 22nd Street- Caltrain		Not analyzed in base scenario development
North Terminal Storage / LMF location - Caltrain		TBD
North Terminal Storage / LMF location - HSR		Brisbane (Potential for some overnight storage at terminal)
Platform Sharing and Assignments		Platforms assigned by service type in development of base service plans. Impacts of use platforms other than those assigned in perturbed conditions to be analyzed in simulation phase.
STC Infrastructure	Number and arrangement of tracks and platforms	Six tracks, three island platforms (HSR southerly platform, Caltrain northerly platform. Middle platform subject to analysis).
	Platform lengths	5 X 1,350'; 1 X 1065' (to bumping post)
	Platform heights	Platforms assigned by service type in development of base service plans. No assumption on platforms heights at this stage.
	Throat design / Interlockings	Per Engineering Track Plans. Changes subject to further input or analysis
4th & Townsend Infrastructure	Number and arrangement of tracks and platforms	3-tracks/1-island and 1-side platform;
	Platform lengths	800'/875'
	Platform heights	Platforms assigned by service type in development of base service plans. No assumption on platforms heights at this stage.
	4th & King Infrastructure (availability of tracks / platforms)	Residual platform availability assumed to be preserved at 4th & King to account for event, disruption, and/or regular revenue service. Number of tracks and platforms TBD.
	Number length and height of available platforms	TBD
	DTX infrastructure (tunnel including speeds, vent zones etc)	Per Engineering Track Plans
	Pennsylvania Avenue Alignment Infrastructure	TBD

Sources: HSR, Caltrain, TJPA - Preliminary Engineering Track Plans; Downtown Rail Extension, October 25, 2018, SF Planning Dept Railyard Alternatives & 1-280 Boulevard (RAB) Feasibility Study

FIGURE 24: TRACK SCHEMATIC NORTH TERMINAL



Key findings from the North Terminal analysis include the following:

- In the Baseline and Moderate Growth service plans, STC could serve all trains, while in the High Growth service plan, STC would serve 12 of the 16 trains. Accommodating all 16 trains at STC is not possible as it results in turn times unacceptably short and operationally unrealistic for all operators. The four additional trains per hour would be routed to the existing platforms at 4th & King.
- There are some potentially tight meets in all three service plans at the at-grade interlocking that sorts trains into and out of STC. All arrivals and departures in the service plan work within the planning parameters and run times on all trains between 4th & Townsend and STC include some schedule margin to account for small variations in arrival and departures in terminal area. These plans will be subject to more detailed analysis and confirmation of operational feasibility with dynamic simulation in the next step of the planning process.
- Turn times at STC above the minimum requirements of 20 minutes are achievable with HSR on two assigned platform faces and Caltrain on four platform faces. It is too early to make a statement at this time on the ability to share platforms among different service types or use platforms. In the Baseline, three platforms assigned to each operator (Caltrain and HSR) is also achievable with tighter turns for Caltrain. In the Moderate and High Growth scenarios, two to four additional trains operate into STC compared to the Baseline and turns at the station are tighter for both HSR and Caltrain, but generally work within minimum parameters with two platform faces assigned to HSR and four to Caltrain. Three and three in normal operation would result in unacceptably short turns for Caltrain.
- Operations through 4th & Townsend and STC work similarly in the Moderate Growth and High Growth service plans, however, there are as of yet unresolved conflicts in this plan at the at-grade junction (CP Common) that connects the lead tracks from 4th & King and lead tracks to STC into to a common two-track main line to the south. Additional service planning work is needed for the High Growth Scenario to develop options for how these conflicts could be resolved. Conflicts could be resolved through adjustment to service patterns and/or construction of additional infrastructure including sending all Local trains to 4th & King and all Express trains to STC, construction of significant, vertically separated junction at or around CP Common, or other adjustments to service plans. In general, viable options exist that will allow for 16 trains per hour service to San Francisco.
- In all scenarios, some residual platform availability is needed at 4th & King to account for special event, service disruption, and/or regular revenue service.

6.2 SOUTH TERMINAL ANALYSIS

Caltrain, HSR, and City of San Jose staff developed an initial framework of planning inputs for the South Terminal (Table 11). As with the North Terminal, these inputs provided a basis for developing initial operating plans consistent with systemwide service plans. A key distinction for the South Terminal is the need to terminate several non-Caltrain operations (HSR, Capitol Corridor, and ACE) in addition to through-running operations for Caltrain, HSR, and Amtrak. While the service planning process has thoroughly examined the track and platform needs and approach track configuration for electrified trains in the South Terminal, analysis of diesel operations and maintenance and storage considerations are still ongoing.

Table 11: South Terminal Planning Parameters

<table>
<tr><th colspan="3">General Inputs & Assumptions</th></tr>
<tr><th colspan="2">Parameter / Input</th><th>Description / Assumption</th></tr>
<tr><td colspan="2">Minimum separation time - Caltrain</td><td>3 minute line headways, 2 minutes on approach to stations</td></tr>
<tr><td colspan="2">Minimum separation time - HSR</td><td>3 minute line headways, 2 minutes on approach to stations</td></tr>
<tr><td colspan="2">Minimum turnaround time - Caltrain</td><td>20 minutes (potential exploration of impacts of shorter turn time on equip & platform requirements at terminals)</td></tr>
<tr><td colspan="2">Minimum turnaround time - HSR</td><td>20 minutes</td></tr>
<tr><td colspan="2">Minimum dwell times at Diridon – Caltrain, HSR CCJPA, ACE Amtrak</td><td>2 minute</td></tr>
<tr><td colspan="2">Minimum Caltrain dwell times- Tamien, Capitol, Blossom Hill</td><td>1 minute</td></tr>
<tr><td colspan="2">Maximum Train Length - Caltrain</td><td>8 Cars - 10 Cars (853')</td></tr>
<tr><td colspan="2">Maximum Train Length - HSR</td><td>205 meters (656') (double train set 410 meters (1312'))</td></tr>
<tr><td colspan="2">Turn facility availability, location and design- Tamien and points south</td><td>Ability to turn Caltrain trains at or close to Tamien. Current HSR design includes two turn track immediately south of Tamien Station</td></tr>
<tr><td colspan="2">Turn facility availability location and design- points north of Diridon</td><td>Ability to turn HSR trains at Diridon on middle platforms with 20 minute dwell.</td></tr>
<tr><td colspan="2">Midday storage needs for diesel operators (CCJPA, ACE)</td><td>ACE at relocated Michael Yard. (HSR design moves Michael Yard from west side of the alignment to the east side.)</td></tr>
<tr><td colspan="2">South Terminal Storage / MF location - Caltrain</td><td>TBD</td></tr>
<tr><td colspan="2">South Terminal Storage / MF location - HSR</td><td>TBD</td></tr>
<tr><td colspan="2">Platform Sharing and Assignments</td><td>Dedicated HSR middle of stations, dedicated electrified Caltrain on either side of HSR platforms. Segregated Electric and diesel platforms</td></tr>
<tr><td colspan="2">HSR runtime requirements</td><td>Commercially viable times San Francisco to San Jose, 40-50 mins</td></tr>
<tr><td rowspan="3">Diridon Station Infrastructure</td><td>Number and arrangement of platforms</td><td>8 tracks / 4 Island platforms for electric system. Legacy system 2 - 3 tracks 1 - 2 platforms</td></tr>
<tr><td>Platform heights</td><td>High level for HSR trains</td></tr>
<tr><td>Approach design / Interlockings</td><td>Segregated NB and SB flows through station area. Ability to turn HSR at Diridon off the main tracks with no crossing conflicts</td></tr>
<tr><td rowspan="5">Infrastructure South of Diridon Station</td><td>General design and alignment of tracks</td><td>Two track electrified corridor for HSR and through Caltrain service. One diesel track for legacy system.</td></tr>
<tr><td>Availability and arrangement of turn tracks at Tamien and/or points south</td><td>Ability to turn Caltrain trains at or close to Tamien. Current HSR design includes two turn track immediately south of Tamien Station</td></tr>
<tr><td>Access to any potential maintenance facility (Caltrain)</td><td>Design TBD. Functionality to allow access to from maintenance facility grade separated from main tracks</td></tr>
<tr><td>General design and alignment of tracks</td><td>Two track electrified corridor for HSR and through Caltrain service. One diesel track for legacy system.</td></tr>
<tr><td>Midday storage access for diesel operators (CCJPA, ACE)</td><td>TBD</td></tr>
</table>

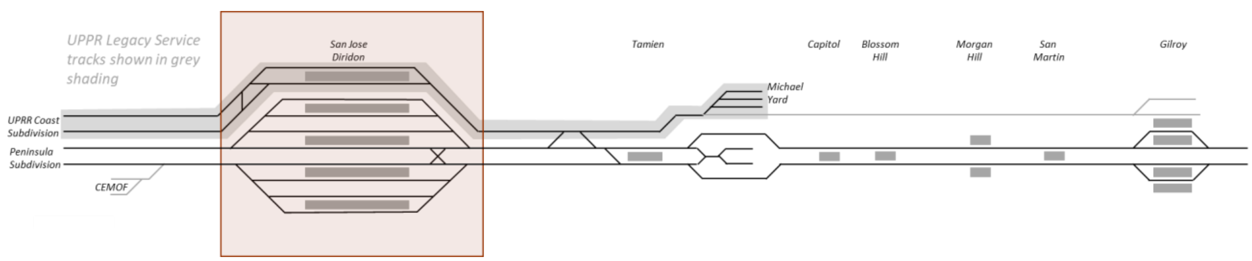
Table 11: South Terminal Planning Parameters

General Inputs & Assumptions		
Parameter / Input		**Description / Assumption**
Infrastructure North of Diridon Station	Presence of CEMOF and/or availability of turn tracks	TBD

Figure 25 shows a schematic of the assumed future baseline infrastructure for the south terminal area and the San Jose to Gilroy Corridor. These baseline assumptions for the approach north of the station and the corridor south of the station are consistent with the High-Speed Rail Preliminary Engineering for Project Definition (PEPD) draft drawings as of December 2018. As defined in these drawings, the future infrastructure includes a four-track approach from the north between CP Coast and the station and three tracks between San Jose and Gilroy with two electrified for HSR and through Caltrain service, and one non-electrified for freight and legacy service. The baseline infrastructure also includes two turn tracks south of Tamien and a reconfigured Michael Yard on the east side of the right of way.

Additional improvements beyond the PEPD are assumed for the track and platform configuration at Diridon station, consistent with the needs identified in the preliminary terminal service planning as well as on-going design work being carried out in the Diridon Integrated Station Concept. The terminal analysis identified the need for eight platform faces to support the electrified service in all future 2040 service plans. Two platforms faces are assumed for diesel operations (ACE, Capitol Corridor, Amtrak, and UP), however, more detailed assessment of operator needs is ongoing.

FIGURE 25: SAN JOSE TERMINAL AREA SCHEMATIC



Key findings from the South Terminal analysis include the following:

- The Baseline Growth service plan generally works within the baseline infrastructure currently contemplated for the South Terminal Area with some level of operational risk which will be tested with the Business Plan's ongoing rail simulation. Operational challenges result from turning six Caltrain and three HSR trains in the San Jose Area (Diridon/Tamien). The two turn tracks south of Tamien are insufficient to turn all six Caltrain trains in the peak hour forcing some turns to remain at Diridon Station. These turns could potentially cause crossing conflicts in the interlocking north of the station.

- The Moderate Growth service plan operates all eight Caltrain trains through Diridon Station in the peak hour, with four operating south of Tamien to Blossom Hill and Gilroy. The turn tracks south of Tamien are sufficient to handle the four trains per hour in the peak assumed to turn at Tamien. The operation of bi-directional service to Blossom Hill and Gilroy in the Moderate Growth service plan allow for turning fewer trains at San Jose/Tamien compared to the Baseline (four trains vs six) which allows for a smother operation through the terminal area. Moreover, enhanced service to Capitol and Blossom Hill presents an opportunity to increase ridership. The Moderate Growth service plan would require an additional infrastructure investment in turn tracks south of Blossom Hill (single turn track south of station).

- The High Growth service plan generally works within the baseline infrastructure assumed for Diridon Station, however, it would require a significant additional investment to turn trains south of Diridon, either at Tamien station or facility south of Tamien. The High Growth service plan operates all 12 trains through Diridon in the peak hour, with four operating south of Tamien to Blossom Hill and Gilroy. This leaves a balance of eight trains that need to turn at Tamien. This total exceeds the capacity of the two turn tracks at Tamien assumed in the baseline - triggering the need for additional investment in this area. This investments could be in additional station platform tracks, additional tail tracks, or relocation of maintenance facility south of Tamien with ability to turn trains. The High Growth service plan would require the same infrastructure investment at Blossom Hill - a single turn track south of station – as the Moderate Growth service plan.

7. EXPLORATIONS

This section explores potential uncertainties and variations in the service plans related to Caltrain-specific and external variables. It qualitatively covers a range of topics related to potential service and infrastructure outcomes.

7.1 SERVICE PLAN FLEXIBILITY

The service plans outline a vision for Caltrain operations based on an operational and infrastructure framework. While these service plans were developed based on the most current forecasts available, changes are expected over the next two decades that may alter service needs. Each service plan includes some flexibility to accommodate changes over time.

There is some flexibility in each scenario to reallocate service levels between stations depending on changes in demand, but the allocation of stops is a zero-sum game. In the Baseline Growth service plan, stops may be reallocated between stations so long as they provide similar overall travel times. Since the Baseline Growth service plan reflects previous analyses over the past decade, there may be some opportunities to further optimize the service pattern. The Moderate Growth service plan also has some flexibility to shift service levels between stops; however, a local stop pattern is not viable due to limited overtake locations.

The High Growth service plan has the most flexibility to reallocate Regional Express stops between stations for the overlay Regional Express service between 4th & King/Townsend and Tamien. Stops may be reallocated in a variety of ways to achieve six or more trains per hour, per direction at more stations, but are somewhat limited by the locations of overtakes relative to the locations of passing tracks:

- Service north of Burlingame cannot be changed due to the need to overtake the Local train;
- Service to Burlingame may be increased by shifting service from Hayward Park, so that Burlingame receives four or six trains per hour, per direction;
- Service to Belmont may be increased by shifting service from Hayward Park or San Carlos, so that Belmont receives six trains per hour, per direction; and
- Service to California Avenue and San Antonio may be increased by shifting service from Mountain View without affecting any infrastructure or overtakes.

7.2 ACE & CAPITOL CORRIDOR INTERFACE

Both ACE and Capitol Corridor plan to double service levels over the next two decades. While there are limited transfers between these services and Caltrain, their operations overlap between Santa Clara Station and Tamien Station. The following service changes are currently planned:

- Capitol Corridor's Vision Plan Implementation Strategy calls for increasing service levels between Oakland and San Jose from seven daily round trips to 11 daily round trips by the late 2020s and 15 daily round trips by 2040. Service would shift to the Coast Subdivision in the East Bay, serving a new Fremont/Newark station near the Dumbarton Bridge.
- The ACE Forward Plan calls for increasing service levels from four daily round trips to six daily round trips by the mid-2020s and 10 daily round trips by the late 2020s. Service would also be extended to Modesto and Merced.

Both services would remain separate services using dedicated tracks under all Business Plan scenarios. However, each agency is now contemplating a broader electrification effort to achieve four trains per hour, per direction.

FIGURE 26: CAPITOL CORRIDOR VISION PLAN IMPLEMENTATION STRATEGY

FIGURE 27: ACE FORWARD EXPANSION PLANS

If ACE and Capitol Corridor are able to achieve comparable fleet performance and reliability to Caltrain, it may introduce interlining possibilities along the Caltrain corridor across the Dumbarton Bridge in the High Growth service plan. In order to accommodate this level of service, trains would need to run through Diridon Station to a new storage and turn facility south of the station. This facility could be shared with a future Caltrain facility.

7.3 CENTRAL COAST RAIL INTERFACE

The State Rail Plan calls for expanded intercity rail service to the Central Coast region. Service would be provided between Los Angeles and Gilroy via stations such as Santa Barbara, San Luis Obispo, and Salinas. This service would connect to Caltrain at Gilroy Station. The Transportation Agency for Monterey County has proposed expanding passenger rail service from San Jose to Salinas with stations in Pajaro, Castroville, and Salinas in the near term.

In order to interline or extend passenger rail service south of Gilroy, the Monterey/Central Coast corridor would need to be electrified. For all scenarios, there are no additional peak-period slots available between San Jose and Gilroy to interline non-Caltrain, non-HSR services without adding passing tracks north of Blossom Hill station.

FIGURE 28: STATE RAIL PLAN – CENTRAL COAST SERVICES

7.4 DUMBARTON RAIL INTERFACE

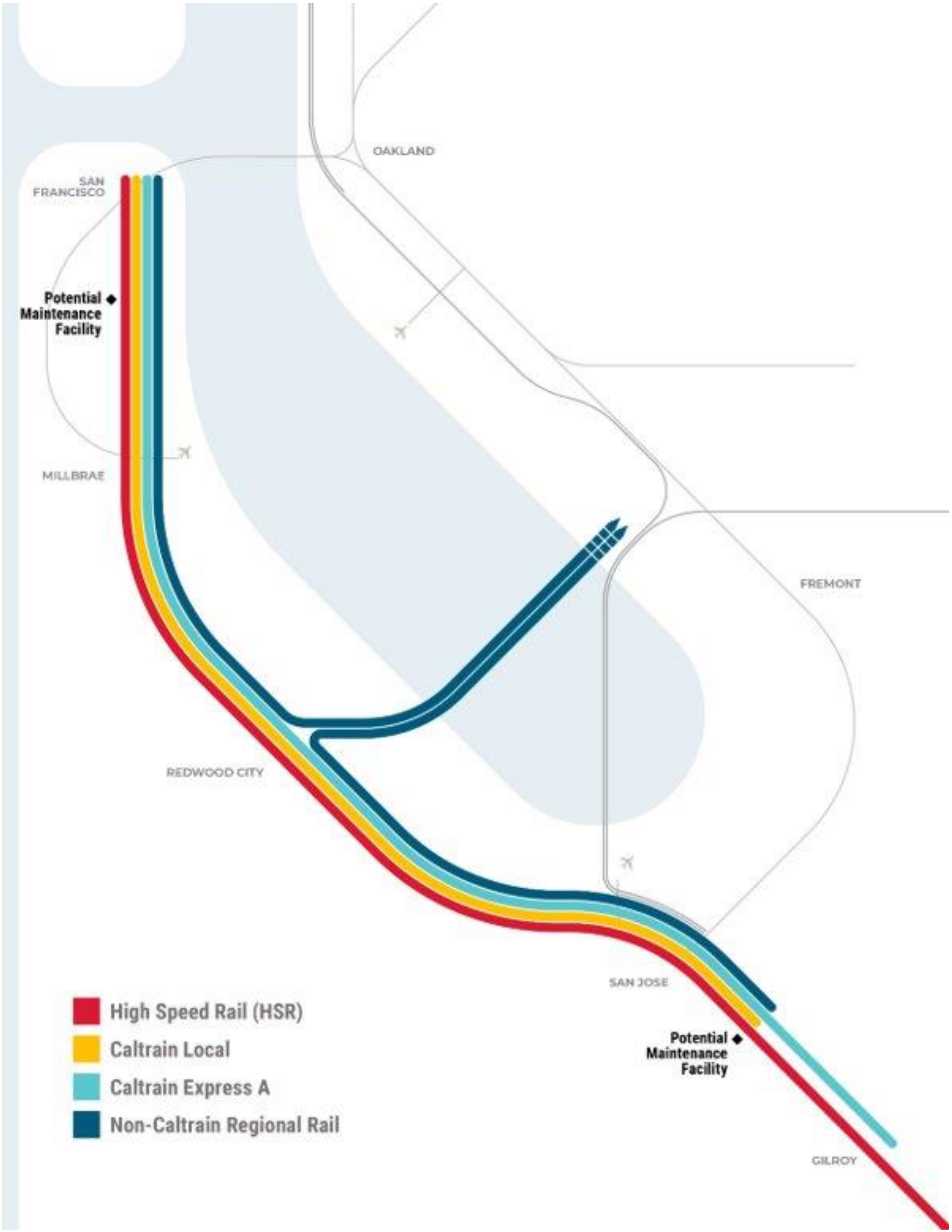
Ongoing studies of the Dumbarton Rail corridor are considering a range of service options spanning the Caltrain Corridor and East Bay. To date, most analysis for service from the East Bay via Dumbarton has focused on a rail shuttle service between the East Bay and Redwood City with a timed connection to Caltrain in the Moderate and High Growth service plans (the connection would not be timed in the Baseline). This hub arrangement for timed connections between Regional Express and Local trains at Redwood City would maximize connectivity for passengers connecting to Caltrain from Dumbarton rail service. Dumbarton trains could arrive at the station just before this Caltrain service "pulse" and depart just after, providing multiple simultaneous connections for Dumbarton passengers. This shuttle service would require dedicated tracks and a platform for Dumbarton service separate and adjacent to the tracks and platforms for Peninsula service. Dumbarton service operating on separate parallel tracks into a dedicated platform on the east side of Redwood City would not provide cross platform transfers for Dumbarton passengers. Additional investments to bring Dumbarton service into the center of the station with a grade separation (either fly over or duck under) could provide cross platform transfers to northbound and southbound Regional Express service.

FIGURE 29: DUMBARTON "RAIL SHUTTLE" CONCEPT

Alternatively, a new station south of Redwood City could facilitate transfers to Local service near North Fair Oaks. Rather than Dumbarton service operating into an expanded Redwood City station, the service could operate into a new, purpose-built station approximately midway between the existing Redwood City and Atherton Station. If the four-track section identified in the Moderate and High Growth service plans for Redwood City is extended down through the new station at North Fair Oaks, this station could be added to the local trains without any additional implications in terms of service or infrastructure changes north or south of this territory. This option may be easier from a constructability standpoint than building adjacent to the existing Redwood City station, however, the Dumbarton trains would only get access to the local service as the Regional Express trains would operate non-stop through this station. The alternative – shifting Regional Express service from Redwood City to North Fair Oaks – would significantly inconvenience a large ridership market at Redwood City.

Another option may be to interline Dumbarton and Caltrain service along the Caltrain Corridor, particularly if a broader investment in the East Bay and Central Valley occurs beyond what was under consideration in previous Dumbarton Rail studies and the State Rail Plan. There are no available train slots to interline trains from Dumbarton to operate through service onto the Peninsula in the Baseline or Moderate service plan. However, in the High Growth Service plan, there may be an opportunity to redirect the "Express B" slots over the Dumbarton Bridge provided that significant megaregional investments are made to allow for grade separated moves to and from the Caltrain mainline and the electrification of the East Bay corridor with comparable rolling stock. In this service plan, trains would operate from the same tracks and platforms at Redwood City and elsewhere on the Peninsula. Trains could be interlined from the Central Valley traveling to San Francisco or San Jose, or from Sacramento traveling to San Jose. However, absent such a megaregional investment, interlining service between Union City and San Francisco or San Jose could result in lower overall ridership compared to the High Growth Scenario.

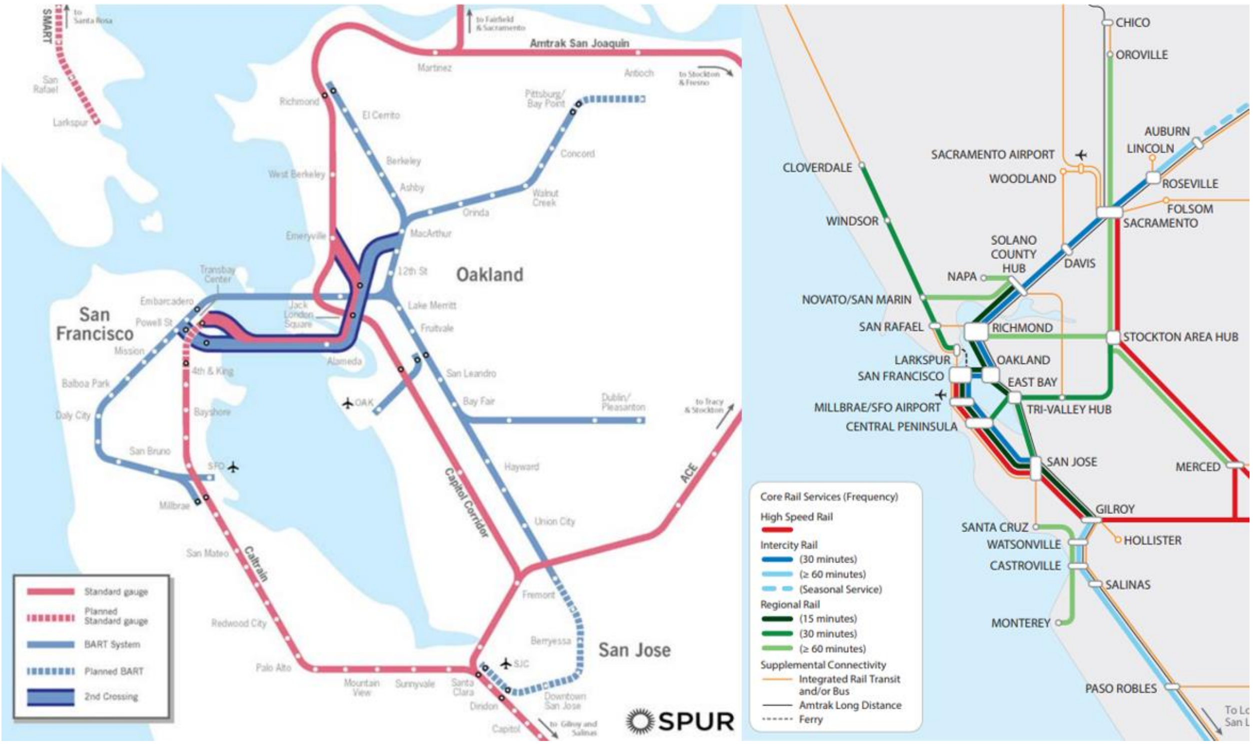
FIGURE 30: DUMBARTON RAIL INTERLINED SERVICE CONCEPT



7.5 SECOND TRANSBAY TUBE

A Second Transbay Rail Tube presents an opportunity to serve travel demand between the Caltrain Corridor, the East Bay, Sacramento, and the Central Valley via conventional rail service. Preliminary discussions have centered around linking the Caltrain corridor and Capitol Corridor services as an intercity rail line (as outlined in the State Rail Plan). BART's Metro Vision Plan also considered a regional rail service along the I-80 corridor in the East Bay. BART will commence a comprehensive study of potential Transbay options later this year.

FIGURE 31: SECOND TRANSBAY TUBE CONCEPTS – SPUR CONCEPT (LEFT) AND STATE RAIL PLAN (RIGHT)

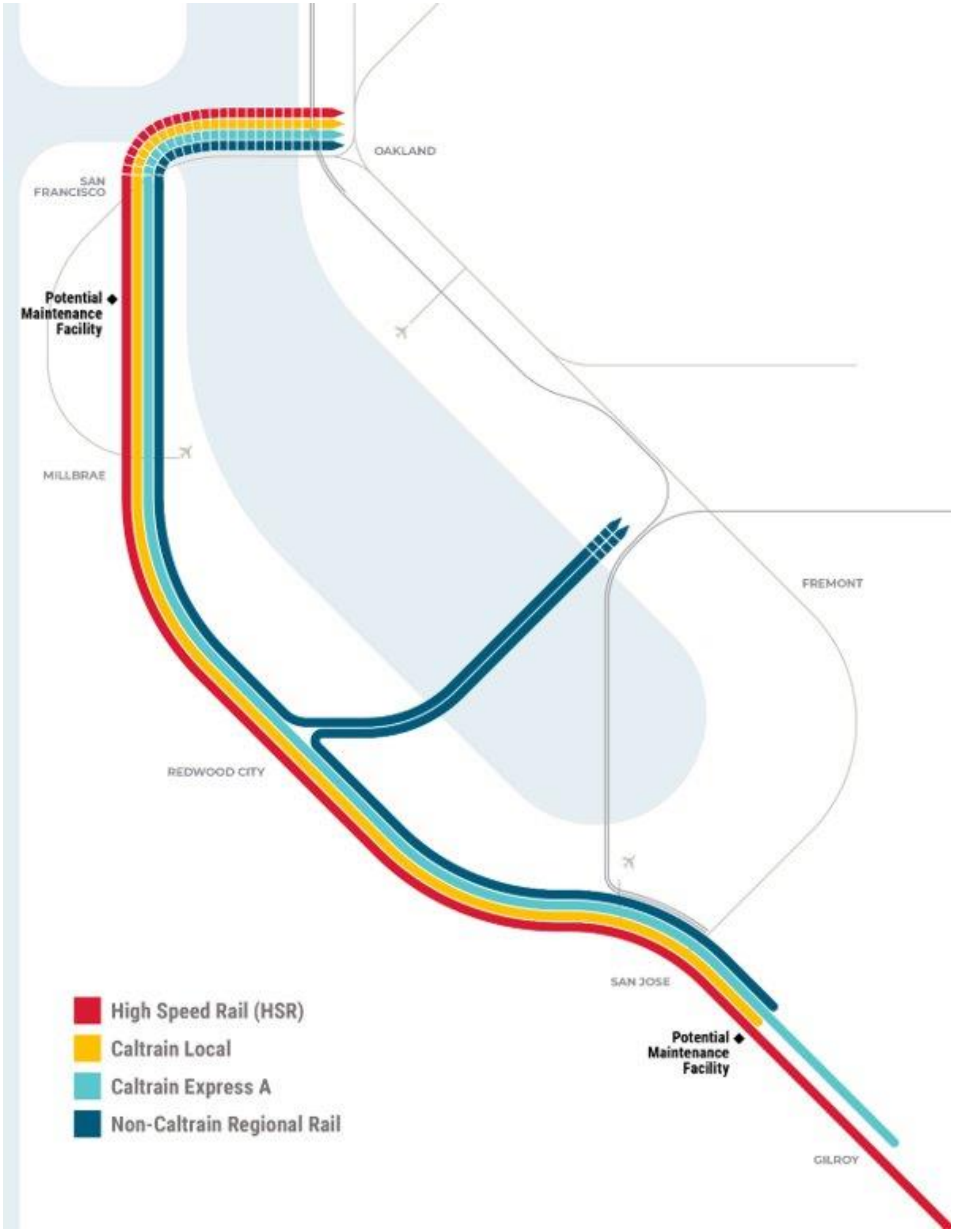


Several options are under consideration for linking Caltrain passengers to the East Bay. One option would transform STC from a stub terminal to a through station with the tunnel extending from the station, with all trains stopping at STC before continuing to the East Bay. STC's six platform tracks could handle all trains operating to San Francisco, even in High Growth service plan if all trains run through, assuming dwell time values are similar to the dwell time values at San Jose Diridon (trains could not turn around at STC). The High Growth service plan may also potentially accommodate an interlined, electrified Capitol Corridor service to Sacramento; however, the Baseline and Moderate Growth service plans do not have available slots to accommodate interlined service.

Another option would extend the tunnel from around 4th & Townsend/4th & King station (either at the station or farther south). For this concept, not all Caltrain service would stop at STC. In order to fully serve demand to both STC and the East Bay, a significant investment to increase the throughput of the corridor to the south beyond what is envisioned in the High Growth service plan to achieve a mostly four-track corridor to San Jose. Otherwise, both investments would be substantially constrained and underutilized. Furthermore, the junction between the tunnel and DTX would need to be fully grade separated; otherwise capacity would be even more limited.

A second Transbay Tube would exacerbate crowding challenges in the Baseline and Moderate Growth service plans. In contrast, the High Growth service plan could accommodate increased demand and new services. As envisioned in the State Rail Plan, new regional trains may be interlined connecting Sacramento, San Francisco, and San Jose using the Express B slots. If rail service is interlined along the Dumbarton corridor as well, regional trains could serve a "C" shaped route via the Second Transbay Tube, San Francisco, and the Dumbarton Bridge. Further analysis of regional and megaregional travel patterns is necessary to determine optimal routing and interlining options.

FIGURE 32: SECOND TRANSBAY TUBE CONCEPTS WITH DUMBARTON RAIL



8. NEXT STEPS

- Board Uses of this Information
- Future Work

Appendix A

Table A-1: Southbound Customer Timetable for Baseline Growth

Train type	HSR	IC (HSR)	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	HSR	IC (HSR)	IC (HSR)	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	HSR	IC (HSR)	REG (C-EXP)
Train number	805	755	407	905	507	301	807	705	757	409	907	509	303	809	759	411
SALESFORCE TRANSIT CENTER (STC)	6:10		6:13	6:16	6:21	6:26	6:40			6:43	6:46	6:51	6:56	7:10		7:13
TOWNSEND / 4TH AND KING	|		6:18	6:21	6:26	6:31	|			6:48	6:51	6:56	7:01	|		7:18
22nd STREET	|		|	|	6:31	6:36	|			|	|	7:01	7:06	|		|
BAYSHORE	|		6:29	|	|	|	|			6:59	|	|	|	|		7:29
SOUTH SAN FRANCISCO	|		|	|	|	6:43	|			|	|	|	7:13	|		|
SAN BRUNO	|		|	|	6:39	|	|			|	|	7:09	|	|		|
MILLBRAE	6:30		6:38	|	6:43	6:48	7:00			7:08	|	7:13	7:18	7:30		7:38
BROADWAY	|		6:41	|	|	|	|			7:11	|	|	|	|		7:41
BURLINGAME	|		|	|	|	6:52	|			|	|	|	7:22	|		|
SAN MATEO	|		|	|	6:47	6:55	|			|	|	7:17	7:25	|		|
HAYWARD PARK	|		6:45	|	|	|	|			7:15	|	|	|	|		7:45
HILLSDALE	|		6:48	|	6:52	6:58	|			7:18	|	7:22	7:28	|		7:48
BELMONT	|		|	|	6:55	|	|			|	|	7:25	|	|		|
SAN CARLOS	|		6:52	|	|	|	|			7:22	|	|	|	|		7:52
REDWOOD CITY	|		6:56	|	|	7:04	|			7:26	|	|	7:34	|		7:56
ATHERTON	|		|	|	|	7:08	|			|	|	|	7:38	|		|
MENLO PARK	|		|	|	7:02	|	|			|	|	7:32	|	|		|
PALO ALTO	|		7:01	|	7:05	7:11	|			7:31	|	7:35	7:41	|		8:01
STANDFORD STADIUM	|		|	|	|	|	|			|	|	|	|	|		|
CALIFORNIA AVENUE	|		|	|	7:08	|	|			|	|	7:38	|	|		|
SAN ANTONIO	|		7:05	|	|	|	|			7:35	|	|	|	|		8:05
MOUNTAIN VIEW	|		7:09	|	7:13	7:18	|			7:39	|	7:43	7:48	|		8:09
SUNNYVALE	|		7:13	|	7:17	|	|			7:43	|	7:47	|	|		8:13
LAWRENCE	|		7:16	|	|	7:27	|			7:46	|	|	7:57	|		8:16
SANTA CLARA	|		|	|	7:23	|	|			|	|	7:53	|	|		|
COLLEGE PARK	|		|	|	|	|	|			|	|	|	|	|		|
SAN JOSE	7:05	7:24	7:26	7:12	7:30	7:38	7:35	7:48	7:54	7:56	7:42	8:00	8:08	8:05	8:24	8:26
TAMIEN	|	|	o 7:29	|	o 7:33	o 7:41	|	|	|	o 7:59	|	o 8:03	o 8:11	|	|	o 8:29
CAPITOL	|	|		|			|	|	|		|			|	|	
BLOSSOM HILL	|	|		|			|	|	|		|			|	|	
MORGAN HILL	|	|		|			|	|	|		|			|	|	
SAN MARTIIN	|	|		|			|	|	|		|			|	|	
GILROY	7:31	7:49		7:37			8:01	8:13	8:19		8:07			8:31	8:49	

Train type	HSR	REG (C-EXP)	REG (C-EXP)	HSR	IC (HSR)	IC (HSR)	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	HSR	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	HSR	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)
Train number	909	511	305	811	707	761	413	911	513	307	813	415	913	515	309	815	417	915	517	311
SALESFORCE TRANSIT CENTER (STC)	7:16	7:21	7:26	7:40			7:43	7:46	7:51	7:56	8:10	8:13	8:16	8:21	8:26	8:40	8:43	8:46	8:51	8:56
TOWNSEND / 4TH AND KING	7:21	7:26	7:31	|			7:48	7:51	7:56	8:01	|	8:18	8:21	8:26	8:31	|	8:48	8:51	8:56	9:01
22nd STREET	|	7:31	7:36	|			|	|	8:01	8:06	|	|	|	8:31	8:36	|	|	|	9:01	9:06
BAYSHORE	|	|	|	|			7:59	|	|	|	|	8:29	|	|	|	|	8:59	|	|	|
SOUTH SAN FRANCISCO	|	|	7:43	|			|	|	|	8:13	|	|	|	|	8:43	|	|	|	|	9:13
SAN BRUNO	|	7:39	|	|			|	|	8:09	|	|	|	|	8:39	|	|	|	|	9:09	|
MILLBRAE	|	7:43	7:48	8:00			8:08	|	8:13	8:18	8:30	8:38	|	8:43	8:48	9:00	9:08	|	9:13	9:18
BROADWAY	|	|	|	|			8:11	|	|	|	|	8:41	|	|	|	|	9:11	|	|	|
BURLINGAME	|	|	7:52	|			|	|	|	8:22	|	|	|	|	8:52	|	|	|	|	9:22
SAN MATEO	|	7:47	7:55	|			|	|	8:17	8:25	|	|	|	8:47	8:55	|	|	|	9:17	9:25
HAYWARD PARK	|	|	|	|			8:15	|	|	|	|	8:45	|	|	|	|	9:15	|	|	|
HILLSDALE	|	7:52	7:58	|			8:18	|	8:22	8:28	|	8:48	|	8:52	8:58	|	9:18	|	9:22	9:28
BELMONT	|	7:55	|	|			|	|	8:25	|	|	|	|	8:55	|	|	|	|	9:25	|
SAN CARLOS	|	|	|	|			8:22	|	|	|	|	8:52	|	|	|	|	9:22	|	|	|
REDWOOD CITY	|	|	8:04	|			8:26	|	|	8:34	|	8:56	|	|	9:04	|	9:26	|	|	9:34
ATHERTON	|	|	8:08	|			|	|	|	8:38	|	|	|	|	9:08	|	|	|	|	9:38
MENLO PARK	|	8:02	|	|			|	|	8:32	|	|	|	|	9:02	|	|	|	|	9:32	|
PALO ALTO	|	8:05	8:11	|			8:31	|	8:35	8:41	|	9:01	|	9:05	9:11	|	9:31	|	9:35	9:41
STANDFORD STADIUM	|	|	|	|			|	|	|	|	|	|	|	|	|	|	|	|	|	|
CALIFORNIA AVENUE	|	8:08	|	|			|	|	8:38	|	|	|	|	9:08	|	|	|	|	9:38	|
SAN ANTONIO	|	|	|	|			8:35	|	|	|	|	9:05	|	|	|	|	9:35	|	|	|
MOUNTAIN VIEW	|	8:13	8:18	|			8:39	|	8:43	8:48	|	9:09	|	9:13	9:18	|	9:39	|	9:43	9:48
SUNNYVALE	|	8:17	|	|			8:43	|	8:47	|	|	9:13	|	9:17	|	|	9:43	|	9:47	|
LAWRENCE	|	|	8:27	|			8:46	|	|	8:57	|	9:16	|	|	9:27	|	9:46	|	|	9:57
SANTA CLARA	|	8:23	|	|			|	|	8:53	|	|	|	|	9:23	|	|	|	|	9:53	|
COLLEGE PARK	|	|	|	|			|	|	|	|	|	|	|	|	|	|	|	|	|	|
SAN JOSE	8:12	8:30	8:38	8:35	8:48	8:54	8:56	8:42	9:00	9:08	9:05	9:26	9:12	9:30	9:38	9:35	9:56	9:42	10:00	10:08
TAMIEN	|	o 8:33	o 8:41	|	|	|	o 8:59	|	o 9:03	o 9:11	|	o 9:29	|	o 9:33	o 9:41	|	o 9:59	|	10:03	10:11
CAPITOL	|			|	|	|		|			|		|			|		|		
BLOSSOM HILL	|			|	|	|		|			|		|			|		|		
MORGAN HILL	|			|	|	|		|			|		|			|		|		
SAN MARTIIN	|			|	|	|		|			|		|			|		|		
GILROY	8:37			9:01	9:13	9:19		9:07			9:31		9:37			10:01		10:07		

Table A-2: Northbound Customer Timetable for Baseline Growth

Train type	REG (C-EXP)	REG (C-EXP)	HSR	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	IC (HSR)	IC (HSR)	HSR	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	IC (HSR)	HSR	REG (C-EXP)	HSR
Train number	512		910	316	810	514		756	704	912	318	812	516		758	914	320	814
GILROY		6:03	6:25		6:31		6:33	6:43	6:49	6:55		7:01		7:03	7:13	7:25		7:31
SAN MARTIIN		|	|		|		|	|	|	|		|		|	|	|		|
MORGAN HILL		6:13	|		|		6:43	|	|	|		|		7:13	|	|		|
BLOSSOM HILL		6:22	|		|		6:52	|	|	|		|		7:22	|	|		|
CAPITOL		6:27	|		|		6:57	|	|	|		|		7:27	|	|		|
TAMIEN	6:27	6:31	|	6:49	|	6:57	7:01	|	|	|	7:19	|	7:27	7:31	|	|	7:49	|
SAN JOSE	6:30	6:34	6:48	6:52	6:55	7:00	7:04	7:06	7:12	7:18	7:22	7:25	7:30	7:34	7:36	7:48	7:52	7:55
SAN JOSE	6:32	6:36	6:50	6:54	6:57	7:02	7:06			7:20	7:24	7:27	7:32	7:36		7:50	7:54	7:57
COLLEGE PARK	|	|	|	|	|	|	|			|	|	|	|	|		|	|	|
SANTA CLARA	6:39	|	|	|	|	7:09	|			|	|	|	7:39	|		|	|	|
LAWRENCE	|	6:45	|	7:08	|	|	7:15			|	7:38	|	|	7:45		|	8:08	|
SUNNYVALE	6:45	6:48	|	|	|	7:15	7:18			|	|	|	7:45	7:48		|	|	|
MOUNTAIN VIEW	6:48	6:52	|	7:13	|	7:18	7:22			|	7:43	|	7:48	7:52		|	8:13	|
SAN ANTONIO	|	6:56	|	|	|	|	7:26			|	|	|	|	7:56		|	|	|
CALIFORNIA AVENUE	6:53	|	|	|	|	7:23	|			|	|	|	7:53	|		|	|	|
PALO ALTO	6:57	7:00	|	7:20	|	7:27	7:30			|	7:50	|	7:57	8:00		|	8:20	|
MENLO PARK	6:59	|	|	|	|	7:29	|			|	|	|	7:59	|		|	|	|
ATHERTON	|	|	|	7:23	|	|	|			|	7:53	|	|	|		|	8:23	|
REDWOOD CITY	|	7:05	|	7:27	|	|	7:35			|	7:57	|	|	8:05		|	8:27	|
SAN CARLOS	|	7:08	|	|	|	|	7:38			|	|	|	|	8:08		|	|	|
BELMONT	7:06	|	|	|	|	7:36	|			|	|	|	8:06	|		|	|	|
HILLSDALE	7:09	7:12	|	7:33	|	7:39	7:42			|	8:03	|	8:09	8:12		|	8:33	|
HAYWARD PARK	|	7:15	|	|	|	|	7:45			|	|	|	|	8:15		|	|	|
SAN MATEO	7:14	|	|	7:36	|	7:44	|			|	8:06	|	8:14	|		|	8:36	|
BURLINGAME	|	|	|	7:39	|	|	|			|	8:09	|	|	|		|	8:39	|
BROADWAY	|	7:19	|	|	|	|	7:49			|	|	|	|	8:19		|	|	|
MILLBRAE	7:18	7:22	|	7:43	7:32	7:48	7:52			|	8:13	8:02	8:18	8:22		|	8:43	8:32
SAN BRUNO	7:22	|	|	|	|	7:52	|			|	|	|	8:22	|		|	|	|
SOUTH SAN FRANCISCO	|	|	|	7:48	|	|	|			|	8:18	|	|	|		|	8:48	|
BAYSHORE	|	7:35	|	|	|	|	8:05			|	|	|	|	8:35		|	|	|
22nd STREET	7:31	|	|	7:55	|	8:01	|			|	8:25	|	8:31	|		|	8:55	|
TOWNSEND / 4TH AND KING	7:35	7:42	7:40	8:00	|	8:05	8:12			8:10	8:30	|	8:35	8:42		8:40	9:00	|
SALESFORCE TRANSIT CENTER (STC)	7:39	7:46	7:44	8:04	7:50	8:09	8:16			8:14	8:34	8:20	8:39	8:46		8:44	9:04	8:50

Train type	REG (C-EXP)	REG (C-EXP)	IC (HSR)	IC (HSR)	HSR	REG (C-EXP)	HSR	REG (C-EXP)	REG (C-EXP)	IC (HSR)	HSR	REG (C-EXP)	HSR	REG (C-EXP)	IC (HSR)	IC (HSR)	HSR	HSR
Train number	518	422	760	706	916	322	816	520	424	762	918	324	818	522	764	708	920	820
GILROY			7:43	7:49	7:55		8:01			8:13	8:25		8:31		8:43	8:49	8:55	9:01
SAN MARTIIN			|	|	|		|			|	|		|		|	|	|	|
MORGAN HILL			|	|	|		|			|	|		|		|	|	|	|
BLOSSOM HILL			|	|	|		|			|	|		|		|	|	|	|
CAPITOL			|	|	|		|			|	|		|		|	|	|	|
TAMIEN	7:57	8:01	|	|	|	8:19	|	8:27	8:31	|	|	8:49	|	8:57	|	|	|	|
SAN JOSE	8:00	8:04	8:06	8:12	8:18	8:22	8:25	8:30	8:34	8:36	8:48	8:52	8:55	9:00	9:06	9:12	9:18	9:25
SAN JOSE	8:02	8:06			8:20	8:24	8:27	8:32	8:36		8:50	8:54	8:57	9:02			9:20	9:27
COLLEGE PARK	|	|			|	|	|	|	|		|	|	|	|			|	|
SANTA CLARA	8:09	|			|	|	|	8:39	|		|	|	|	9:09			|	|
LAWRENCE	|	8:15			|	8:38	|	|	8:45		|	9:08	|	|			|	|
SUNNYVALE	8:15	8:19			|	|	|	8:45	8:49		|	|	|	9:15			|	|
MOUNTAIN VIEW	8:18	8:22			|	8:43	|	8:48	8:52		|	9:13	|	9:18			|	|
SAN ANTONIO	|	8:26			|	|	|	|	8:56		|	|	|	|			|	|
CALIFORNIA AVENUE	8:23	|			|	|	|	8:53	|		|	|	|	9:23			|	|
PALO ALTO	8:27	8:30			|	8:50	|	8:57	9:00		|	9:20	|	9:27			|	|
MENLO PARK	8:29	|			|	|	|	8:59	|		|	|	|	9:29			|	|
ATHERTON	|	|			|	8:53	|	|	|		|	9:23	|	|			|	|
REDWOOD CITY	|	8:36			|	8:57	|	|	9:06		|	9:27	|	|			|	|
SAN CARLOS	|	8:39			|	|	|	|	9:09		|	|	|	|			|	|
BELMONT	8:36	|			|	|	|	9:06	|		|	|	|	9:36			|	|
HILLSDALE	8:39	8:43			|	9:03	|	9:09	9:13		|	9:33	|	9:39			|	|
HAYWARD PARK	|	8:46			|	|	|	|	9:16		|	|	|	|			|	|
SAN MATEO	8:44	|			|	9:06	|	9:14	|		|	9:36	|	9:44			|	|
BURLINGAME	|	|			|	9:09	|	|	|		|	9:39	|	|			|	|
BROADWAY	|	8:50			|	|	|	|	9:20		|	|	|	|			|	|
MILLBRAE	8:48	8:53			|	9:13	9:02	9:18	9:23		|	9:43	9:32	9:48			|	10:02
SAN BRUNO	8:52	|			|	|	|	9:22	|		|	|	|	9:52			|	|
SOUTH SAN FRANCISCO	|	|			|	9:18	|	|	|		|	9:48	|	|			|	|
BAYSHORE	|	9:05			|	|	|	|	9:35		|	|	|	|			|	|
22nd STREET	9:01	|			|	9:25	|	9:31	|		|	9:55	|	10:01			|	|
TOWNSEND / 4TH AND KING	9:05	9:13			9:10	9:30	|	9:35	9:43		9:40	10:00	|	10:05			10:10	|
SALESFORCE TRANSIT CENTER (STC)	9:09	9:17			9:14	9:34	9:20	9:39	9:47		9:44	10:04	9:50	10:09			10:14	10:20

Table A-3: Southbound Customer Timetable for Moderate Growth

Train type	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR
Train number	103	811	305	715	5	813	405	203	815	307	719	7	817	407	721	105	819	309	723
SALESFORCE TRANSIT CENTER (STC)	6:02	6:10	6:13		6:17	6:25	6:28	6:32	6:40	6:43		6:47	6:55	6:58		7:02	7:10	7:13	
TOWNSEND / 4TH AND KING	6:07	|	6:18		6:21	6:31	6:33	6:37	|	6:48		6:51	7:01	7:03		7:07	|	7:18	
22nd STREET	6:11	|	6:23		6:26	|	6:38	6:41	|	6:53		6:56	|	7:08		7:11	|	7:23	
BAYSHORE	6:15	|	|		6:30	|	|	6:45	|	|		7:00	|	|		7:15	|	|	
SOUTH SAN FRANCISCO	6:20	|	6:31		6:35	|	6:46	6:49	|	7:01		7:05	|	7:16		7:20	|	7:31	
SAN BRUNO	6:23	|	|		6:38	|	|	6:53	|	|		7:08	|	|		7:23	|	|	
MILLBRAE	6:27	6:31	6:36		|	6:46	6:51	6:56	7:01	7:06		|	7:16	7:21		7:27	7:31	7:36	
BROADWAY	|	|	|		6:43	|	|	|	|	|		7:13	|	|		|	|	|	
BURLINGAME	6:30	|	|		|	|	|	7:00	|	|		|	|	|		7:30	|	|	
SAN MATEO	|	|	|		6:46	|	|	|	|	|		7:16	|	|		|	|	|	
HAYWARD PARK	6:34	|	|		6:49	|	|	7:04	|	|		7:19	|	|		7:34	|	|	
HILLSDALE	6:38	|	6:43		6:53	|	6:58	7:08	|	7:13		7:23	|	7:28		7:38	|	7:43	
BELMONT	6:41	|	|		|	|	|	7:11	|	|		|	|	|		7:41	|	|	
SAN CARLOS	|	|	|		6:57	|	|	|	|	|		7:27	|	|		|	|	|	
REDWOOD CITY	6:50	|	6:48		7:05	|	7:03	7:20	|	7:18		7:35	|	7:33		7:50	|	7:48	
ATHERTON	6:53	|	|		|	|	|	|	|	|		|	|	|		7:53	|	|	
MENLO PARK	|	|	|		7:09	|	|	7:24	|	|		7:39	|	|		|	|	|	
PALO ALTO	6:57	|	6:53		7:12	|	7:08	7:27	|	7:23		7:42	|	7:38		7:57	|	7:53	
STANDFORD STADIUM	|	|	|		|	|	|	|	|	|		|	|	|		|	|	|	
CALIFORNIA AVENUE	7:03	|	|		7:18	|	|	7:33	|	|		7:48	|	|		8:03	|	|	
SAN ANTONIO	7:07	|	|		7:22	|	|	7:37	|	|		7:52	|	|		8:07	|	|	
MOUNTAIN VIEW	7:11	|	6:59		7:26	|	7:14	7:40	|	7:29		7:56	|	7:44		8:11	|	7:59	
SUNNYVALE	7:14	|	7:04		7:29	|	7:19	7:44	|	7:34		7:59	|	7:49		8:14	|	8:04	
LAWRENCE	7:17	|	|		7:32	|	|	7:47	|	|		8:02	|	|		8:17	|	|	
SANTA CLARA	7:22	|	|		7:37	|	|	7:51	|	|		8:07	|	|		8:22	|	|	
COLLEGE PARK	|	|	|		|	|	|	|	|	|		|	|	|		|	|	|	
SAN JOSE	7:30	7:03	7:20	7:43	7:45	7:18	7:35	8:00	7:33	7:50	8:13	8:15	7:48	8:05	8:28	8:30	8:03	8:20	8:43
TAMIEN	o 7:33	|	7:24	|	o 7:48	|	7:39	o 8:03	|	7:54	|	o 8:18	|	8:09	|	o 8:33	|	8:24	|
CAPITOL		|	7:28	|		|	7:43		|	7:58	|		|	8:13	|		|	8:28	|
BLOSSOM HILL		|	7:32	|		|	o 7:46		|	8:02	|		|	o 8:16	|		|	8:32	|
MORGAN HILL		|	7:41	|		|			|	8:11	|		|		|		|	8:41	|
SAN MARTIIN		|	|	|		|			|	|	|		|		|		|	|	|
GILROY		7:28	o 7:50	8:09		7:43			7:58	o 8:20	8:39		8:13		8:54		8:28	o 8:50	9:09

Train type	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)	REG (C-LCL)	HSR	REG (C-EXP)
Train number	9	821	409	205	823	311	11	825	411	107	827	313	13	829	413	207	831	315	15	833	415
SALESFORCE TRANSIT CENTER (STC)	7:17	7:25	7:28	7:32	7:40	7:43	7:47	7:55	7:58	8:02	8:10	8:13	8:17	8:25	8:28	8:32	8:40	8:43	8:47	8:55	8:58
TOWNSEND / 4TH AND KING	7:21	7:31	7:33	7:37	|	7:48	7:51	8:01	8:03	8:07	|	8:18	8:21	8:31	8:33	8:37	|	8:48	8:51	9:01	9:03
22nd STREET	7:26	|	7:38	7:41	|	7:53	7:56	|	8:08	8:11	|	8:23	8:26	|	8:38	8:41	|	8:53	8:56	|	9:08
BAYSHORE	7:30	|	|	7:45	|	|	8:00	|	|	8:15	|	|	8:30	|	|	8:45	|	|	9:00	|	|
SOUTH SAN FRANCISCO	7:35	|	7:46	7:49	|	8:01	8:05	|	8:16	8:20	|	8:31	8:35	|	8:46	8:49	|	9:01	9:05	|	9:16
SAN BRUNO	7:38	|	|	7:53	|	|	8:08	|	|	8:23	|	|	8:38	|	|	8:53	|	|	9:08	|	|
MILLBRAE	|	7:46	7:51	7:56	8:01	8:06	|	8:16	8:21	8:27	8:31	8:36	|	8:46	8:51	8:56	9:01	9:06	|	9:16	9:21
BROADWAY	7:43	|	|	|	|	|	8:13	|	|	|	|	|	8:43	|	|	|	|	|	9:13	|	|
BURLINGAME	|	|	|	8:00	|	|	|	|	|	8:30	|	|	|	|	|	9:00	|	|	|	|	|
SAN MATEO	7:46	|	|	|	|	|	8:16	|	|	|	|	|	8:46	|	|	|	|	|	9:16	|	|
HAYWARD PARK	7:49	|	|	8:04	|	|	8:19	|	|	8:34	|	|	8:49	|	|	9:04	|	|	9:19	|	|
HILLSDALE	7:53	|	7:58	8:08	|	8:13	8:23	|	8:28	8:38	|	8:43	8:53	|	8:58	9:08	|	9:13	9:23	|	9:28
BELMONT	|	|	|	8:11	|	|	|	|	|	8:41	|	|	|	|	|	9:11	|	|	|	|	|
SAN CARLOS	7:57	|	|	|	|	|	8:27	|	|	|	|	|	8:57	|	|	|	|	|	9:27	|	|
REDWOOD CITY	8:05	|	8:03	8:20	|	8:18	8:35	|	8:33	8:50	|	8:48	9:05	|	9:03	9:20	|	9:18	9:35	|	9:33
ATHERTON	|	|	|	|	|	|	|	|	|	8:53	|	|	|	|	|	|	|	|	|	|	|
MENLO PARK	8:09	|	|	8:24	|	|	8:39	|	|	|	|	|	9:09	|	|	9:24	|	|	9:39	|	|
PALO ALTO	8:12	|	8:08	8:27	|	8:23	8:42	|	8:38	8:57	|	8:53	9:12	|	9:08	9:27	|	9:23	9:42	|	9:38
STANDFORD STADIUM	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|
CALIFORNIA AVENUE	8:18	|	|	8:33	|	|	8:48	|	|	9:03	|	|	9:18	|	|	9:33	|	|	9:48	|	|
SAN ANTONIO	8:22	|	|	8:37	|	|	8:52	|	|	9:07	|	|	9:22	|	|	9:37	|	|	9:52	|	|
MOUNTAIN VIEW	8:26	|	8:14	8:40	|	8:29	8:56	|	8:44	9:11	|	8:59	9:26	|	9:14	9:40	|	9:29	9:56	|	9:44
SUNNYVALE	8:29	|	8:19	8:44	|	8:34	8:59	|	8:49	9:14	|	9:04	9:29	|	9:19	9:44	|	9:34	9:59	|	9:49
LAWRENCE	8:32	|	|	8:47	|	|	9:02	|	|	9:17	|	|	9:32	|	|	9:47	|	|	10:02	|	|
SANTA CLARA	8:37	|	|	8:51	|	|	9:07	|	|	9:22	|	|	9:37	|	|	9:51	|	|	10:07	|	|
COLLEGE PARK	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|
SAN JOSE	8:45	8:18	8:35	9:00	8:33	8:50	9:15	8:48	9:05	9:30	9:03	9:20	9:45	9:18	9:35	10:00	9:33	9:50	10:15	9:48	10:05
TAMIEN	o 8:48	|	8:39	o 9:03	|	8:54	o 9:18	|	9:09	o 9:33	|	9:24	o 9:48	|	9:39	o 10:03	|	9:54	o 10:18	|	10:09
CAPITOL		|	8:43		|	8:58		|	9:13		|	9:28		|	9:43		|	9:58		|	10:13
BLOSSOM HILL		|	o 8:46		|	9:02		|	o 9:16		|	9:32		|	o 9:46		|	10:02		|	o 10:16
MORGAN HILL		|			|	9:11		|			|	9:41		|			|	10:11		|	
SAN MARTIIN		|			|	|		|			|	|		|			|	|		|	
GILROY		8:43			8:58	o 9:20		9:13			9:28	o 9:50		9:43			9:58	o 10:20		10:13	

Table A-4: Northbound Customer Timetable for Moderate Growth

Train type	REG (C-EXP)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR
Train number	404	806	102	304	808	8	406	810	206	702	306	812
GILROY		6:03		6:10	6:18			6:33		6:38	6:40	6:48
SAN MARTIIN		|		|	|			|		|	|	|
MORGAN HILL		|		6:20	|			|		|	6:50	|
BLOSSOM HILL	6:14	|		6:29	|		6:44	|		|	6:59	|
CAPITOL	6:18	|		6:33	|		6:48	|		|	7:03	|
TAMIEN	6:22	|	6:27	6:37	|	6:42	6:52	|	6:57	|	7:07	|
SAN JOSE	6:25	6:27	6:30	6:40	6:42	6:45	6:55	6:57	7:00	7:02	7:10	7:12
SAN JOSE	6:31	6:29	6:33	6:46	6:44	6:48	7:01	6:59	7:03		7:16	7:14
COLLEGE PARK	|	|	|	|	|	|	|	|	|		|	|
SANTA CLARA	|	|	6:39	|	|	6:54	|	|	7:09		|	|
LAWRENCE	|	|	6:44	|	|	6:59	|	|	7:14		|	|
SUNNYVALE	6:42	|	6:47	6:57	|	7:02	7:12	|	7:17		7:27	|
MOUNTAIN VIEW	6:47	|	6:50	7:02	|	7:06	7:17	|	7:20		7:32	|
SAN ANTONIO	|	|	6:54	|	|	7:09	|	|	7:24		|	|
CALIFORNIA AVENUE	|	|	7:01	|	|	7:16	|	|	7:31		|	|
PALO ALTO	6:53	|	7:04	7:08	|	7:19	7:23	|	7:34		7:38	|
MENLO PARK	|	|	|	|	|	7:22	|	|	7:37		|	|
ATHERTON	|	|	7:07	|	|	|	|	|	|		|	|
REDWOOD CITY	6:58	|	7:15	7:13	|	7:30	7:28	|	7:45		7:43	|
SAN CARLOS	|	|	|	|	|	7:34	|	|	|		|	|
BELMONT	|	|	7:20	|	|	|	|	|	7:50		|	|
HILLSDALE	7:04	|	7:23	7:19	|	7:38	7:34	|	7:53		7:49	|
HAYWARD PARK	|	|	7:27	|	|	7:41	|	|	7:57		|	|
SAN MATEO	|	|	|	|	|	7:44	|	|	|		|	|
BURLINGAME	|	|	7:31	|	|	|	|	|	8:01		|	|
BROADWAY	|	|	|	|	|	7:47	|	|	|		|	|
MILLBRAE	7:10	7:01	7:34	7:25	7:16	|	7:40	7:31	8:04		7:55	7:46
SAN BRUNO	|	|	7:38	|	|	7:52	|	|	8:08		|	|
SOUTH SAN FRANCISCO	7:15	|	7:41	7:30	|	7:55	7:45	|	8:11		8:00	|
BAYSHORE	|	|	7:45	|	|	8:00	|	|	8:15		|	|
22nd STREET	7:23	|	7:50	7:38	|	8:04	7:53	|	8:20		8:08	|
TOWNSEND / 4TH AND KING	7:28	7:16	7:54	7:43	|	8:09	7:58	7:46	8:24		8:13	|
SALESFORCE TRANSIT CENTER (STC)	7:32	7:20	7:58	7:47	7:35	8:13	8:02	7:50	8:28		8:17	8:05

Train type	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)
Train number	10	704	408	814	104	308	816	12	708	410	818	208	710	310	820	14
GILROY		6:53		7:03		7:10	7:18		7:23		7:33		7:38	7:40	7:48	
SAN MARTIIN		|		|		|	|		|		|		|	|	|	
MORGAN HILL		|		|		7:20	|		|		|		|	7:50	|	
BLOSSOM HILL		|	7:14	|		7:29	|		|	7:44	|		|	7:59	|	
CAPITOL		|	7:18	|		7:33	|		|	7:48	|		|	8:03	|	
TAMIEN	7:12	|	7:22	|	7:27	7:37	|	7:42	|	7:52	|	7:57	|	8:07	|	8:12
SAN JOSE	7:15	7:17	7:25	7:27	7:30	7:40	7:42	7:45	7:47	7:55	7:57	8:00	8:02	8:10	8:12	8:15
SAN JOSE	7:18		7:31	7:29	7:33	7:46	7:44	7:48		8:01	7:59	8:03		8:16	8:14	8:18
COLLEGE PARK	|		|	|	|	|	|	|		|	|	|		|	|	|
SANTA CLARA	7:24		|	|	7:39	|	|	7:54		|	|	8:09		|	|	8:24
LAWRENCE	7:29		|	|	7:44	|	|	7:59		|	|	8:14		|	|	8:29
SUNNYVALE	7:32		7:42	|	7:47	7:57	|	8:02		8:12	|	8:17		8:27	|	8:32
MOUNTAIN VIEW	7:36		7:47	|	7:50	8:02	|	8:06		8:17	|	8:20		8:32	|	8:36
SAN ANTONIO	7:39		|	|	7:54	|	|	8:09		|	|	8:24		|	|	8:39
CALIFORNIA AVENUE	7:46		|	|	8:01	|	|	8:16		|	|	8:31		|	|	8:46
PALO ALTO	7:49		7:53	|	8:04	8:08	|	8:19		8:23	|	8:34		8:38	|	8:49
MENLO PARK	7:52		|	|	|	|	|	8:22		|	|	8:37		|	|	8:52
ATHERTON	|		|	|	8:07	|	|	|		|	|	|		|	|	|
REDWOOD CITY	8:00		7:58	|	8:15	8:13	|	8:30		8:28	|	8:45		8:43	|	9:00
SAN CARLOS	8:04		|	|	|	|	|	8:34		|	|	|		|	|	9:04
BELMONT	|		|	|	8:20	|	|	|		|	|	8:50		|	|	|
HILLSDALE	8:08		8:04	|	8:23	8:19	|	8:38		8:34	|	8:53		8:49	|	9:08
HAYWARD PARK	8:11		|	|	8:27	|	|	8:41		|	|	8:57		|	|	9:11
SAN MATEO	8:14		|	|	|	|	|	8:44		|	|	|		|	|	9:14
BURLINGAME	|		|	|	8:31	|	|	|		|	|	9:01		|	|	|
BROADWAY	8:17		|	|	|	|	|	8:47		|	|	|		|	|	9:17
MILLBRAE	|		8:10	8:01	8:34	8:25	8:16	|		8:40	8:31	9:04		8:55	8:46	|
SAN BRUNO	8:22		|	|	8:38	|	|	8:52		|	|	9:08		|	|	9:22
SOUTH SAN FRANCISCO	8:25		8:15	|	8:41	8:30	|	8:55		8:45	|	9:11		9:00	|	9:25
BAYSHORE	8:30		|	|	8:45	|	|	9:00		|	|	9:15		|	|	9:30
22nd STREET	8:34		8:23	|	8:50	8:38	|	9:04		8:53	|	9:20		9:08	|	9:34
TOWNSEND / 4TH AND KING	8:39		8:28	8:16	8:54	8:43	|	9:09		8:58	8:46	9:24		9:13	|	9:39
SALESFORCE TRANSIT CENTER (STC)	8:43		8:32	8:20	8:58	8:47	8:35	9:13		9:02	8:50	9:28		9:17	9:05	9:43

Train type	HSR	REG (C-EXP)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (C-EXP)	HSR	HSR
Train number	712	412	822	106	312	824	16	716	414	826	210	718	314	828	720
GILROY	7:53		8:03		8:10	8:18		8:23		8:33		8:38	8:40	8:48	8:53
SAN MARTIIN	|		|		|	|		|		|		|	|	|	|
MORGAN HILL	|		|		8:20	|		|		|		|	8:50	|	|
BLOSSOM HILL	|	8:14	|		8:29	|		|	8:44	|		|	8:59	|	|
CAPITOL	|	8:18	|		8:33	|		|	8:48	|		|	9:03	|	|
TAMIEN	|	8:22	|	8:27	8:37	|	8:42	|	8:52	|	8:57	|	9:07	|	|
SAN JOSE	8:17	8:25	8:27	8:30	8:40	8:42	8:45	8:47	8:55	8:57	9:00	9:02	9:10	9:12	9:17
SAN JOSE		8:31	8:29	8:33	8:46	8:44	8:48		9:01	8:59	9:03		9:16	9:14	
COLLEGE PARK		|	|	|	|	|	|		|	|	|		|	|	
SANTA CLARA		|	|	8:39	|	|	8:54		|	|	9:09		|	|	
LAWRENCE		|	|	8:44	|	|	8:59		|	|	9:14		|	|	
SUNNYVALE		8:42	|	8:47	8:57	|	9:02		9:12	|	9:17		9:27	|	
MOUNTAIN VIEW		8:47	|	8:50	9:02	|	9:06		9:17	|	9:20		9:32	|	
SAN ANTONIO		|	|	8:54	|	|	9:09		|	|	9:24		|	|	
CALIFORNIA AVENUE		|	|	9:01	|	|	9:16		|	|	9:31		|	|	
PALO ALTO		8:53	|	9:04	9:08	|	9:19		9:23	|	9:34		9:38	|	
MENLO PARK		|	|	|	|	|	9:22		|	|	9:37		|	|	
ATHERTON		|	|	9:07	|	|	|		|	|	|		|	|	
REDWOOD CITY		8:58	|	9:15	9:13	|	9:30		9:28	|	9:45		9:43	|	
SAN CARLOS		|	|	|	|	|	9:34		|	|	|		|	|	
BELMONT		|	|	9:20	|	|	|		|	|	9:50		|	|	
HILLSDALE		9:04	|	9:23	9:19	|	9:38		9:34	|	9:53		9:49	|	
HAYWARD PARK		|	|	9:27	|	|	9:41		|	|	9:57		|	|	
SAN MATEO		|	|	|	|	|	9:44		|	|	|		|	|	
BURLINGAME		|	|	9:31	|	|	|		|	|	10:01		|	|	
BROADWAY		|	|	|	|	|	9:47		|	|	|		|	|	
MILLBRAE		9:10	9:01	9:34	9:25	9:16	|		9:40	9:31	10:04		9:55	9:46	
SAN BRUNO		|	|	9:38	|	|	9:52		|	|	10:08		|	|	
SOUTH SAN FRANCISCO		9:15	|	9:41	9:30	|	9:55		9:45	|	10:11		10:00	|	
BAYSHORE		|	|	9:45	|	|	10:00		|	|	10:15		|	|	
22nd STREET		9:23	|	9:50	9:38	|	10:04		9:53	|	10:20		10:08	|	
TOWNSEND / 4TH AND KING		9:28	9:16	9:54	9:43	|	10:09		9:58	9:46	10:24		10:13	|	
SALESFORCE TRANSIT CENTER (STC)		9:32	9:20	9:58	9:47	9:35	10:13		10:02	9:50	10:28		10:17	10:05	

Table A-5: Southbound Customer Timetable for High Growth

Train type	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR
Train number	103	909	503	301	713	3	811	505	403	715	203	911
SALESFORCE TRANSIT CENTER (STC)	6:01	6:10		6:13		6:16	6:25		6:28		6:31	6:40
TOWNSEND / 4TH AND KING	6:06	|		6:18		6:21	6:31		6:33		6:36	|
22nd STREET	6:10	|	6:14	6:22		6:25	|	6:29	6:37		6:40	|
BAYSHORE	6:14	|	|	|		6:29	|	|	|		6:44	|
SOUTH SAN FRANCISCO	6:19	|	|	6:30		6:34	|	|	6:45		6:49	|
SAN BRUNO	6:22	|	|	|		6:37	|	|	|		6:52	|
MILLBRAE	6:26	6:31	|	6:35		6:41	6:47	|	6:50		6:56	7:01
BROADWAY	|	|	|	|		6:44	|	|	|		|	|
BURLINGAME	6:30	|	|	|		|	|	|	|		7:00	|
SAN MATEO	6:33	|	6:28	|		6:48	|	6:43	|		7:03	|
HAYWARD PARK	6:36	|	6:31	|		6:51	|	6:46	|		7:06	|
HILLSDALE	6:39	|	6:34	6:42		6:54	|	6:49	6:57		7:09	|
BELMONT	6:42	|	|	|		6:57	|	|	|		7:12	|
SAN CARLOS	6:45	|	6:37	|		7:00	|	6:52	|		7:15	|
REDWOOD CITY	6:50	|	6:43	6:48		7:05	|	6:58	7:03		7:20	|
ATHERTON	|	|	|	|		|	|	|	|		7:24	|
MENLO PARK	6:55	|	|	|		7:10	|	|	|		|	|
PALO ALTO	6:58	|	6:48	6:53		7:12	|	7:03	7:08		7:27	|
STANDFORD STADIUM	|	|	|	|		|	|	|	|		|	|
CALIFORNIA AVENUE	7:00	|	|	|		7:15	|	|	|		7:30	|
SAN ANTONIO	7:04	|	|	|		7:19	|	|	|		7:34	|
MOUNTAIN VIEW	7:07	|	6:55	6:59		7:22	|	7:10	7:14		7:37	|
SUNNYVALE	7:11	|	6:59	7:03		7:26	|	7:14	7:18		7:41	|
LAWRENCE	7:14	|	7:03	|		7:29	|	7:18	|		7:44	|
SANTA CLARA	7:19	|	|	|		7:34	|	|	|		7:49	|
COLLEGE PARK	|	|	|	|		|	|	|	|		|	|
SAN JOSE	7:26	7:02	7:15	7:19	7:28	7:41	7:17	7:30	7:34	7:43	7:56	7:32
TAMIEN	o 7:29	|	o 7:18	7:23	|	o 7:44	|	o 7:33	7:38	|	o 7:59	|
CAPITOL		|		7:27	|		|		7:41	|		|
BLOSSOM HILL		|		7:31	|		|		o 7:45	|		|
MORGAN HILL		|		7:40	|		|			|		|
SAN MARTIIN		|		|	|		|			|		|
GILROY		7:27		o 7:49	7:53		7:42			8:08		7:57

Train type	REG (CT-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR
Train number	507	303	717	5	813	509	405	719	105	913	511	305	721	7	815
SALESFORCE TRANSIT CENTER (STC)		6:43		6:46	6:55		6:58		7:01	7:10		7:13		7:16	7:25
TOWNSEND / 4TH AND KING		6:48		6:51	7:01		7:03		7:06	|		7:18		7:21	7:31
22nd STREET	6:44	6:52		6:55	|	6:59	7:07		7:10	|	7:14	7:22		7:25	|
BAYSHORE	|	|		6:59	|	|	|		7:14	|	|	|		7:29	|
SOUTH SAN FRANCISCO	|	7:00		7:04	|	|	7:15		7:19	|	|	7:30		7:34	|
SAN BRUNO	|	|		7:07	|	|	|		7:22	|	|	|		7:37	|
MILLBRAE	|	7:05		7:11	7:17	|	7:20		7:26	7:31	|	7:35		7:41	7:47
BROADWAY	|	|		7:14	|	|	|		|	|	|	|		7:44	|
BURLINGAME	|	|		|	|	|	|		7:30	|	|	|		|	|
SAN MATEO	6:58	|		7:18	|	7:13	|		7:33	|	7:28	|		7:48	|
HAYWARD PARK	7:01	|		7:21	|	7:16	|		7:36	|	7:31	|		7:51	|
HILLSDALE	7:04	7:12		7:24	|	7:19	7:27		7:39	|	7:34	7:42		7:54	|
BELMONT	|	|		7:27	|	|	|		7:42	|	|	|		7:57	|
SAN CARLOS	7:07	|		7:30	|	7:22	|		7:45	|	7:37	|		8:00	|
REDWOOD CITY	7:13	7:18		7:35	|	7:28	7:33		7:50	|	7:43	7:48		8:05	|
ATHERTON	|	|		|	|	|	|		|	|	|	|		|	|
MENLO PARK	|	|		7:40	|	|	|		7:55	|	|	|		8:10	|
PALO ALTO	7:18	7:23		7:42	|	7:33	7:38		7:58	|	7:48	7:53		8:12	|
STANDFORD STADIUM	|	|		|	|	|	|		|	|	|	|		|	|
CALIFORNIA AVENUE	|	|		7:45	|	|	|		8:00	|	|	|		8:15	|
SAN ANTONIO	|	|		7:49	|	|	|		8:04	|	|	|		8:19	|
MOUNTAIN VIEW	7:25	7:29		7:52	|	7:40	7:44		8:07	|	7:55	7:59		8:22	|
SUNNYVALE	7:29	7:33		7:56	|	7:44	7:48		8:11	|	7:59	8:03		8:26	|
LAWRENCE	7:33	|		7:59	|	7:48	|		8:14	|	8:03	|		8:29	|
SANTA CLARA	|	|		8:04	|	|	|		8:19	|	|	|		8:34	|
COLLEGE PARK	|	|		|	|	|	|		|	|	|	|		|	|
SAN JOSE	7:45	7:49	7:58	8:11	7:47	8:00	8:04	8:13	8:26	8:02	8:15	8:19	8:28	8:41	8:17
TAMIEN	o 7:48	7:53	|	o 8:14	|	o 8:03	8:08	|	o 8:29	|	o 8:18	8:23	|	o 8:44	|
CAPITOL		7:57	|		|		8:11	|		|		8:27	|		|
BLOSSOM HILL		8:01	|		|		o 8:15	|		|		8:31	|		|
MORGAN HILL		8:10	|		|			|		|		8:40	|		|
SAN MARTIIN		|	|		|			|		|		|	|		|
GILROY		o 8:19	8:23		8:12			8:38		8:27		o 8:49	8:53		8:42

Train type	REG (CT-LCL)	REG (C-EXP)	HSR	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	REG (C-LCL)	HSR	REG (C	REG (C-EXP)	REG (C-LCL)	HSR
Train number	513	407	723	205	915	515	307	9	817	517	409	107	917
SALESFORCE TRANSIT CENTER (STC)		7:28		7:31	7:40		7:43	7:46	7:55		7:58	8:01	8:10
TOWNSEND / 4TH AND KING		7:33		7:36	|		7:48	7:51	8:01		8:03	8:06	|
22nd STREET	7:29	7:37		7:40	|	7:44	7:52	7:55	|	7:59	8:07	8:10	|
BAYSHORE	|	|		7:44	|	|	|	7:59	|	|	|	8:14	|
SOUTH SAN FRANCISCO	|	7:45		7:49	|	|	8:00	8:04	|	|	8:15	8:19	|
SAN BRUNO	|	|		7:52	|	|	|	8:07	|	|	|	8:22	|
MILLBRAE	|	7:50		7:56	8:01	|	8:05	8:11	8:17	|	8:20	8:26	8:31
BROADWAY	|	|		|	|	|	|	8:14	|	|	|	|	|
BURLINGAME	|	|		8:00	|	|	|	|	|	|	|	8:30	|
SAN MATEO	7:43	|		8:03	|	7:58	|	8:18	|	8:13	|	8:33	|
HAYWARD PARK	7:46	|		8:06	|	8:01	|	8:21	|	8:16	|	8:36	|
HILLSDALE	7:49	7:57		8:09	|	8:04	8:12	8:24	|	8:19	8:27	8:39	|
BELMONT	|	|		8:12	|	|	|	8:27	|	|	|	8:42	|
SAN CARLOS	7:52	|		8:15	|	8:07	|	8:30	|	8:22	|	8:45	|
REDWOOD CITY	7:58	8:03		8:20	|	8:13	8:18	8:35	|	8:28	8:33	8:50	|
ATHERTON	|	|		8:24	|	|	|	|	|	|	|	|	|
MENLO PARK	|	|		|	|	|	|	8:40	|	|	|	8:55	|
PALO ALTO	8:03	8:08		8:27	|	8:18	8:23	8:42	|	8:33	8:38	8:58	|
STANDFORD STADIUM	|	|		|	|	|	|	|	|	|	|	|	|
CALIFORNIA AVENUE	|	|		8:30	|	|	|	8:45	|	|	|	9:00	|
SAN ANTONIO	|	|		8:34	|	|	|	8:49	|	|	|	9:04	|
MOUNTAIN VIEW	8:10	8:14		8:37	|	8:25	8:29	8:52	|	8:40	8:44	9:07	|
SUNNYVALE	8:14	8:18		8:41	|	8:29	8:33	8:56	|	8:44	8:48	9:11	|
LAWRENCE	8:18	|		8:44	|	8:33	|	8:59	|	8:48	|	9:14	|
SANTA CLARA	|	|		8:49	|	|	|	9:04	|	|	|	9:19	|
COLLEGE PARK	|	|		|	|	|	|	|	|	|	|	|	|
SAN JOSE	8:30	8:34	8:43	8:56	8:32	8:45	8:49	9:11	8:47	9:00	9:04	9:26	9:02
TAMIEN	o 8:33	8:38	|	o 8:59	|	o 8:48	8:53	o 9:14	|	o 9:03	9:08	o 9:29	|
CAPITOL		8:41	|		|		8:57		|		9:11		|
BLOSSOM HILL		o 8:45	|		|		9:01		|		o 9:15		|
MORGAN HILL			|		|		9:10		|				|
SAN MARTIIN			|		|		|		|				|
GILROY			9:08		8:57		o 9:19		9:12				9:27

Train type	REG (CT-LCL)	REG (C-EXP)	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)	REG (C-LCL)	HSR	REG (CT-LCL)	REG (C-EXP)
Train number	519	309	11	819	521	411	207	919	523	311	13	821	525	413
SALESFORCE TRANSIT CENTER (STC)		8:13	8:16	8:25		8:28	8:31	8:40		8:43	8:46	8:55		8:58
TOWNSEND / 4TH AND KING		8:18	8:21	8:31		8:33	8:36	|		8:48	8:51	9:01		9:03
22nd STREET	8:14	8:22	8:25	|	8:29	8:37	8:40	|	8:44	8:52	8:55	|	8:59	9:07
BAYSHORE	|	|	8:29	|	|	|	8:44	|	|	|	8:59	|	|	|
SOUTH SAN FRANCISCO	|	8:30	8:34	|	|	8:45	8:49	|	|	9:00	9:04	|	|	9:15
SAN BRUNO	|	|	8:37	|	|	|	8:52	|	|	|	9:07	|	|	|
MILLBRAE	|	8:35	8:41	8:47	|	8:50	8:56	9:01	|	9:05	9:11	9:17	|	9:20
BROADWAY	|	|	8:44	|	|	|	|	|	|	|	9:14	|	|	|
BURLINGAME	|	|	|	|	|	|	9:00	|	|	|	|	|	|	|
SAN MATEO	8:28	|	8:48	|	8:43	|	9:03	|	8:58	|	9:18	|	9:13	|
HAYWARD PARK	8:31	|	8:51	|	8:46	|	9:06	|	9:01	|	9:21	|	9:16	|
HILLSDALE	8:34	8:42	8:54	|	8:49	8:57	9:09	|	9:04	9:12	9:24	|	9:19	9:27
BELMONT	|	|	8:57	|	|	|	9:12	|	|	|	9:27	|	|	|
SAN CARLOS	8:37	|	9:00	|	8:52	|	9:15	|	9:07	|	9:30	|	9:22	|
REDWOOD CITY	8:43	8:48	9:05	|	8:58	9:03	9:20	|	9:13	9:18	9:35	|	9:28	9:33
ATHERTON	|	|	|	|	|	|	9:24	|	|	|	|	|	|	|
MENLO PARK	|	|	9:10	|	|	|	|	|	|	|	9:40	|	|	|
PALO ALTO	8:48	8:53	9:12	|	9:03	9:08	9:27	|	9:18	9:23	9:42	|	9:33	9:38
STANDFORD STADIUM	|	|	|	|	|	|	|	|	|	|	|	|	|	|
CALIFORNIA AVENUE	|	|	9:15	|	|	|	9:30	|	|	|	9:45	|	|	|
SAN ANTONIO	|	|	9:19	|	|	|	9:34	|	|	|	9:49	|	|	|
MOUNTAIN VIEW	8:55	8:59	9:22	|	9:10	9:14	9:37	|	9:25	9:29	9:52	|	9:40	9:44
SUNNYVALE	8:59	9:03	9:26	|	9:14	9:18	9:41	|	9:29	9:33	9:56	|	9:44	9:48
LAWRENCE	9:03	|	9:29	|	9:18	|	9:44	|	9:33	|	9:59	|	9:48	|
SANTA CLARA	|	|	9:34	|	|	|	9:49	|	|	|	10:04	|	|	|
COLLEGE PARK	|	|	|	|	|	|	|	|	|	|	|	|	|	|
SAN JOSE	9:15	9:19	9:41	9:17	9:30	9:34	9:56	9:32	9:45	9:49	10:11	9:47	10:00	10:04
TAMIEN	o 9:18	9:23	o 9:44	|	o 9:33	9:38	o 9:59	|	o 9:48	9:53	o 10:14	|	o 10:03	10:08
CAPITOL		9:27		|		9:41		|		9:57		|		10:11
BLOSSOM HILL		9:31		|		o 9:45		|		10:01		|		o 10:15
MORGAN HILL		9:40		|				|		10:10		|		
SAN MARTIIN		|		|				|		|		|		
GILROY		o 9:49		9:42				9:57		o 10:19		10:12		

Table A-6: Northbound Customer Timetable for High Growth

Train type	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-LCL)
Train number	4	404	806	504	104	306	906	506	6	406	808	508	702	204
GILROY			6:05			6:11	6:20				6:35		6:39	
SAN MARTIIN			|			|	|				|		|	
MORGAN HILL			|			6:21	|				|		|	
BLOSSOM HILL		6:14	|			6:30	|			6:44	|		|	
CAPITOL		6:19	|			6:34	|			6:49	|		|	
TAMIEN	6:16	6:23	|	6:27	6:31	6:38	|	6:42	6:46	6:53	|	6:57	|	7:01
SAN JOSE	6:19	6:26	6:28	6:30	6:34	6:41	6:43	6:45	6:49	6:56	6:58	7:00	7:02	7:04
SAN JOSE	6:21	6:32	6:30	6:34	6:36	6:47	6:45	6:49	6:51	7:02	7:00	7:04		7:06
COLLEGE PARK	|	|	|	|	|	|	|	|	|	|	|	|		|
SANTA CLARA	6:27	|	|	|	6:42	|	|	|	6:57	|	|	|		7:12
LAWRENCE	6:32	|	|	6:43	6:47	|	|	6:58	7:02	|	|	7:13		7:17
SUNNYVALE	6:35	6:43	|	6:47	6:50	6:58	|	7:02	7:05	7:13	|	7:17		7:20
MOUNTAIN VIEW	6:39	6:47	|	6:51	6:54	7:02	|	7:06	7:09	7:17	|	7:21		7:24
SAN ANTONIO	6:42	|	|	|	6:57	|	|	|	7:12	|	|	|		7:27
CALIFORNIA AVENUE	6:46	|	|	|	7:01	|	|	|	7:16	|	|	|		7:31
PALO ALTO	6:49	6:53	|	6:58	7:04	7:08	|	7:13	7:19	7:23	|	7:28		7:34
MENLO PARK	6:52	|	|	|	7:07	|	|	|	7:22	|	|	|		|
ATHERTON	|	|	|	|	|	|	|	|	|	|	|	|		7:38
REDWOOD CITY	6:58	6:58	|	7:05	7:13	7:13	|	7:20	7:28	7:28	|	7:35		7:43
SAN CARLOS	7:02	|	|	7:09	7:17	|	|	7:24	7:32	|	|	7:39		7:47
BELMONT	7:04	|	|	|	7:19	|	|	|	7:34	|	|	|		7:49
HILLSDALE	7:08	7:04	|	7:13	7:23	7:19	|	7:28	7:38	7:34	|	7:43		7:53
HAYWARD PARK	7:11	|	|	7:15	7:26	|	|	7:30	7:41	|	|	7:45		7:56
SAN MATEO	7:13	|	|	7:18	7:28	|	|	7:33	7:43	|	|	7:48		7:58
BURLINGAME	|	|	|	|	7:31	|	|	|	|	|	|	|		8:01
BROADWAY	7:17	|	|	|	|	|	|	|	7:47	|	|	|		|
MILLBRAE	7:20	7:11	7:00	|	7:35	7:26	7:15	|	7:50	7:41	7:30	|		8:05
SAN BRUNO	7:23	|	|	|	7:39	|	|	|	7:53	|	|	|		8:09
SOUTH SAN FRANCISCO	7:27	7:16	|	|	7:42	7:31	|	|	7:57	7:46	|	|		8:12
BAYSHORE	7:31	|	|	|	7:47	|	|	|	8:01	|	|	|		8:17
22nd STREET	7:36	7:23	|	7:32	7:51	7:39	|	7:47	8:06	7:53	|	8:02		8:21
TOWNSEND / 4TH AND KING	7:40	7:28	7:16		7:55	7:43	|		8:10	7:58	7:46			8:25
SALESFORCE TRANSIT CENTER (STC)	7:44	7:32	7:20		7:59	7:47	7:35		8:14	8:02	7:50			8:29

Train type	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR
Train number	308	908	510	704	8	408	810	512	706	106	310	910	514	708
GILROY	6:41	6:50		6:54			7:05		7:09		7:11	7:20		7:24
SAN MARTIIN	|	|		|			|		|		|	|		|
MORGAN HILL	6:51	|		|			|		|		7:21	|		|
BLOSSOM HILL	7:00	|		|		7:14	|		|		7:30	|		|
CAPITOL	7:04	|		|		7:19	|		|		7:34	|		|
TAMIEN	7:08	|	7:12	|	7:16	7:23	|	7:27	|	7:31	7:38	|	7:42	|
SAN JOSE	7:11	7:13	7:15	7:17	7:19	7:26	7:28	7:30	7:32	7:34	7:41	7:43	7:45	7:47
SAN JOSE	7:17	7:15	7:19		7:21	7:32	7:30	7:34		7:36	7:47	7:45	7:49	
COLLEGE PARK	|	|	|		|	|	|	|		|	|	|	|	
SANTA CLARA	|	|	|		7:27	|	|	|		7:42	|	|	|	
LAWRENCE	|	|	7:28		7:32	|	|	7:43		7:47	|	|	7:58	
SUNNYVALE	7:28	|	7:32		7:35	7:43	|	7:47		7:50	7:58	|	8:02	
MOUNTAIN VIEW	7:32	|	7:36		7:39	7:47	|	7:51		7:54	8:02	|	8:06	
SAN ANTONIO	|	|	|		7:42	|	|	|		7:57	|	|	|	
CALIFORNIA AVENUE	|	|	|		7:46	|	|	|		8:01	|	|	|	
PALO ALTO	7:38	|	7:43		7:49	7:53	|	7:58		8:04	8:08	|	8:13	
MENLO PARK	|	|	|		7:52	|	|	|		8:07	|	|	|	
ATHERTON	|	|	|		|	|	|	|		|	|	|	|	
REDWOOD CITY	7:43	|	7:50		7:58	7:58	|	8:05		8:13	8:13	|	8:20	
SAN CARLOS	|	|	7:54		8:02	|	|	8:09		8:17	|	|	8:24	
BELMONT	|	|	|		8:04	|	|	|		8:19	|	|	|	
HILLSDALE	7:49	|	7:58		8:08	8:04	|	8:13		8:23	8:19	|	8:28	
HAYWARD PARK	|	|	8:00		8:11	|	|	8:15		8:26	|	|	8:30	
SAN MATEO	|	|	8:03		8:13	|	|	8:18		8:28	|	|	8:33	
BURLINGAME	|	|	|		|	|	|	|		8:31	|	|	|	
BROADWAY	|	|	|		8:17	|	|	|		|	|	|	|	
MILLBRAE	7:56	7:45	|		8:20	8:11	8:00	|		8:35	8:26	8:15	|	
SAN BRUNO	|	|	|		8:23	|	|	|		8:39	|	|	|	
SOUTH SAN FRANCISCO	8:01	|	|		8:27	8:16	|	|		8:42	8:31	|	|	
BAYSHORE	|	|	|		8:31	|	|	|		8:47	|	|	|	
22nd STREET	8:09	|	8:17		8:36	8:23	|	8:32		8:51	8:39	|	8:47	
TOWNSEND / 4TH AND KING	8:13	|			8:40	8:28	8:16			8:55	8:43	|		
SALESFORCE TRANSIT CENTER (STC)	8:17	8:05			8:44	8:32	8:20			8:59	8:47	8:35		

Train type	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)
Train number	10	410	812	516	710	206	312	912	518	712	12	412	814	520
GILROY			7:35		7:39		7:41	7:50		7:54			8:05	
SAN MARTIIN			|		|		|	|		|			|	
MORGAN HILL			|		|		7:51	|		|			|	
BLOSSOM HILL		7:44	|		|		8:00	|		|		8:14	|	
CAPITOL		7:49	|		|		8:04	|		|		8:19	|	
TAMIEN	7:46	7:53	|	7:57	|	8:01	8:08	|	8:12	|	8:16	8:23	|	8:27
SAN JOSE	7:49	7:56	7:58	8:00	8:02	8:04	8:11	8:13	8:15	8:17	8:19	8:26	8:28	8:30
SAN JOSE	7:51	8:02	8:00	8:04		8:06	8:17	8:15	8:19		8:21	8:32	8:30	8:34
COLLEGE PARK	|	|	|	|		|	|	|	|		|	|	|	|
SANTA CLARA	7:57	|	|	|		8:12	|	|	|		8:27	|	|	|
LAWRENCE	8:02	|	|	8:13		8:17	|	|	8:28		8:32	|	|	8:43
SUNNYVALE	8:05	8:13	|	8:17		8:20	8:28	|	8:32		8:35	8:43	|	8:47
MOUNTAIN VIEW	8:09	8:17	|	8:21		8:24	8:32	|	8:36		8:39	8:47	|	8:51
SAN ANTONIO	8:12	|	|	|		8:27	|	|	|		8:42	|	|	|
CALIFORNIA AVENUE	8:16	|	|	|		8:31	|	|	|		8:46	|	|	|
PALO ALTO	8:19	8:23	|	8:28		8:34	8:38	|	8:43		8:49	8:53	|	8:58
MENLO PARK	8:22	|	|	|		|	|	|	|		8:52	|	|	|
ATHERTON	|	|	|	|		8:38	|	|	|		|	|	|	|
REDWOOD CITY	8:28	8:28	|	8:35		8:43	8:43	|	8:50		8:58	8:58	|	9:05
SAN CARLOS	8:32	|	|	8:39		8:47	|	|	8:54		9:02	|	|	9:09
BELMONT	8:34	|	|	|		8:49	|	|	|		9:04	|	|	|
HILLSDALE	8:38	8:34	|	8:43		8:53	8:49	|	8:58		9:08	9:04	|	9:13
HAYWARD PARK	8:41	|	|	8:45		8:56	|	|	9:00		9:11	|	|	9:15
SAN MATEO	8:43	|	|	8:48		8:58	|	|	9:03		9:13	|	|	9:18
BURLINGAME	|	|	|	|		9:01	|	|	|		|	|	|	|
BROADWAY	8:47	|	|	|		|	|	|	|		9:17	|	|	|
MILLBRAE	8:50	8:41	8:30	|		9:05	8:56	8:45	|		9:20	9:11	9:00	|
SAN BRUNO	8:53	|	|	|		9:09	|	|	|		9:23	|	|	|
SOUTH SAN FRANCISCO	8:57	8:46	|	|		9:12	9:01	|	|		9:27	9:16	|	|
BAYSHORE	9:01	|	|	|		9:17	|	|	|		9:31	|	|	|
22nd STREET	9:06	8:53	|	9:02		9:21	9:09	|	9:17		9:36	9:23	|	9:32
TOWNSEND / 4TH AND KING	9:10	8:58	8:46			9:25	9:13	|			9:40	9:28	9:16	
SALESFORCE TRANSIT CENTER (STC)	9:14	9:02	8:50			9:29	9:17	9:05			9:44	9:32	9:20	

Train type	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-LCL)	REG (C-EXP)	HSR	REG (CT-LCL)	HSR	REG (C-EXP)	HSR	HSR
Train number	714	108	314	914	522	716	14	414	816	524	718	316	916	720
GILROY	8:09		8:11	8:20		8:24			8:35		8:39	8:41	8:50	8:54
SAN MARTIIN	|		|	|		|			|		|	|	|	|
MORGAN HILL	|		8:21	|		|			|		|	8:51	|	|
BLOSSOM HILL	|		8:30	|		|		8:44	|		|	9:00	|	|
CAPITOL	|		8:34	|		|		8:49	|		|	9:04	|	|
TAMIEN	|	8:31	8:38	|	8:42	|	8:46	8:53	|	8:57	|	9:08	|	|
SAN JOSE	8:32	8:34	8:41	8:43	8:45	8:47	8:49	8:56	8:58	9:00	9:02	9:11	9:13	9:17
SAN JOSE		8:36	8:47	8:45	8:49		8:51	9:02	9:00	9:04		9:17	9:15	
COLLEGE PARK		|	|	|	|		|	|	|	|		|	|	
SANTA CLARA		8:42	|	|	|		8:57	|	|	|		|	|	
LAWRENCE		8:47	|	|	8:58		9:02	|	|	9:13		|	|	
SUNNYVALE		8:50	8:58	|	9:02		9:05	9:13	|	9:17		9:28	|	
MOUNTAIN VIEW		8:54	9:02	|	9:06		9:09	9:17	|	9:21		9:32	|	
SAN ANTONIO		8:57	|	|	|		9:12	|	|	|		|	|	
CALIFORNIA AVENUE		9:01	|	|	|		9:16	|	|	|		|	|	
PALO ALTO		9:04	9:08	|	9:13		9:19	9:23	|	9:28		9:38	|	
MENLO PARK		9:07	|	|	|		9:22	|	|	|		|	|	
ATHERTON		|	|	|	|		|	|	|	|		|	|	
REDWOOD CITY		9:13	9:13	|	9:20		9:28	9:28	|	9:35		9:43	|	
SAN CARLOS		9:17	|	|	9:24		9:32	|	|	9:39		|	|	
BELMONT		9:19	|	|	|		9:34	|	|	|		|	|	
HILLSDALE		9:23	9:19	|	9:28		9:38	9:34	|	9:43		9:49	|	
HAYWARD PARK		9:26	|	|	9:30		9:41	|	|	9:45		|	|	
SAN MATEO		9:28	|	|	9:33		9:43	|	|	9:48		|	|	
BURLINGAME		9:31	|	|	|		|	|	|	|		|	|	
BROADWAY		|	|	|	|		9:47	|	|	|		|	|	
MILLBRAE		9:35	9:26	9:15	|		9:50	9:41	9:30	|		9:56	9:45	
SAN BRUNO		9:39	|	|	|		9:53	|	|	|		|	|	
SOUTH SAN FRANCISCO		9:42	9:31	|	|		9:57	9:46	|	|		10:01	|	
BAYSHORE		9:47	|	|	|		10:01	|	|	|		|	|	
22nd STREET		9:51	9:39	|	9:47		10:06	9:53	|	10:02		10:09	|	
TOWNSEND / 4TH AND KING		9:55	9:43	|			10:10	9:58	9:46			10:13	|	
SALESFORCE TRANSIT CENTER (STC)		9:59	9:47	9:35			10:14	10:02	9:50			10:17	10:05	

Figure A-7: Baseline Growth Stringline Graphic

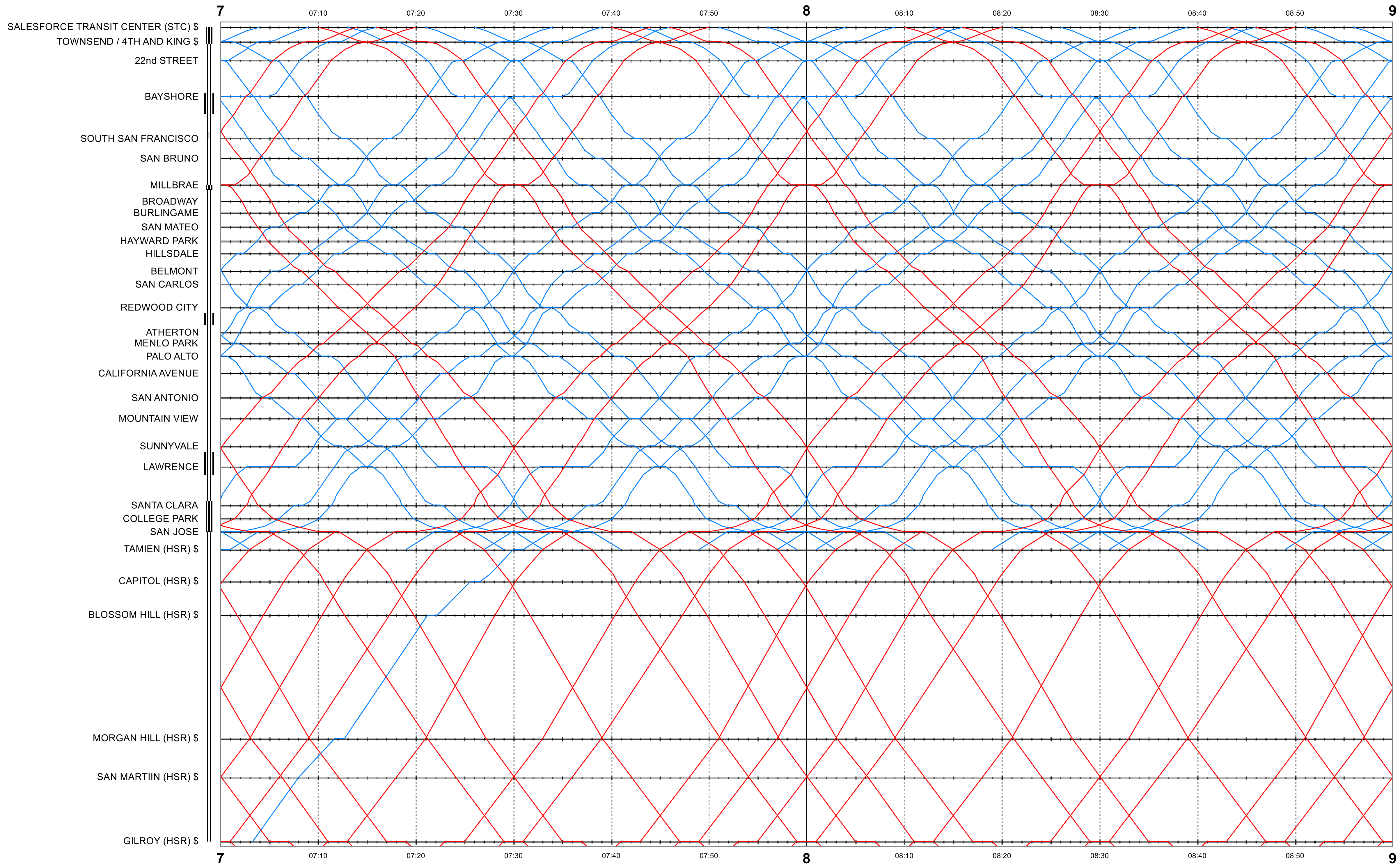


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Figure A-8: Moderate Growth Stringline Graphic

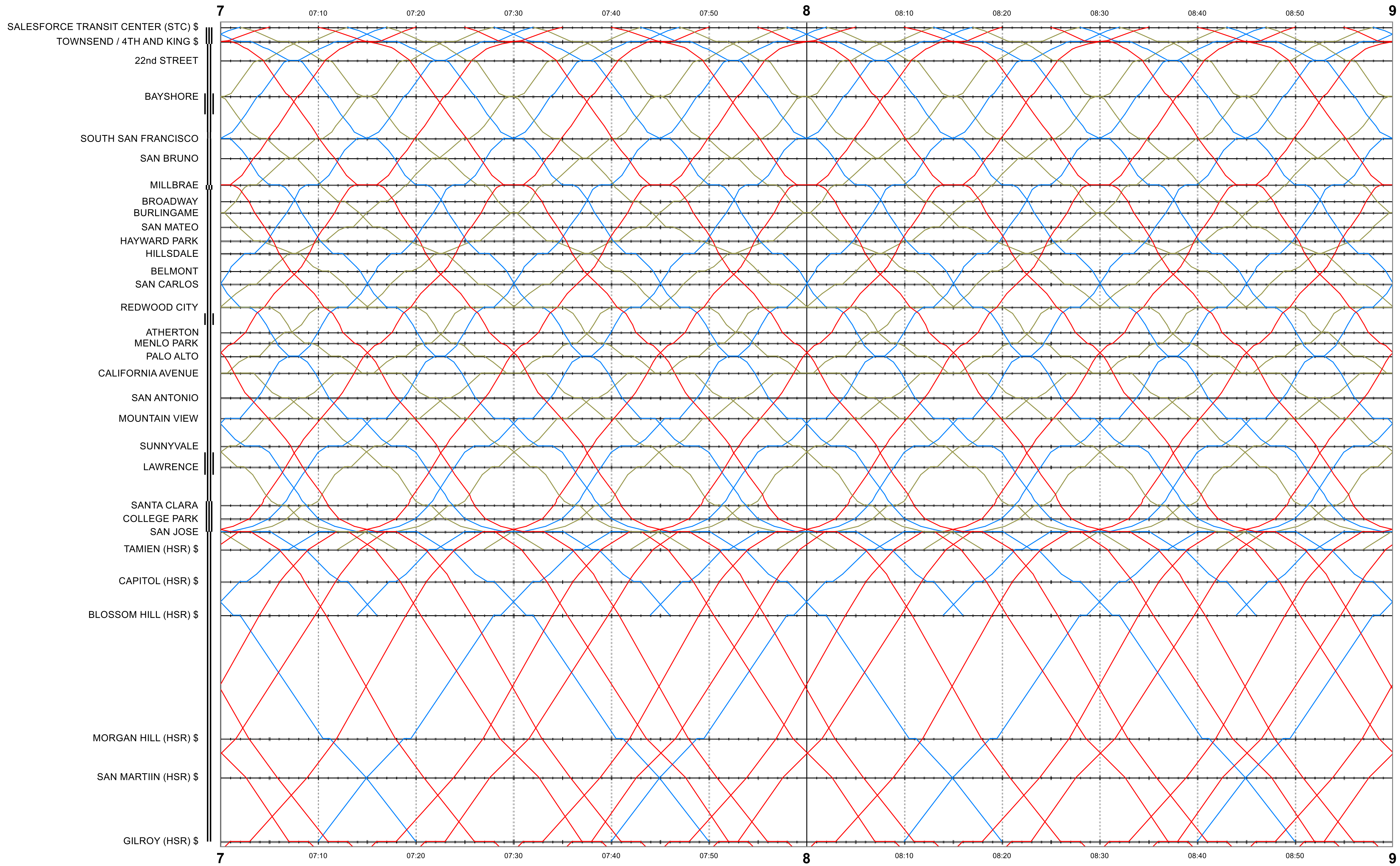

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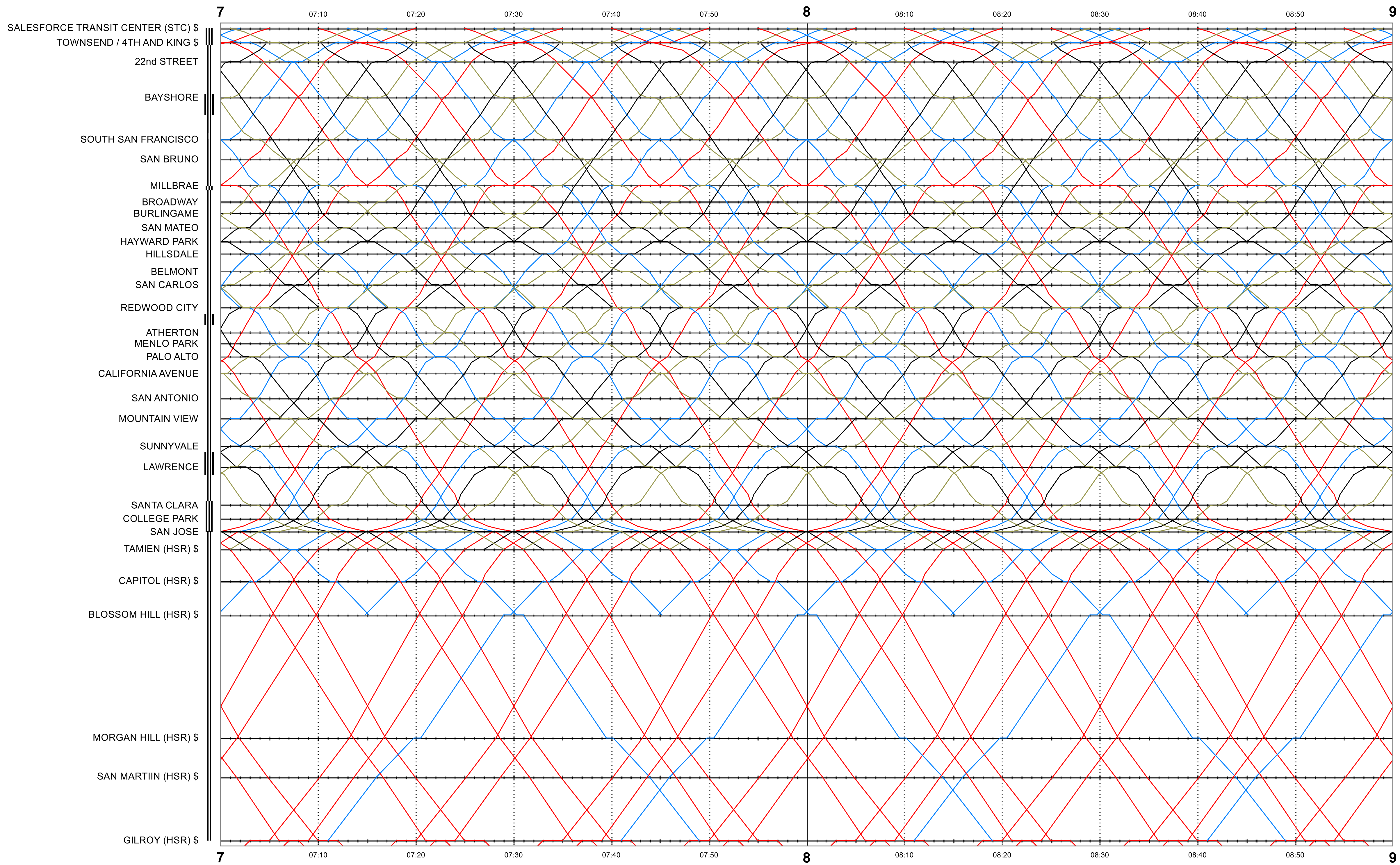
Figure A-9: High Growth Stringline Graphic



DB Engineering & Consulting USA IInc

Market Analysis and Ridership Forecasts

Prepared for:

October 2019

OK18-0254.00

Prepared by:

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1. MARKET ANALYSIS AND RIDERSHIP FORECASTS

This memo describes the ridership forecasting process for the Caltrain Business Plan (Business Plan). It covers existing ridership patterns and future context that informs ridership forecasts for each Growth Scenario. It also details the methodology and underlying assumptions used to update the Caltrain Ridership Model for use in the Business Plan. Outcomes include ridership forecasts by scenario and time period at system, station, and origin-destination levels to inform the Caltrain Integrated Business Model and other technical analyses such as the capital costing and economic analysis tasks. This document also discusses assumptions and uncertainties that may affect ridership outcomes.

1.1 INTRODUCTION

PURPOSE

The market analysis and ridership forecasts provide a measure of the changing nature of Caltrain's demand over the next two decades and beyond. Ridership forecasts were developed to quantify the mobility effects of Business Plan growth scenarios, provide an input to the Caltrain Integrated Business Model, capital costing and economic analyses, and inform a comparison of growth scenarios.

METHODOLOGY

The travel market analysis draws upon a review of existing Caltrain data as well as Plan Bay Area 2040 forecasts and recently approved plans by cities and agencies. This type of analysis identifies land use, transportation, and socioeconomic conditions conducive to Caltrain ridership. It considers current and future markets such as commuters traveling from San Francisco to the Peninsula and Silicon Valley, origin-destination patterns, population and employment density and other factors informing market demand.

The Caltrain Ridership Model considers changes to regional transportation and land use context as well as changes associated with Caltrain service patterns over time. Using the C/CAG-VTA Regional Travel Demand Model as a base, it employs a statistical analysis of Caltrain-specific ridership factors such as socioeconomic characteristics, service differentiation between stations, and station area land use and access. The approach also considers changes in travel patterns with the introduction of California High Speed Rail (HSR) and constrains ridership forecasts for a comfortable crowding condition appropriate for business planning.

FINDINGS

Caltrain has experienced substantial ridership growth over the past two decades, serving over 60,000 daily riders at this time. Unlike traditional commuter railroads, Caltrain serves a polycentric corridor with strong travel markets in both directions. Caltrain's existing ridership is highly concentrated at a few stations with the highest service levels, fastest travel times, and convenient access to population and employment hubs.

Over the next two decades, the Caltrain corridor is expected to see considerable growth. Moreover, major regional transit investments will open new markets to Caltrain. On its current path, Caltrain will serve over 150,000 daily riders by 2040. While electrification will expand Caltrain's passenger capacity, the opening of DTX around 2029 could push Caltrain demand above a comfortable level of crowding on trains during peak commute hours.

The Moderate and High Growth Scenarios (defined below) would increase Caltrain 2040 ridership to approximately 180,000 and 210,000 daily riders, respectively. Despite increasing peak period service levels, Caltrain would still experience uncomfortable crowding conditions on express trains under the Moderate Growth Scenario. The High Growth Scenario would comfortably serve 2040 demand within its seated capacity. Potential future changes to Caltrain's fare structure and uncertainties around the second Transbay tube, Dumbarton Rail, intra-San Francisco travel demand, and off peak and weekend demand may affect ridership over time.

APPLICATIONS IN THE BUSINESS PLAN

The market analysis informed the service planning process, including the optimization of service patterns based on relative demand between stations. The ridership forecasts serve as an input into the Caltrain Integrated Business Model, economic benefit analysis, rail simulation, capital cost estimates, and evaluation of growth scenarios.

Table 1: Definitions & Abbreviations

ACE	Altamont Corridor Express
Baseline Growth Scenario	All service and infrastructure improvements currently in planning or reasonably foreseeable based on current policy commitments. Includes 6 Caltrains and 4 high speed trains per hour, per direction, by 2033.
Blended Service	Shared operations between Caltrain and HSR on a mostly two track corridor
Crowding-constrained ridership	The total forecasted ridership that may be comfortably served after considering seated and standing room on trains given train lengths and service levels.
DTX	The Downtown Extension of Caltrain to the Salesforce Transit Center
EMU	Electric Multiple Unit
High Growth Scenario	2040 service expansions to 16 trains per hour, per direction, including 12 Caltrains and 4 high speed trains
HSR	High-Speed Rail
Moderate Growth Scenario	2040 service expansions to 12 trains per hour, per direction, including 8 Caltrains and 4 high speed trains
PCEP	Peninsula Corridor Electrification Project (also known as Caltrain Electrification)
Ridership demand	The total forecasted ridership in response to a train service plan given a set of land use and transportation parameters
STC	Salesforce Transit Center
VMT	Vehicle Miles Traveled
VTA	Valley Transportation Authority

1.2 EXISTING RIDERSHIP PATTERNS

SYSTEMWIDE RIDERSHIP TRENDS

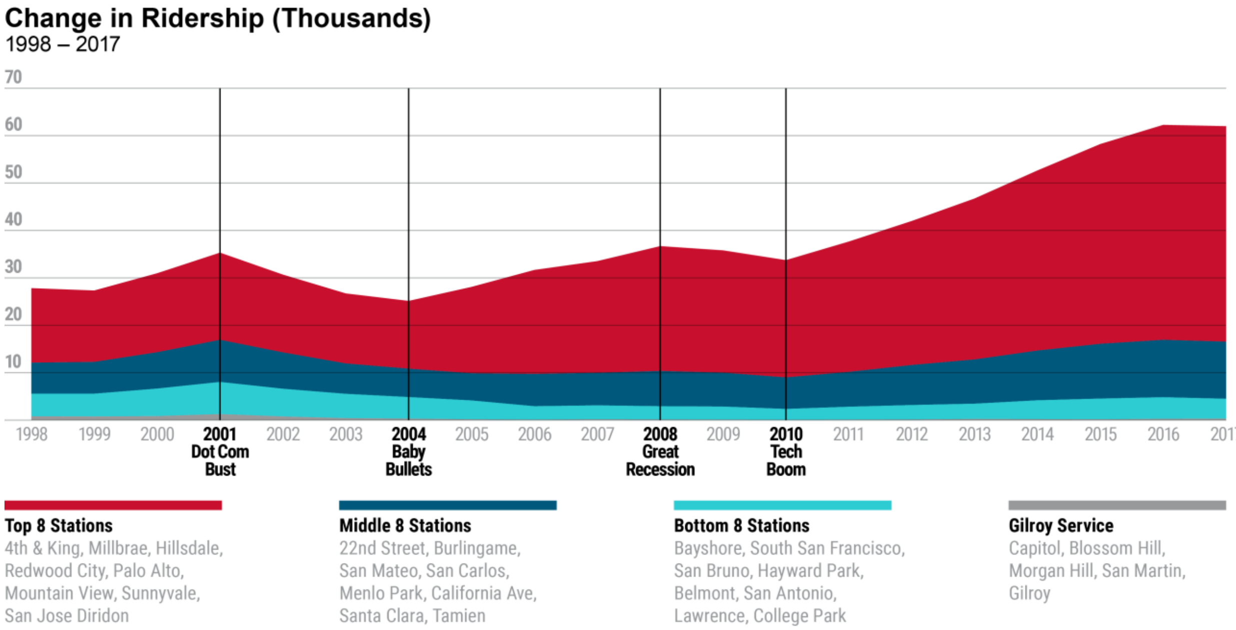
In 2017, Caltrain served over 62,000 riders on weekdays and 13,000 riders on weekends, translating to approximately 19 million passengers per year.[1] On weekdays, about 80 percent of ridership occurs during peak commuting periods when service levels are highest and regional traffic congestion is at its worst. The railroad has experienced substantial ridership growth over the past two decades – nearly tripling its ridership since the mid-1990s and doubling since the Great Recession in 2010. Caltrain's ridership growth is fueled by a combination of service improvements (e.g. the introduction of Baby Bullets in 2004), access improvements (e.g. the BART to Millbrae connection in 2003), and regional economic growth (especially employment growth in the technology sector and transit-oriented development near to stations).

Caltrain's existing ridership is highly concentrated at a few stations with the highest service levels, fastest travel times, and convenient access to population and employment hubs. Consequently, one in four Caltrain riders do not use the station closest to their origin or destination to access the train service. The busiest tier of eight stations accounts for 73 percent of Year 2017 daily boardings and 85 percent of ridership growth over the past 20 years. Travel between these major origin-destination pairs constitutes a majority of ridership in the system. Two Caltrain stations serve greater than

[1] In 2018, Caltrain changed its ridership data collection methodology to count mid-week ridership instead of average daily ridership. Ridership increased from 64,000 mid-weekday boardings in 2017 to 65,000 mid-weekday boardings in 2018.

5,000 boardings per day (4th & King and Palo Alto). The middle tier of eight stations accounts for about 19 percent of daily boardings and the remaining 15 percent of historical growth. The bottom tier of eight stations accounts for about seven percent of daily boardings and has lost about 1,000 boardings over the past 20 years. This group includes the five stations south of Tamien that accounts for about one percent or daily boardings. **Figure 1** illustrates the change in Caltrain ridership over the past two decades.

FIGURE 1: CHANGE IN RIDERSHIP, 1998-2017



ORIGIN-DESTINATION PATTERNS

Unlike traditional commuter railroads that primarily serve one peak direction, Caltrain serves a polycentric corridor with strong travel markets in both directions. During the AM peak period, 64 percent of riders travel northbound to employment hubs primarily in San Francisco, San Mateo, Redwood City, and Palo Alto. In the southbound direction, 36 percent of riders travel to employment hubs mostly in San Mateo, Redwood City, Palo Alto, Mountain View, and San Jose. On a daily basis, 55 percent of trips have an origin or destination in San Francisco; of these, about two thirds of passengers are traveling to or from Santa Clara County and one third traveling to or from San Mateo County. **Figure 2** illustrates AM peak period boardings and alightings by station.

FIGURE 2: AM PEAK PERIOD BOARDINGS AND ALIGHTINGS, 2017

Red indicates boardings, blue indicates alightings

ENVIRONMENTAL BENEFITS

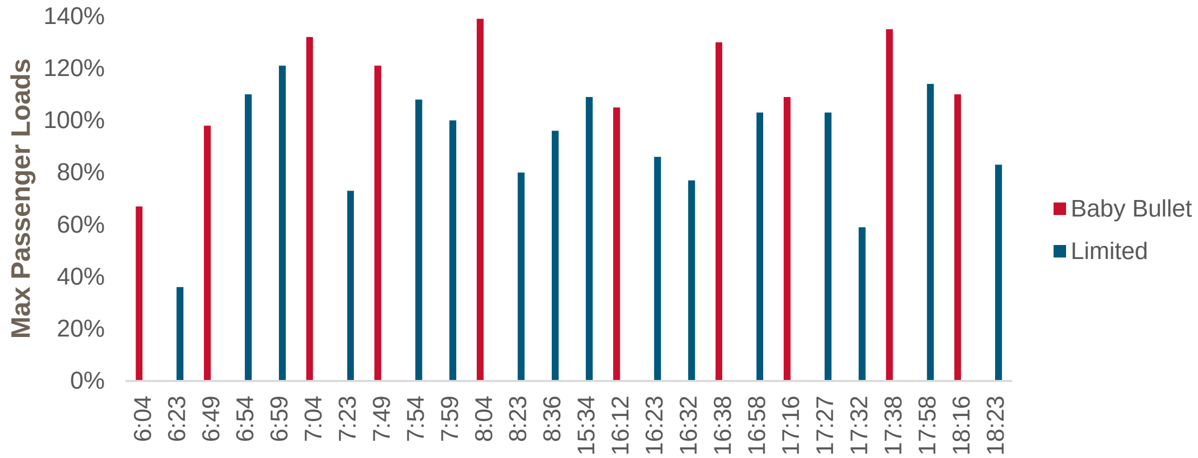
Caltrain provides substantial environmental benefits today. Caltrain reduces vehicle miles traveled (VMT) by approximately 400 million miles per year[2]. This translates to a reduction of approximately 160,000 metric tons of CO_2 per year. Caltrain's benefits extend to the physical environment as well - during peak hours, Caltrain accounts for about two and a half lanes of freeway traffic in the peak direction.

TRAIN CROWDING

Train crowding beyond seated capacity occurs in both directions. Ridership typically exceeds seated capacity on about half of peak period trains. Baby Bullet trains usually operate beyond their seated capacity (up to 140 percent above seated capacity) while Limited trains are typically near capacity (80 to 100 percent occupancy). Train crowding indicates that there may be latent demand for increased Caltrain service on the corridor amongst people who would ride if a more comfortable riding condition was achieved. **Figure 3** depicts peak period, peak direction passenger loads as a measure of train crowding.

[2] Based on Caltrain trip lengths from the C/CAG-VTA Model and assuming that all passengers would otherwise drive alone

FIGURE 3: PEAK PERIOD, PEAK DIRECTION PASSENGER LOADS, 2017



RIDER DEMOGRAPHICS

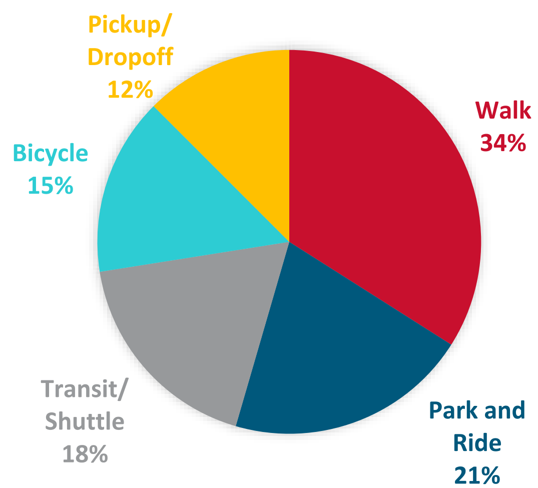
Caltrain riders are more likely to be white and earn higher incomes than residents of the Caltrain corridor (defined as living within two miles of a station). Over 60 percent of Caltrain riders earn an annual household income greater than $100,000, compared with 46 percent of residents on the Caltrain corridor. Caltrain serves fewer low-income households and people of color than SamTrans, VTA, Muni, or BART. Fares and travel patterns play a key role in shaping rider demographics – Caltrain mostly serves a commuter market with fares that are around 50 percent to 450 percent more expensive than comparable bus fares. **Figure 4** summarizes socioeconomic characteristics of Caltrain riders.

FIGURE 4: EXISTING CALTRAIN RIDER SOCIOECONOMICS

MODE OF ACCESS/EGRESS

Caltrain riders travel to and from stations by a variety of means. A plurality of trips occur via walking (34 percent), while park-and-ride (21 percent), transit and shuttles (18 percent), bicycling (15 percent), and pickup/drop off (12 percent) account for the remainder of access/egress trips. Unlike many commuter railroads, park-and-ride trips represent a relatively small fraction of trips at most stations with the exception of those south of Diridon. Caltrain's high rate of bicycle access/egress is also unique, especially at stations like 4th & King, Palo Alto, Mountain View, Diridon, and Menlo Park. Access facilities for all modes are often oversubscribed, particularly at high ridership stations where vehicle and bicycle parking, passenger loading areas, and bus/shuttle bays are in high demand. **Figure 5** illustrates existing mode of access.

FIGURE 5: MODE OF ACCESS/EGRESS, 2016



1.3 TRANSPORTATION & LAND USE CONTEXT

EXISTING REGIONAL TRANSPORTATION CONTEXT

Caltrain serves as the primary north-south transit connection between San Francisco and San Jose. Transfers are provided to a dozen operators, including Muni (San Francisco), BART (Millbrae), SamTrans (San Mateo County), Commute.org (San Mateo County), VTA (Santa Clara County), Highway 17 Express (Santa Cruz), County Express (San Benito County),

Caltrain carries a relatively small share of regional travel relative to US-101 and I-280 – the two freeway corridors that parallel the train line. During peak periods, Caltrain carries around 10 percent of all people traveling through the Mid-Peninsula (including US-101 and I-280). During off-peak and weekend periods, this mode share is around one to two percent. Whereas US-101 experiences high traffic volumes and varying levels of traffic congestion throughout the day, Caltrain experiences two distinct peak periods in the morning and evening. **Figure 6** and **Figure 7** depict weekday and weekend travel volumes along the Caltrain corridor crossing the San Francisco County line for Caltrain and US-101.[3]

[3] Based on Caltrain ridership data and Caltrans PEMS traffic counts. I-280, BART, bus, and local street traffic are not shown, because these facilities are less directly comparable in proximity and travel markets served.

FIGURE 6: WEEKDAY USAGE – US-101 VS. CALTRAIN

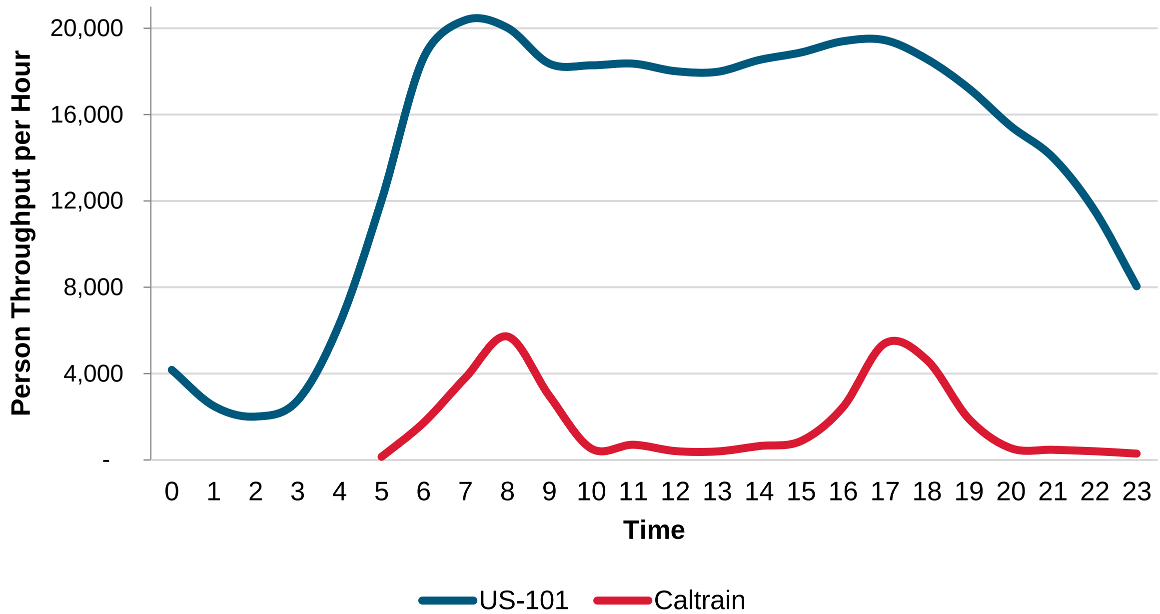
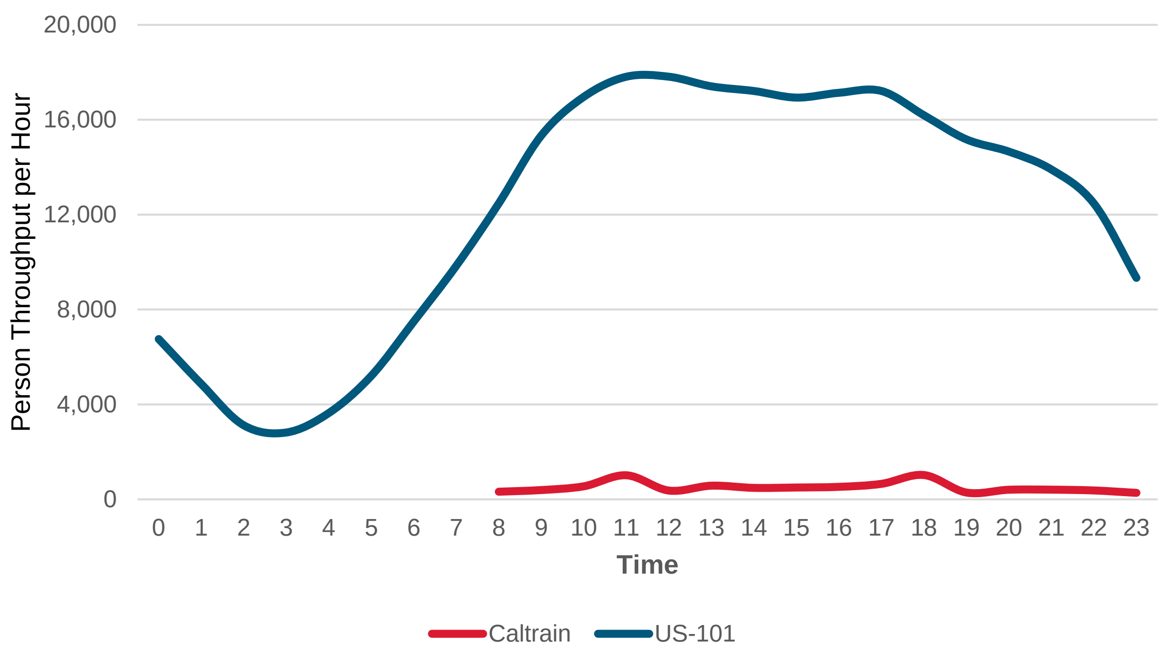


FIGURE 7: WEEKEND USAGE – US-101 VS. CALTRAIN



FUTURE TRANSPORTATION CONTEXT

Major regional transit investments over the next two decades will open new markets to Caltrain, while some projects will introduce new potentially competitive options to Caltrain riders. Key projects include, but are not limited to:

- The **Central Subway** will reduce travel times between 4th & King Station and Union Square/Chinatown.
- The **US-101 Managed Lanes Project** and reintroduction of **SamTrans Express Bus Service** will expand travel choices on the Peninsula.
- **High Speed Rail (HSR)** provides a statewide intercity rail system sharing the Caltrain corridor.
- The **Downtown Extension (DTX)** closes last mile gap between 4th & King Station and Salesforce Transit Center in downtown San Francisco while providing more direct regional connections to the East Bay and North Bay via BART, buses, and ferries.
- **Dumbarton Rail** links southern Alameda County and the Peninsula, facilitating transfers to Caltrain in Redwood City.
- **Silicon Valley BART Extension** enhances regional connectivity between the East Bay and San Jose and improves access to Caltrain from eastern San Jose, while also providing another option to reach San Francisco.
- Other regional rail investments in Capitol Corridor, ACE, and rail service to Salinas envisioned in the **State Rail Plan** create a more extensive commuter and intercity rail system connecting to Caltrain.

By 2040, Caltrain will connect to a regional and statewide rail network that spans the East Bay, Central Valley, Central Coast, and Southern California. Consequently, the market for Caltrain would expand from a Peninsula- and South Bay-focus to include a more diverse array of origins and destinations.

LAND USE CONTEXT

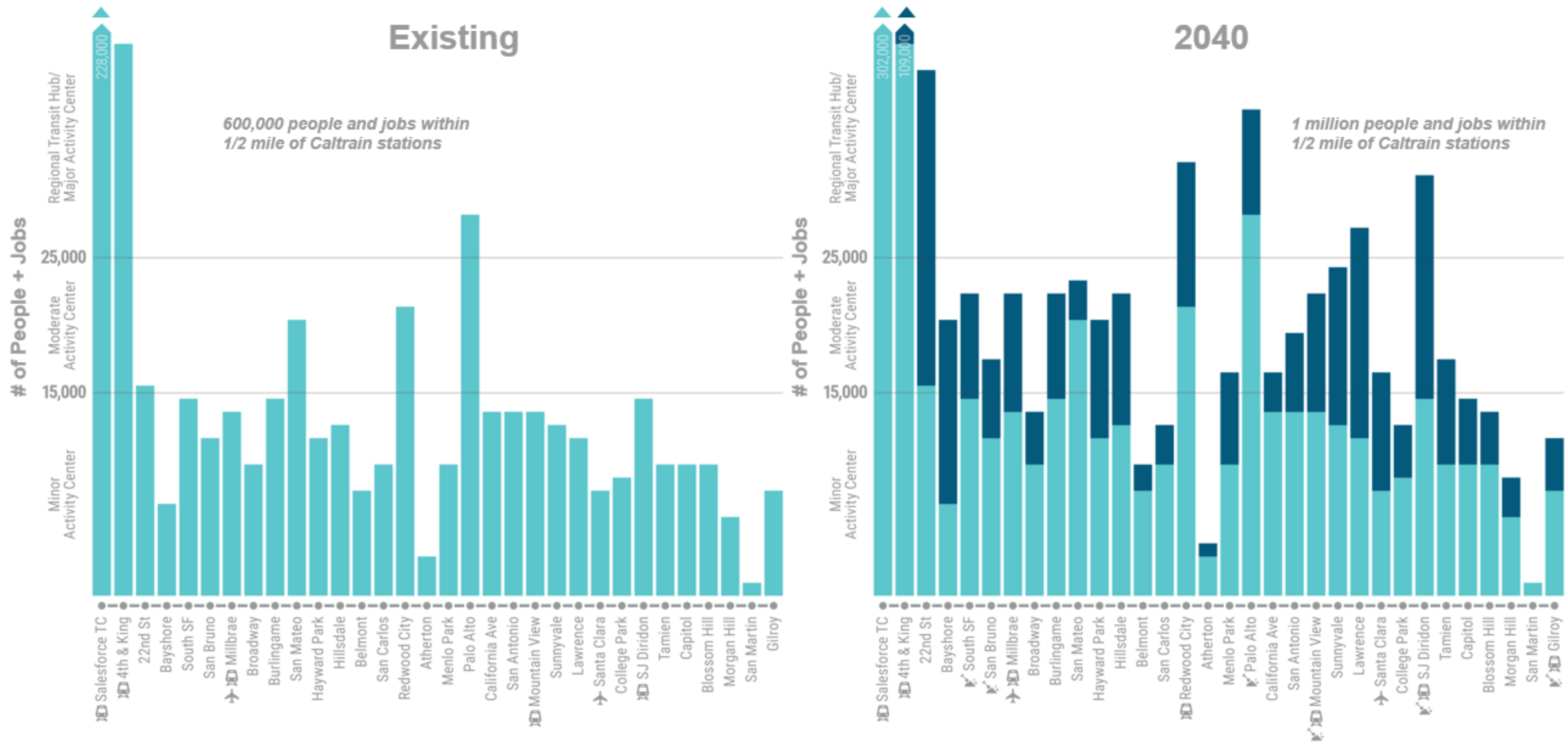
The Caltrain corridor spans nearly 80 miles of urban, suburban, and rural environments. Today, Caltrain serves about three million people and jobs within two miles of stations, about 20 percent or 600,000 of which are within one half mile of stations. Land use densities around immediate ½ mile station areas are highest in San Francisco but are also high in major Peninsula downtowns such as San Mateo, Redwood City, and Palo Alto. Within two-mile catchment areas, land use densities are also fairly high around stations in Santa Clara County, whereas closely-spaced mid-Peninsula stations have smaller catchment areas and consequently serve less people overall. Land use density does not necessarily correlate with station ridership. Some stations like Hillsdale experience relatively high service levels and ridership with relatively low densities, while other stations like Lawrence serve a dense catchment area, but experience relatively low service and ridership levels.

Over the next two decades, the Caltrain corridor is expected to see considerable growth. Plan Bay Area forecasts and approved developments by individual cities amount to 1.2 million additional people and jobs within two miles of the corridor by 2040.[4] Immediately adjacent to stations (within ½ mile), population and employment would nearly double from 600,000 to one million people and jobs. Growth is expected to be most heavily concentrated at the northern and southern ends of the corridor, including San Francisco, northern San Mateo County, and northern/central Santa Clara County, while less development is expected in the mid-Peninsula and southern Santa Clara County. Land use growth on the Caltrain corridor is likely to drive additional demand for Caltrain service over time. **Figure 8** and **Figure 9** illustrate existing and future population and employment within one half mile and two miles of Caltrain stations.[5]

[4] Approved projects by individual cities amount to an extra 12,000 people and 115,000 jobs along the Caltrain corridor as described in Table A-2 on Appendix A.

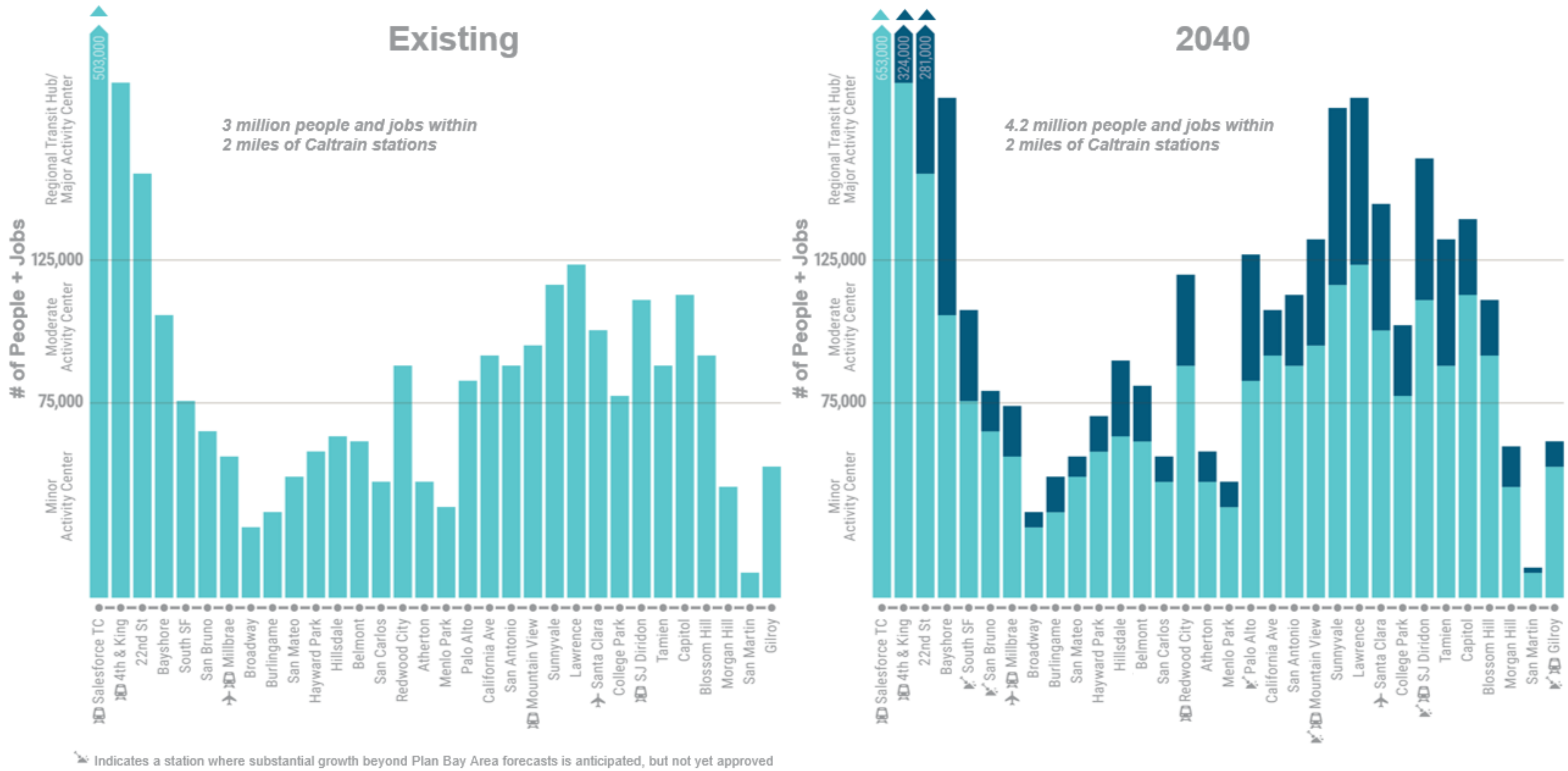
[5] Several development plans are underway on the Caltrain Corridor but were not approved prior to this analysis and therefore have been omitted from land use forecasts. This list of pending projects includes large developments in South San Francisco (Genentech Master Plan and other East of 101 and Lindenville developments), San Bruno (Bayhill Specific Plan), Menlo Park (Facebook Willow Village project), Palo Alto (Stanford General Use Permit update), Mountain View (East Whisman Specific Plan), San Jose (Google Diridon development and Downtown Plan), and Gilroy (Station Area Plan). Combined, these would result in an additional 12,000 people and 80,000 jobs along the study corridor beyond Plan Bay Area forecasts and approved land use growth. If these developments are realized, they are likely to further increase demand on the Caltrain corridor and exacerbate capacity challenges.

FIGURE 8: POPULATION AND EMPLOYMENT WITHIN ½ MILE OF STATIONS – EXISTING AND 2040



Indicates a station where substantial growth beyond Plan Bay Area forecasts is anticipated, but not yet approved

FIGURE 9: POPULATION AND EMPLOYMENT WITHIN 2 MILES OF STATIONS – EXISTING AND 2040



1.4 BASELINE GROWTH RIDERSHIP FORECASTS

SYSTEMWIDE CHANGE IN RIDERSHIP OVER TIME

Over the next 20 years, the completion of two key investments will shape how people use Caltrain: the introduction of electrified service in 2022, and the extension to Salesforce Transit Center in 2029. These projects, coupled with underlying ridership growth fueled by land use development, will propel Caltrain from a commuter rail service serving around 62,000 riders per day to a regional rail service serving 150,000 riders per day. This section summarizes how Caltrain's ridership is expected to change over time given planned and programmed activities through the Year 2040. These activities combined with project population and employment growth comprise the Baseline Growth Scenario.

Electrification (2022)

Electrification will unlock considerable latent demand in the Caltrain system related to today's comparatively low service levels and crowded train conditions. Electrification results in two significant changes in service: first, it increases frequency and reduces crowding for trips between major origin-destination pairs like San Francisco to Palo Alto; second, it substantially increases service levels at non-Baby Bullet stations, increasing many stations from one to two trains per hour or two to four trains per hour. As a result, all stations would experience relatively fast skip stop service. Outside of peak periods, Caltrain would operate two local trains per hour, per direction. Combined, these effects are expected to result in a 20 percent increase in Caltrain ridership – from about 70,000 riders pre-electrification to 85,000 daily riders post-electrification in 2022.

DTX (2029)

DTX will reshape Caltrain's interface with San Francisco and the region's transit network. By enabling a more seamless connection with downtown San Francisco and more efficient transfer opportunities to the East Bay and North Bay, DTX will further improve Caltrain's competitiveness in its core markets while opening new markets and transfer opportunities. Consequently, ridership is expected to increase by 25 percent after completion of DTX.

High Speed Rail (2029)

HSR affects Caltrain ridership in several ways, but the net effect is marginal relative to other changes. First, Caltrain trips to and from stations with HSR service would increase as a mode of access for statewide HSR trips. Second, Caltrain trips between HSR stations would decrease since HSR would provide a more time-competitive option for some travelers. Third, the blended service plan between HSR and Caltrain results in some changes to Caltrain's service pattern at the station-level and origin-destination level, which increases or decreases ridership at individual stations and markets. Overall, these factors generally balance out and result in a ridership increase of less than one percent upon complete implementation of Phase 1 service between San Francisco to Los Angeles in 2033, and about two percent by 2040.

Other Transportation and Land Use Changes

Several regional factors will influence Caltrain's ridership. In the early 2020s, the Central Subway will increase Caltrain's accessibility in San Francisco and help deliver more riders to 4th & King Station in tandem with electrification. In the late 2020s, Dumbarton Rail and BART to San Jose will further enhance regional connectivity and present new transfer opportunities to the East Bay, contributing about 1,000-2,000 daily riders each.

However, some regional improvements also provide new options that may compete with Caltrain in certain travel markets. The US-101 Managed Lanes project and the reintroduction of lower cost express bus service by SamTrans are likely to shift some of Caltrain's ridership potential to driving, carpooling, and bus ridership. BART to San Jose will also provide a more affordable one-seat ride to San Francisco for people in eastern Santa Clara County to reach San Francisco. Nonetheless, the aggregate effect of these changes and background population and employment growth will contribute to sustained gains in Caltrain ridership throughout the 2020s and 2030s.

BASELINE GROWTH SCENARIO – 2040 RIDERSHIP DEMAND AND PASSENGER LOADS

Caltrain would experience demand for approximately 161,000 weekday riders and 43,000 weekend riders in the 2040 Baseline Growth Scenario. Ridership demand would continue to be highly concentrated around key markets and distributed bi-directionally. The busiest stations would be Salesforce Transit Center, 4th & King, Palo Alto, Mountain View, and San Jose, resulting in a northbound/southbound split of 57/43 percent during the AM peak period. Approximately 61 percent of trips would have and origin or destination in San Francisco, a slight increase over existing ridership patterns.

Most stations would see ridership demand of about double or triple existing levels. In particular, Bayshore, Lawrence, South San Francisco, and Hayward Park would see substantial gains over existing levels associated with station area land use growth and improved service. In total, eleven stations would serve greater than 5,000 riders per day.

Passenger demand loads would be up to 200 percent of seated capacity during peak hours in the peak direction and up to 120 percent in the reverse peak direction. Loads would generally be comparable between trains since all would provide similar travel times to major markets due to the skip stop service pattern. The exception is the first train arriving after the 15- to 20-minute service gap that is required to blend fleeted HSR and Caltrain patterns on limited infrastructure. This train would experience higher loads given the long wait time during which passengers would continue to arrive at the station.

BASELINE GROWTH SCENARIO – CROWDING-CONSTRAINED FORECASTS

For the purposes of business planning such as financial forecasts and cost benefit calculations, ridership demand is constrained by the available capacity provided by the service plan. For the Baseline Growth Scenario, there is a significant difference between raw 2040 ridership demand and reasonable peak hour train capacity as discussed in this section.

Although Caltrain would experience near-term crowding relief after electrification in 2022, the opening of DTX in 2029 will push Caltrain demand above a comfortable crowding level during peak commute hours. Caltrain's 8-car EMUs would carry about 800 seated passengers assuming a load of 135 percent of seated capacity – a comfortable condition. This equates to a one-way passenger throughput of around 6,500 passengers per hour. After completion of DTX, Caltrain would experience a maximum peak direction demand of over 8,000 passengers during the peak hour, growing to over 9,000 passengers by 2040. Consequently, the Baseline Growth scenario would not fully serve 30 to 50 percent of peak hour demand, translating to about 6,000 to 10,000 unserved riders daily. From a rider's perspective, trains would feel crowded during peak hours and finding a seat would be difficult. The Baseline Growth Scenario would serve approximately 43 million passengers per year in 2040.

Figure 10 and **Table 2** display the change in Baseline Growth ridership over time.

FIGURE 10: CHANGE IN WEEKDAY RIDERSHIP, BASELINE GROWTH SCENARIO (CROWDING-CONSTRAINED)

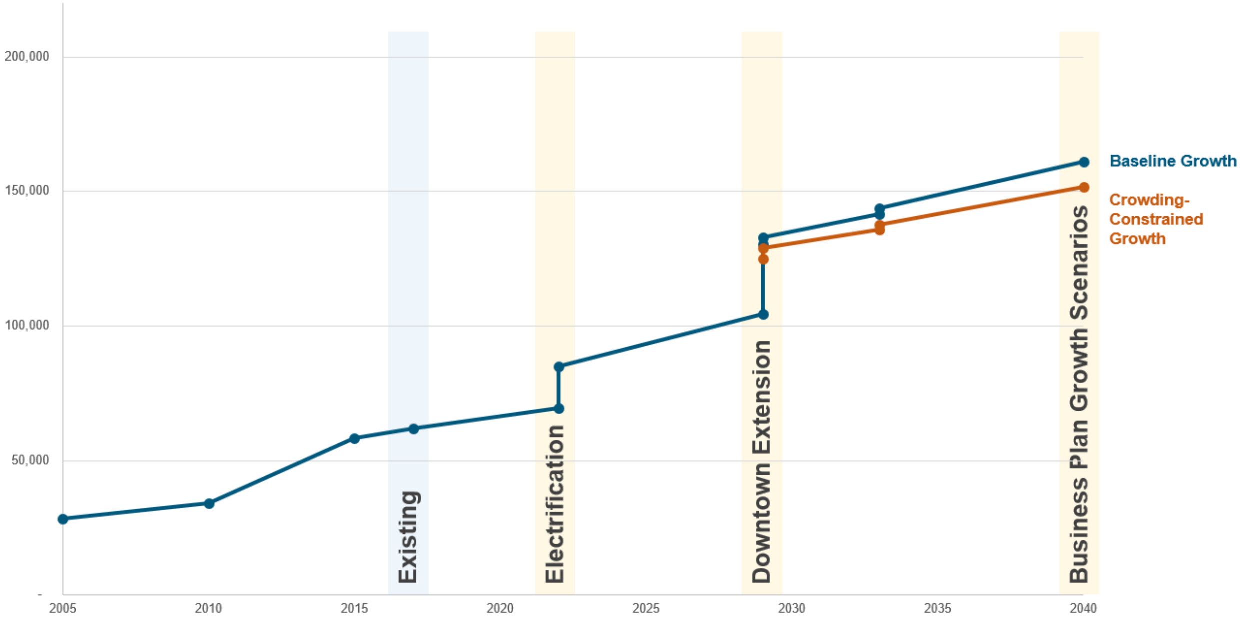


Table 2: Change in Ridership Over Time				
Model Year	**Service Plan**	**Weekday Ridership Demand**	**Weekday Crowding Constrained Ridership**	**Weekend Ridership**
2017	5 TPH (Existing)	62,100	62,100	13,400
2022	5 TPH (Existing)	69,700	69,700	15,000
	6 TPH (Electrification)	85,000	85,000	25,700
2029	6 TPH (Electrification)	103,100	103,100	27,800
	6 TPH (Electrification + DTX)	130,600	124,900	34,900
	6 TPH (Baseline + DTX + 2 HSR)	132,900	128,900	33,700
2033	6 TPH (Baseline + DTX + 2 HSR)	141,700	135,700	36,400
	6 TPH (Baseline + DTX + 4 HSR)	143,800	137,600	37,500
2040	6 TPH (Baseline + DTX + 4 HSR)	161,200	151,700	43,300

ENVIRONMENTAL BENEFITS

To evaluate environmental benefits of increased ridership and electrification, the California Air Resources Board (CARB) Transit and Intercity Rail Capital program (TIRCP) Calculator Tool was used. This methodology estimates both the greenhouse gas (GHG) and non-GHG emission reductions for transit projects. There are four possible Quantified Components, or project types; these are New/Expanded Service, System and Efficiency Improvements, Cleaner

Vehicles/Technology/Fuels, and Fuel Reductions. Each Quantified Component requires project-specific inputs that are used in calculating the difference in emissions from a baseline year[6].

This analysis used the New/Expanded Service and Cleaner Vehicles/Technology/Fuels components. The New/Expanded Service component calculates emission reductions due to increased ridership, based on the difference in emissions between displaced automobiles and new service vehicles. The Cleaner Vehicles/Technology/Fuels component calculates the emission reductions due to electrification, based on the difference in emissions between the displaced service fleet (diesel) and new service fleet (electric). The CARB methodology assumes GHG emissions from electricity based on current in-state and imported electricity emissions. This analysis assumed this default mix prior to 2040, but pivots to a 100% renewable mix after 2040. This assumption is consistent with other regional transit systems' commitments. BART has committed to 100% carbon-free electricity by 2035 and 100% renewable energy by 2045[7], while the California High-Speed Rail Authority has committed to net-zero GHG emissions in construction and 100% renewable energy in operations[8].

This analysis considered five different time periods: 2022-2029, 2029-2040, 2040-2070 (Baseline), 2040-2070 (Moderate), and 2040-2070 (High). As the fleet will remain diesel prior to 2022, no emissions reductions were calculated for 2018-2022. The reductions for each Growth Scenario are presented as the cumulative reduction savings between 2022 and 2070. For 2022-2029 and 2029-2040, there will be both expanded ridership and electrification, so both the New/Expanded Service and Cleaner Vehicles/Technology/Fuels components were considered. Between 2040 and 2070, the Baseline, Moderate, and High Growth Scenario fleets are fully electric, so just the New/Expanded Service component was considered.

After 2040, there is an increase in ridership but no increase in the vehicle fleet in the Baseline Growth Scenario. The majority of GHG emissions reductions are achieved between 2022 and 2040, with a reduction of over 700,000 Metric Tons of Carbon Dioxide Equivalent (MTCO2e) due to ridership expansion and electrification. In the Baseline Growth Scenario, ridership is then expected to increase by 3,484,000 rides over the thirty-year period between 2040 and 2070. The 2022-2070 cumulative benefit provides 1,108,045 MTCO2e in GHG emission reductions, as well as the non-GHG emissions reductions outlined in **Table 3**. It was assumed that 17% of riders will be transit-dependent (default from CARB model) and that the length of the average trip will be 20.1 miles from 2022-2029 and 19.3 miles from 2029-2070, based on the outputs from the Caltrain ridership model discussed elsewhere in this document.

Table 3: GHG and non-GHG Emissions Reductions, Baseline Growth Scenario

Time Period	GHG Emission Reductions (MTCO2e)	ROG Emissions Reductions (lbs)	NOx Emissions Reductions (lbs)	PM2.5 Emissions Reductions (lbs)	Diesel PM Emissions Reductions (lbs)
2022-2029	516,575	355,792	6,118,596	215,213	228,839
2029-2040	200,729	59,865	881,521	30,699	33,170
2040-2070 (baseline)	390,741	11,313	65,578	1,838	2,579
2022-2070 (baseline)	**1,108,045**	**426,970**	**7,065,695**	**247,750**	**264,588**

Note: Methodology and inputs are available in Appendix B.

[6] The CARB TIRCP Quantification Methodology, as well as the Calculator Tool, are available at: https://ww2.arb.ca.gov/resources/documents/cci-quantification-benefits-and-reporting-materials
[7] See: https://www.bart.gov/about/projects/cars/sustainability
[8] See: https://hsr.ca.gov/docs/programs/green_practices/sustainability/Sustainability_signed_policy.pdf

1.5 MODERATE AND HIGH GROWTH RIDERSHIP FORECASTS

MODERATE GROWTH SCENARIO – 2040 RIDERSHIP DEMAND AND LOAD

The Moderate Growth Scenario builds on the Baseline Growth Scenario including all of the same planned and programmed improvements but adding substantial increases in Caltrain service levels by 2040. Under this scenario, Caltrain would offer two differentiated service products during peak periods – a slower local stop service using two similar stopping patterns with four trains per hour, per direction, and a faster express stop service with four trains per hour, per direction. A timed transfer between the service types would occur at Redwood City station. Most stations would receive at least four trains per hour, per direction, but some mid-Peninsula stations would receive two trains per hour, per direction. The Moderate Growth service plan would also increase service south of Tamien to four trains per hour, per direction at Capitol and Blossom Hill, and two trains per hour, per direction at Morgan Hill and Gilroy. Outside of peak periods, Caltrain would operate four express trains and two local trains per hour, per direction.

Caltrain would experience demand for approximately 185,000 weekday riders and 57,000 weekend riders in the 2040 Moderate Growth Scenario. Ridership patterns would be similar compared to the Baseline Growth Scenario, with a slightly higher proportion of trips to or from San Francisco. Most stations would see a 10 to 30 percent increase in ridership demand. A few stations would experience more than double the ridership relative to the Baseline Growth Scenario due to substantially increased service levels, including South San Francisco, Capitol, Blossom Hill, Morgan Hill, and Gilroy. However, San Mateo would experience a 50 percent reduction in demand due to reduced service levels (two trains per hour, per direction instead of four trains per hour, per direction). Twelve stations would serve greater than 5,000 riders per day.

Passenger loads would be about 150 percent of seated capacity on express trains in the peak direction, but under 100 percent of seated capacity in the reverse peak direction.

MODERATE GROWTH SCENARIO – CROWDING-CONSTRAINED FORECASTS

Despite increasing peak period service levels, Caltrain would still experience uncomfortable crowding conditions on express trains under the Moderate Growth Scenario. Caltrain would operate 10-car EMUs that comfortably carry about 1,000 seated assuming a load of 135 percent of seated capacity. This amounts to a one-way passenger throughput of over 5,500 passengers per hour each service type. Caltrain would experience a 2040 maximum peak direction demand of over 11,000 passengers during the peak hour, about three-quarters of which or 7,000 passengers would occur on Express trains. Consequently, the Moderate Growth scenario would not fully serve demand on the Express trains by about 2,000 riders in the morning and evening peak hour. From a rider's perspective, trains would still feel crowded and finding a seat would be difficult. While some riders may opt for a longer travel time on less crowded Local trains, others may shift to other modes. The Moderate Growth Scenario would serve approximately 51 million passengers per year in 2040.

Table 4: 2040 Scenario Comparison

Service Plan	Weekday Ridership Demand	Weekday Crowding Constrained Ridership	Weekend Ridership	Annual Crowding Constrained Ridership
Baseline 6 TPH (+ 4 HSR)	161,200	151,700	43,300	43,200,000
Moderate 8 TPH (+ 4 HSR)	184,800	177,200	58,800	51,500,000
High 12 TPH (+ 4 HSR)	207,300	207,300	61,200	59,500,000

HIGH GROWTH SCENARIO – 2040 RIDERSHIP DEMAND

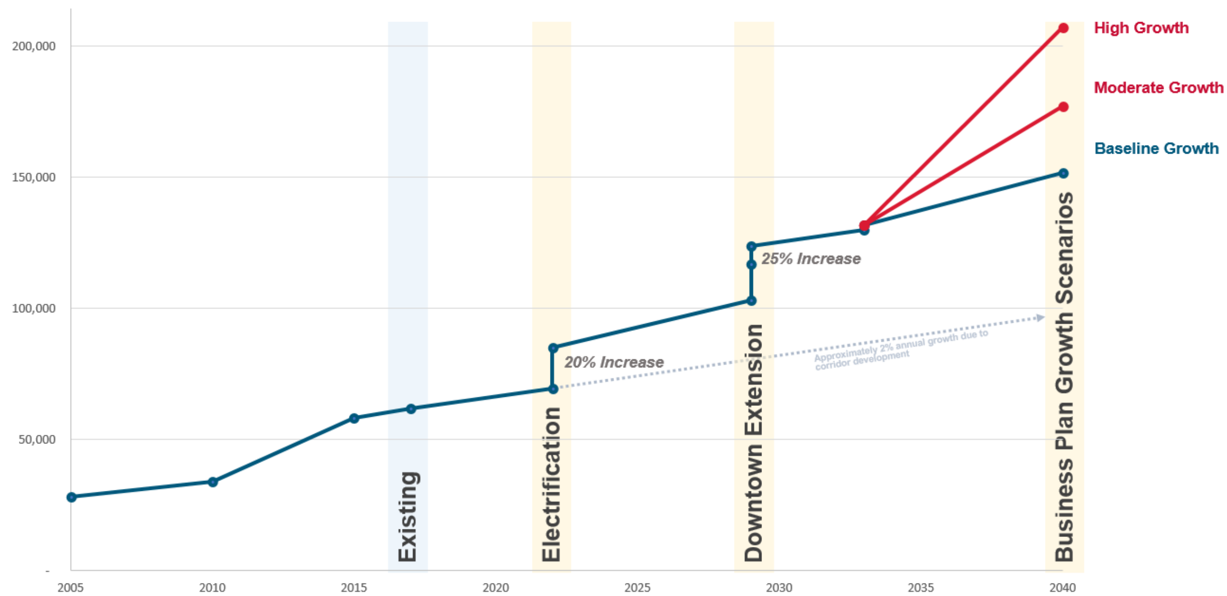
Under the High Growth Scenario, Caltrain would operate 12 trains per hour, per direction during peak periods using a local and express structure similar to the Moderate Growth Scenario with the addition of four peak period trains providing express service between 4th & King and Tamien stations. A majority of stations would receive eight or 12 trains per hour, per direction. Unlike the Baseline Growth and Moderate Growth Scenarios, the High Growth Scenario would include a Local service that stops at nearly all stations, with the exception of skip stop service to Broadway, Burlingame, Menlo Park, and Atherton. Four express and two local trains would be provided during off-peak periods and on weekends.

Caltrain would experience demand for approximately 207,000 weekday riders and 61,000 weekend riders in the 2040 Moderate Growth Scenario. Most stations would see a 10 to 30 percent increase in ridership demand relative to the Moderate Growth Scenario. A few stations (San Mateo, Hayward Park, and San Carlos) would see greater than a 50 percent increase in ridership by receiving more service. Fourteen stations would serve greater than 5,000 riders per day. The High Growth Scenario would serve approximately 59 million passengers per year in 2040.

The High Growth Scenario comfortably serves 2040 peak direction demand of nearly 12,000 riders per hour within a comfortable crowding capacity of 11,000 passengers per hour on Express trains and 5,500 passengers per hour on Local trains. It provides additional capacity to serve further growth beyond 2040.

Figure 11 shows the change in crowding-constrained weekday ridership over time for the Moderate and High Growth Scenarios relative to the Baseline Growth Scenario.

FIGURE 11: CHANGE IN WEEKDAY RIDERSHIP, MODERATE AND HIGH GROWTH SCENARIOS VERSUS BASELINE GROWTH SCENARIO (CROWDING-CONSTRAINED FORECASTS)



ENVIRONMENTAL BENEFITS

To evaluate environmental benefits of increased ridership and electrification, the California Air Resources Board (CARB) Transit and Intercity Rail Capital program (TIRCP) Calculator Tool was used. The methodology is described in Section 1.4.

After 2040, there is an increase in ridership but no increase in the vehicle fleet in the Moderate Growth and High Growth Scenarios. Over 700,000 MTCO2e of GHG emissions reductions will be gained between 2022 and 2040 due to ridership and electrification. In the Moderate Growth Scenario, use is then expected to increase by 9,610,000 rides over the thirty-year period between 2040 and 2070. The cumulative (2022-2070) benefit provides 1,898,330 MTCO2e in GHG emission reductions, as well as the non-GHG emissions reductions outlined in **Table 5**. It was assumed that 17% of riders will be transit-dependent and that the length of the average trip will be 20.1 miles from 2022-2029, 19.3 miles from 2029-2040, and 18.4 miles from 2040-2070.

In the High Growth Scenario, an additional 18,380,000 rides are projected over the thirty-year period between 2040 and 2070. The cumulative (2022-2070) benefit provides 3,006,028 MTCO2e in GHG emission reductions, as well as the non-GHG emissions reductions outlined in **Table 5.** It was assumed that 17% of riders will be transit-dependent and that the length of the average trip will be 20.1 miles from 2022-2029, 19.3 miles from 2029-2040, and 17.9 miles from 2040-2070.

Table 5: GHG and non-GHG Emissions Reductions, Moderate and High Growth Scenarios

Time Period	GHG Emission Reductions (MTCO2e)	ROG Emissions Reductions (lbs)	NOx Emissions Reductions (lbs)	PM2.5 Emissions Reductions (lbs)	Diesel PM Emissions Reductions (lbs)
2022-2029	516,575	355,792	6,118,596	215,213	228,839
2029-2040	200,729	59,865	881,521	30,699	33,170
2040-2070 (moderate)	1,181,026	34,473	199,549	5,623	7,880
2040-2070 (high)	2,288,724	67,004	387,707	10,941	15,326
2022-2070 (moderate)	**1,898,330**	**450,131**	**7,199,666**	**251,535**	**269,889**
2022-2070 (high)	**3,006,028**	**482,662**	**7,387,824**	**256,854**	**277,336**

Note: Methodology and inputs are available in Appendix B.

1.6 RIDERSHIP COMPARISON

STATION AND ORIGIN-DESTINATION PATTERNS

Caltrain would experience substantial ridership growth across nearly all stations and origin-destination pairs over the next two decades. Changes in ridership are influenced heavily by changes in land use and transportation connections as well as changes in service frequency and travel time, resulting in a greater concentration of ridership among some stations and origin-destination pairs relative to others. **Table 6** compares ridership by station, while **Table 7, Table 8,** and **Table 9** compare origin-destination flows between each growth scenario.

Table 6: Ridership by Station

Station	2017	2022		2029			2033		2040		
	Observed	Existing Service	PCEP	PCEP	PCEP with DTX	Baseline (Valley to Valley HSR)	Baseline (Valley to Valley HSR)	Baseline (Phase 1 HSR)	Baseline	Moderate	High
STC	0	0	0	0	16,700	19,100	20,100	20,000	21,600	26,800	25,000
4th and King	15,206	15,500	17,800	19,500	17,000	17,800	19,000	18,900	20,600	23,800	27,300
22nd St	1,686	1,900	2,900	3,500	3,700	4,500	4,900	4,900	5,800	7,100	9,500
Bayshore	239	800	1,500	2,200	2,300	2,000	2,200	2,300	2,700	3,200	3,200
South San Francisco	495	800	1,800	2,200	2,600	1,600	1,800	1,800	2,100	5,500	5,600
San Bruno	699	1,000	800	900	1,200	900	1,000	1,000	1,100	1,700	1,700
Millbrae	3,372	3,800	5,000	5,700	6,200	7,400	7,800	8,200	8,900	7,900	8,100
Broadway	0	0	500	600	800	1,200	1,300	1,300	1,400	1,100	1,100
Burlingame	1,061	1,400	1,100	1,500	1,900	1,300	1,400	1,400	1,700	1,900	2,100
San Mateo	2,100	2,400	3,300	3,800	4,400	3,700	4,000	4,000	4,500	2,300	5,100
Hayward Park	376	600	700	1,100	1,500	1,200	1,300	1,300	1,500	1,900	2,900

Table 6: Ridership by Station

Station	2017	2022		2029			2033		2040		
	Observed	Existing Service	PCEP	PCEP	PCEP with DTX	Baseline (Valley to Valley HSR)	Baseline (Valley to Valley HSR)	Baseline (Phase 1 HSR)	Baseline	Moderate	High
Hillsdale	2,961	3,400	4,400	5,300	5,900	7,000	7,400	7,600	8,500	9,000	10,400
Belmont	601	800	900	1,200	1,500	1,300	1,400	1,400	1,600	1,300	1,200
San Carlos	1,328	1,500	1,500	2,100	2,500	1,900	2,000	2,000	2,500	2,000	4,400
Redwood City	3,877	4,400	5,500	7,200	7,800	6,700	7,200	7,300	8,400	9,400	11,500
Atherton	0	0	300	400	700	1,200	1,200	1,300	1,400	900	800
Menlo Park	1,740	1,900	2,600	4,100	4,600	2,300	2,500	2,500	2,800	3,500	3,000
Palo Alto	7,412	7,700	9,100	10,200	11,400	12,500	13,100	13,400	14,900	15,700	18,000
California Ave	1,666	1,900	1,900	2,700	3,600	3,100	3,300	3,400	3,700	4,800	4,200
San Antonio	904	1,100	1,300	1,800	2,500	2,000	2,200	2,200	2,500	3,700	3,000
Mountain View	4,589	4,800	6,100	8,500	9,500	10,000	10,400	10,600	11,700	12,800	14,100
Sunnyvale	3,312	3,800	4,300	4,700	5,900	6,200	6,700	6,700	7,600	9,700	11,000
Lawrence	907	1,300	1,500	2,200	3,000	4,200	4,500	4,600	5,400	4,600	6,100
Santa Clara	1,022	1,300	1,700	1,900	2,600	2,000	2,200	2,200	2,500	3,300	3,300
College Park	76	100	100	100	100	0	0	0	0	0	0
San Jose Diridon	4,664	5,200	6,100	6,700	7,800	8,700	9,200	9,900	11,200	12,000	13,400
Tamien	1,264	1,500	1,800	2,000	2,000	2,300	2,600	2,600	3,300	3,900	5,100
Capitol	55	100	100	200	200	200	200	200	300	1,400	1,700
Blossom Hill	107	100	100	300	300	300	300	300	400	2,100	2,600
Morgan Hill	181	200	200	200	200	300	300	300	400	700	900
San Martin	69	100	100	100	100	0	0	0	0	0	0
Gilroy	173	200	200	200	200	200	200	200	200	600	700
Systemwide	**62,142**	**69,500**	**85,100**	**103,100**	**130,600**	**133,100**	**141,700**	**143,700**	**161,200**	**184,700**	**207,200**

Note: ridership at a few stations are highly sensitive to changes in service plans. Some stations experience an increase in ridership with more service (such as South San Francisco, Hayward Park, San Carlos, Capitol, and Blossom Hill), while other stations see reductions in ridership due to lower service levels (such as San Mateo or Menlo Park) or competition from nearby stations with increase service levels (such as Belmont, California Avenue, San Antonio, or Lawrence).

Table 7: County to County Travel Demand

Daily County to County Ridership Demand				
County OD Pair	**Existing**	**Baseline Growth**	**Moderate Growth**	**High Growth**
San Francisco-San Mateo	11,500	36,500	37,200	37,700
San Francisco-Santa Clara	22,600	57,400	71,200	74,800
San Mateo-Santa Clara	15,800	29,700	35,500	46,400
Within San Francisco	100	4,400	7,000	7,100
Within San Mateo	4,900	13,300	11,900	16,000
Within Santa Clara	7,200	19,900	21,900	24,500

Table 8: Top 5 Station Origin-Destination Pairs

Station-Station OD Pair	Existing	Baseline Growth	Moderate	High Growth
STC/4th & King-Palo Alto	4,300	9,100	12,300	12,300
STC/4th & King-Mountain View	4,100	8,100	9,300	9,300
STC/4th & King-Sunnyvale	3,700	6,900	8,400	8,600
STC/4th & King-San Jose	3,700	5,000	5,900	6,500
STC/4th & King-Lawrence	500	4,600	4,700	5,200

Table 9: Top 5 Station Origin-Destination Pairs, Excluding San Francisco

Top 5 Station OD Pairs, Excluding Downtown San Francisco				
Station-Station OD Pair	**Existing**	**Baseline Growth**	**Moderate**	**High Growth**
San Jose-Palo Alto	1,500	4,200	3,500	3,600
San Jose-Mountain View	400	2,900	3,300	3,500
Redwood City-Palo Alto	600	2,200	2,000	3,100
22nd Street-Palo Alto	1,400	1,700	2,000	2,600
Redwood City-Hillsdale	300	1,500	2,100	2,400

PEER COMPARISON – SYSTEM LEVEL RIDERSHIP

Caltrain's 2040 demand for all three growth scenarios would remain lower than peer commuter rail and regional rail systems given its comparatively smaller scale operations. On a daily ridership basis, Caltrain could move up to fifth nationally among commuter rail systems (presently seventh) or 10th nationally among metro systems (currently 11th). Relative to BART, Metro North, and the Long Island Railroad, Caltrain's ridership demand would be about one-third to one-half of peak direction ridership at their respective peak load points. However, Caltrain would serve a substantially higher reverse-peak demand than peer systems. **Figure 12** and **Table 10** compares peak hour ridership among peer railroads.

FIGURE 12: PEER COMPARISON, PEAK HOUR RIDERSHIP

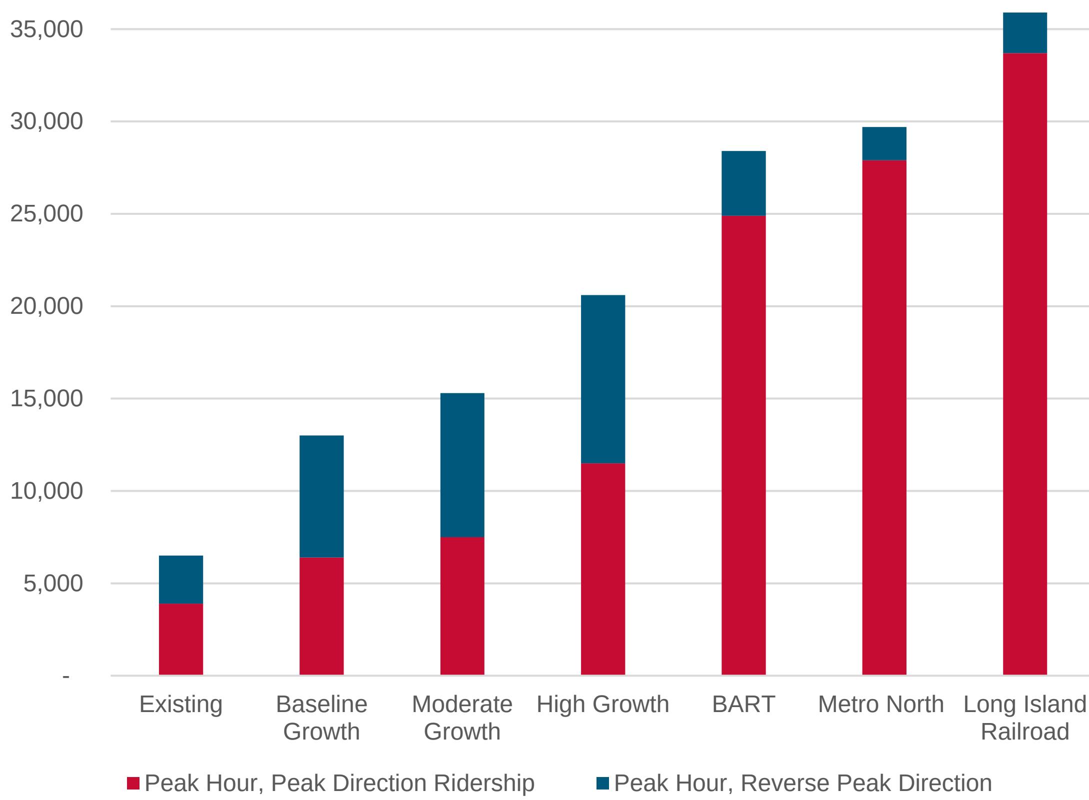


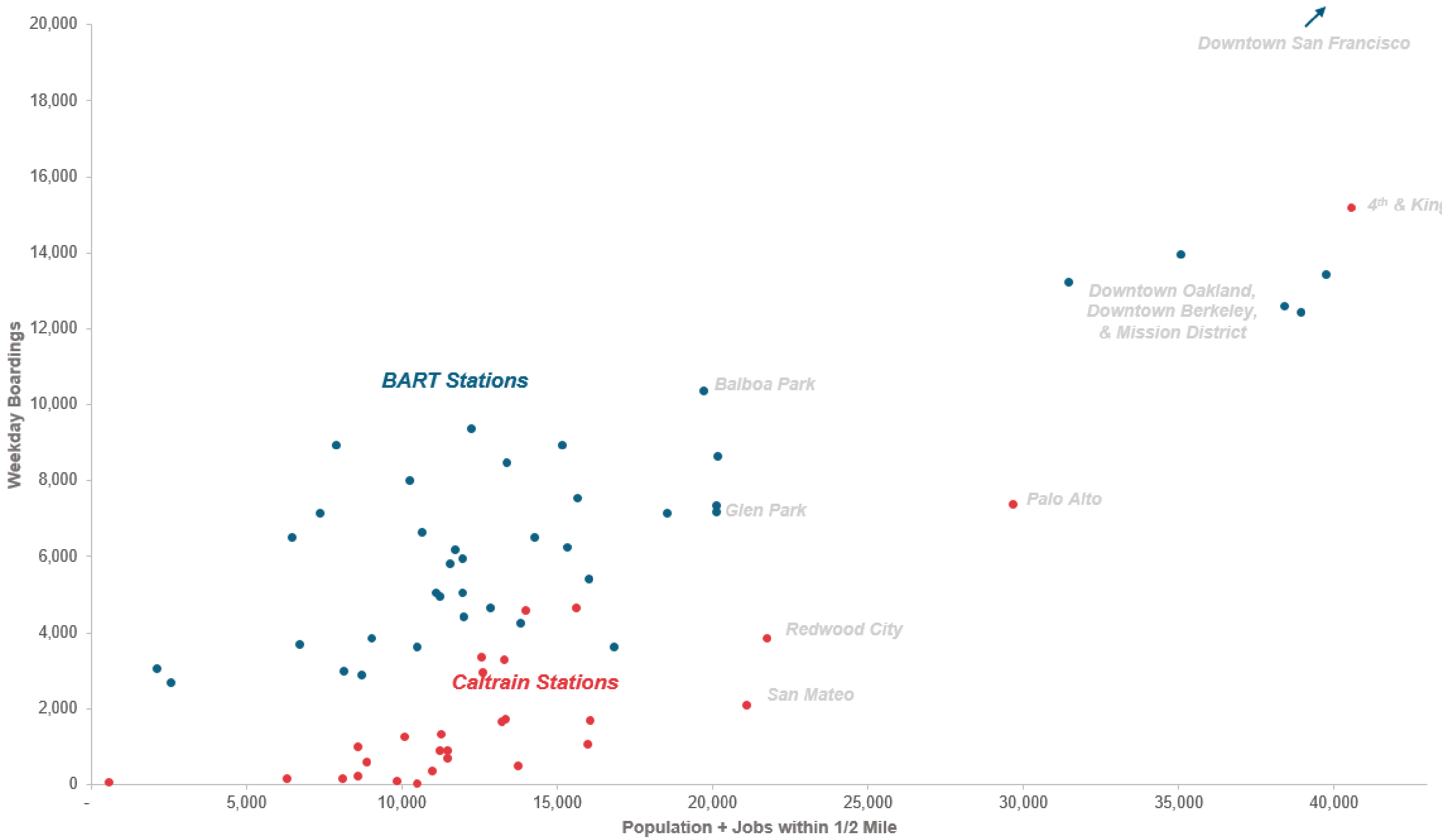
Table 10: System Comparison

System		Daily	Peak Hour, Max Load Point	Peak % - Reverse Peak %	Peak Hour, Peak Direction Max Load Point
Caltrain	Existing	62,000	6,500	60% - 40%	3,900
	2040 Baseline	161,000*	15,300*	57% - 43%*	8,700
	2040 Moderate	185,000*	17,700*	56% - 44%*	9,900
	2040 High	207,000	20,600	56% - 44%	11,500
BART (All Lines)		414,000	28,400	88% - 12%	24,900
Metro North (Harlem & New Haven Lines)		176,000	27,900	94% - 6%	26,200
Long Island Railroad (All Lines)		350,000	35,900	94% - 6%	33,700

PEER COMPARISON – STATION RIDERSHIP

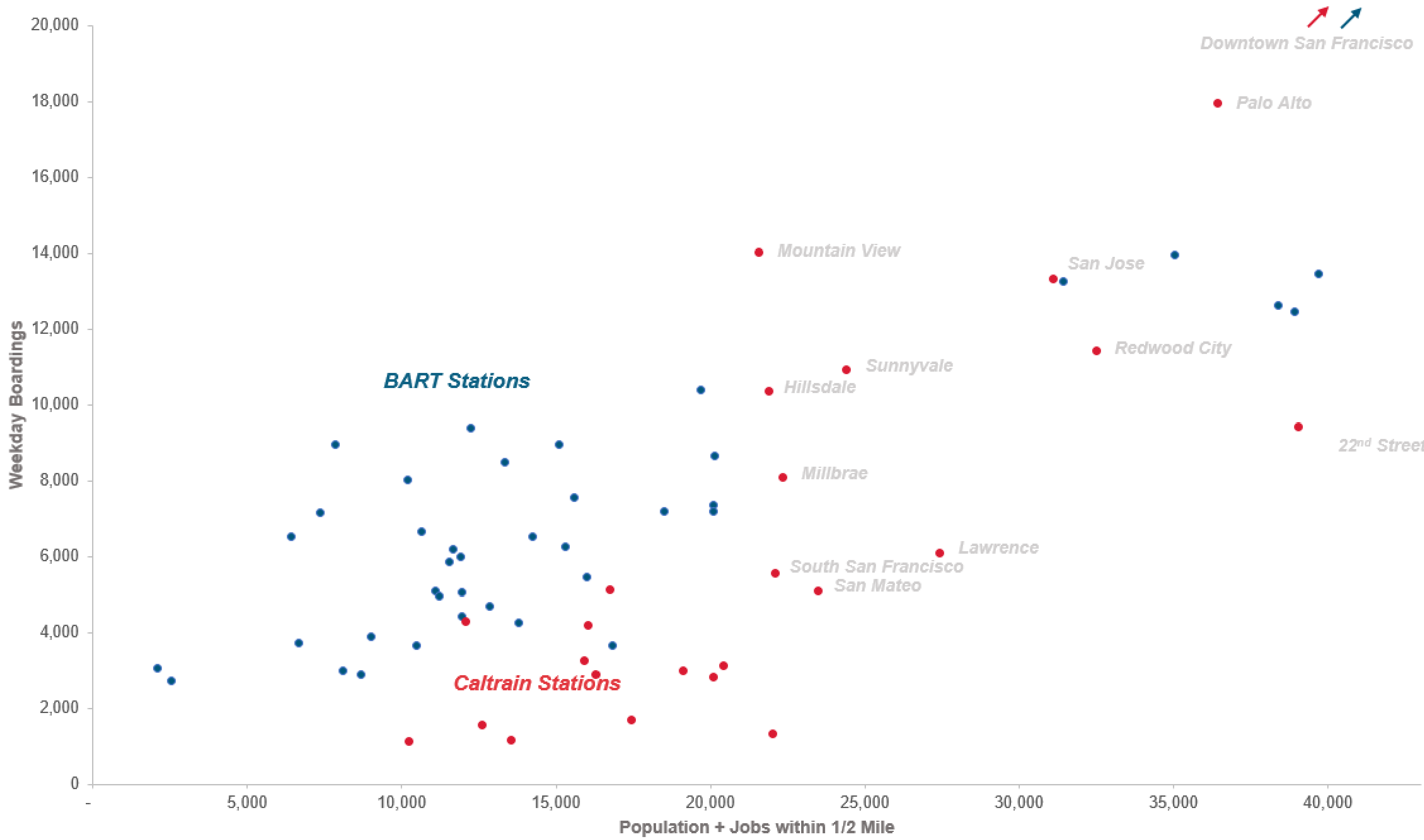
Service improvements would make individual Caltrain stations function more like BART stations. Caltrain stations presently exhibit comparable land use characteristics to BART stations, but have lower ridership primarily due to lower service levels. As shown in **Figure 13** below, four Caltrain stations serve greater than 20,000 people and jobs within ½ mile of stations (a measure of a high density of transit-oriented land uses), compared with 12 BART stations (mostly in San Francisco, Oakland, and Berkeley).

FIGURE 13: RIDERSHIP VS. POPULATION/JOBS WITHIN ½ MILE, EXISTING CALTRAIN VS. EXISTING BART



Land use growth would make many Caltrain station areas denser in 2040 than BART stations are today. Sixteen Caltrain stations would serve greater than 20,000 people and jobs within ½ mile of stations. Most of these would serve comparable ridership volumes to BART stations – around 6,000 to 14,000 daily riders as shown in **Figure 14** below.

FIGURE 14: RIDERSHIP VS. POPULATION/JOBS WITHIN ½ MILE, 2040 CALTRAIN VS. EXISTING BART



1.7 EXPLORATIONS

This section explores uncertainties in the ridership forecasts related to Caltrain-specific and external variables, and considers potential optimization opportunities. It qualitatively covers a range of topics related to service structure, fares, interface with major infrastructure projects, and capacity load management.

OFF-PEAK AND WEEKEND SERVICE

Off-peak and weekend forecasts include a higher level of uncertainty due to limited available data on these travel markets. Not only is there less Caltrain service and ridership during this period, but also fewer rider surveys available and less extensive calibration of the VTA-C/CAG Model (while the VTA-C/CAG Model includes an aggregated off-peak period, it does not include a weekend period). Consequently, off-peak and weekend forecasts represent a rough order of magnitude estimate.

Given the latent demand for increased service and growing station-area development, off-peak and weekend ridership forecasts appear conservative relative to existing BART demand. The Moderate and High Growth forecasts suggest that off-peak ridership would account for 17 percent of daily ridership, and weekend ridership would account for about 32 percent of weekday daily ridership. In comparison, off-peak ridership accounts for 23 percent of daily ridership for BART in San Mateo County, and weekend daily ridership is 41 percent of weekday daily ridership.

FARE STRUCTURE

Changes to Caltrain's fare structure may affect how existing and potential riders use Caltrain. Caltrain fares are 50 percent to 450 percent more expensive than comparable bus fares. While the 2018 Fare Study illustrates that current Caltrain riders are not very sensitive to changes in price, many bus riders on the Caltrain corridor exhibit a higher price sensitivity and choose to ride slower and more affordable bus services instead. While not unique to Caltrain, this difference in fare structures inhibits equitable mobility benefits to all transit riders on the Caltrain corridor and plays a role in reducing ridership. In contrast, Caltrain's GoPass program – providing discounted passes to major employers – has the potential to concentrate ridership and mobility benefits amongst higher earners at participating employers.

Caltrain's zone-based fare structure can similarly affect ridership patterns and equity outcomes. For example, a 20-mile one-way trip from San Bruno to Palo Alto costs $8.25 with a three-zone fare, whereas a 20-mile one-way trip from Burlingame to Mountain View costs $6.00 with a two-zone fare. Stations near zone boundaries are most affected by higher fares and reductions in ridership demand; many of these zone boundaries correspond with Communities of Concern (near South San Francisco, San Bruno, Redwood City, Menlo Park, Sunnyvale, Lawrence, Tamien, and Capitol Stations).

Caltrain's fare structure may play a role in depressing weekend ridership. With a higher proportion of non-work trips, comparatively lower levels of traffic congestion, and free parking on Sundays in many jurisdictions, Caltrain's fares are less competitive for weekend travel.

DUMBARTON RAIL

There is some uncertainty around the effects of the planned Dumbarton Rail connection on Caltrain ridership. Of the approximately 15,000 daily riders using a potential rail shuttle service between Union City and Redwood City, about 1,000-2,000 are projected to transfer to or from Caltrain. While a relatively small total, these forecasts may underestimate travel demand along the corridor and the potential for Dumbarton Rail to interface with improvements to ACE and Capitol Corridor, especially in the context of a broader investment in service to the Tri-Valley and Central Valley regions.

A convenient connection to Dumbarton Rail presents an opportunity for ridership growth. The greatest ridership opportunities for East Bay passengers transferring to Caltrain via Dumbarton Rail are along the portion of the Peninsula between South San Francisco and Sunnyvale; markets to the north and south are more directly served by BART and therefore less competitive[9]. Given that the market demand is for locations relatively close to the transfer at Redwood City, demand for local trains may be comparable to express trains. Therefore, an infill station at North Fair Oaks may

[9] The exception would be trips between San Francisco and Menlo Park, which would be more efficiently served by express trains.

also appropriately facilitate transfers between Dumbarton and Local trains while serving a new ridership market around the station area, particularly if a transfer station at Redwood City presents engineering challenges.

Interlining trains from the Dumbarton Rail onto the Caltrain mainline is also of potential interest but presents challenges. A ridership comparison of the Moderate and High Growth scenarios illustrates the opportunities and challenges of interlining Dumbarton and Caltrain trains. Compared to the High Growth scenario, the Moderate Growth scenario serves approximately 20,000 fewer riders traveling through Redwood City to or from Santa Clara County because of lower frequency and limited capacity for express trains. If some express trains in the High Growth scenario turned onto the Dumbarton Corridor instead of continuing to San Jose, a net loss in ridership may occur. However, further consideration is warranted as the Dumbarton Rail project evolves, particularly if it is integrated with a broader investment in rail service to the Tri-Valley and Central Valley regions beyond what is presently contemplated in the State Rail Plan.

INTRA-SAN FRANCISCO TRAVEL DEMAND, STC SURCHARGE EFFECTS, AND 22ND STREET STATION

Caltrain's post-DTX market serving intra-San Francisco travel is unclear and warrants further analysis as planning and design efforts continue in San Francisco. While the intra-San Francisco Caltrain market serves fewer than 100 riders today, DTX and growth on the eastern waterfront increase this total to about 7,000 daily riders in the Moderate and High Growth Scenarios (about three to four percent of total daily ridership)[10]. Given the potential travel time savings of 60 to 70 percent relative to Muni, it's possible that this market may be significantly larger than estimated by the model. **Table 11** compares intra-San Francisco travel times.

Table 11: Intra-San Francisco Travel Time Comparison

Origin-Destination Pair	Estimated Travel Time (& Frequency)	
	Muni	Caltrain
4th & King - STC/Montgomery Station	15 minutes (6 trains per hour)	4 minutes (8 trains per hour)
22nd Street - STC/Montgomery Station	25 minutes (6 trains per hour)	8 minutes (8 trains per hour)
Bayshore – STC/Montgomery Station	37 minutes (8 buses per hour)	13 minutes (4 trains per hour)

Note: Assumes completion of Central Subway.

One factor influencing intra-San Francisco travel patterns as well as overall station ridership forecasts is the planned fare surcharge for passengers traveling to STC. While no fare surcharge has been adopted, a $2.50 surcharge in Year 2018 dollars was assumed – comparable to designating STC as a separate Caltrain zone. This surcharge reduces overall ridership at STC, either shifting trips to 4th & King or to other modes (driving alone, carpooling, BART, or express bus). Depending on the actual surcharge amount, ridership demand may increase or decrease at STC.

Another factor influencing intra-San Francisco travel demand is the location of 22nd Street Station. The present station location offers a connection to Potrero Hill and the growing Pier 70 and Dogpatch neighborhoods, but access challenges depress its ridership potential. A location closer to 16th Street may offer the greatest potential ridership gains given its proximity to UCSF, the Warriors Arena, and the 22-Filmore bus line. Given the rapid growth occurring on the City's southeastern waterfront, the area between 22nd Street and Bayshore is underserved by Caltrain; however, as discussed in the *Service Planning* memorandum, there is constrained operational capacity to add another station without delaying all trains or reducing local service at another station.

SECOND TRANSBAY TUBE

A second Transbay Tube presents an opportunity to serve travel demand between the East Bay and Caltrain corridor. While this market is highly constrained today due to severe traffic congestion and lack of transit connectivity, the completion of DTX will enable more direct connections. A second Transbay Tube would help fully realize potential

[10] For a point of comparison, about 13 percent of BART trips are fully within San Francisco, although some Muni passes include access to BART.

ridership and mobility benefits. There are a number of potential alignments and service types under consideration; BART is studying both standard-gauge and BART-gauge services, while the State Rail Plan contemplates intercity rail service between Sacramento and the Peninsula.

A second tube would increase ridership demand for Caltrain service and exacerbate the need for more passenger capacity. Further investigation is needed to determine whether the High Growth scenario could accommodate this increased demand. New markets served by a second tube would span from Oakland to Richmond, but may extend to eastern Contra Costa County, Solano County, and beyond. South of Oakland, Transbay trips may be more directly served by enhancements to the Dumbarton and San Mateo Bridge corridors. Demand could be strongest on the northern branch from Oakland to Richmond, where conventional rail service serves a distinct market from BART. BART's Metro Vision considered potential demand of about 50,000 daily riders on this corridor.

SERVICE OPTIMIZATION OPPORTUNITIES

The Baseline Growth Scenario service plan (and the PCEP service plan) largely reflects prior service plans that have not been optimized for changing ridership patterns. Consequently, there may be some opportunities to further optimize the Baseline scenario to increase ridership, such as increasing service to stations like Sunnyvale, Redwood City, South San Francisco, and 22nd Street which underperform relative to the Moderate and High scenarios. However, while such changes may increase demand, this would exacerbate peak period crowding issues.

The Moderate and High Growth service plans were subject to an extended planning process described in the Service Planning Memorandum; consequently, the service plans may be considered nearly optimized for ridership. Further optimization may consider the tradeoffs of spreading express service to more local-only stations with high levels of demand (such as California and San Antonio) or augmenting stations with reduced local service levels (such as Burlingame and Menlo Park). Spreading two express trains per hour to most stations may help improve access to express service, but is not expected to increase ridership or overall mobility due to lack of frequency.

2040-2070 DEMAND

In order to inform the Integrated Business Model and cost benefit analyses, 50-year ridership forecasts were developed to 2070. These forecasts are inherently conceptual given that no regional forecasts have been developed. Therefore, they conservatively assume that population and employment growth will slow over time relative to the next 20 years. Moreover, these forecasts reflect crowding-constrained ridership, primarily reflect growth outside of the peak hours, and assume that no additional regional or statewide investments are made in a Second Transbay Tube or other large-scale transportation projects in early planning phases. Given these assumptions, Caltrain could serve about 180,000-230,000 daily riders by 2070 for the growth scenarios under consideration. **Table 12** displays conceptual ridership forecasts for 2050 through 2070.

Table 12: Conceptual Ridership Forecasts, 2050-2070

Service Plan	2050 Estimate	2060 Estimate	2070 Estimate
6 TPH (Baseline + DTX + 4 HSR)	171,000	176,000	179,000
Moderate 8 TPH (+ 4 HSR)	196,000	202,000	205,000
High 12 TPH (+ 4 HSR)	220,000	227,000	230,000

1.8 NEXT STEPS

RELATED WORK

The ridership forecasts described in this memo inform several aspects of the Business Plan, including the following:

- Understand revenue forecasts in the Caltrain Integrated Business Model
- Analyze economic benefits in the cost-benefit analysis
- Inform station dwell times in the rail simulation
- Inform station improvements in the capital cost estimates
- Compare and evaluate Growth Scenarios
- Update the Station Toolbox and Mode of Access Model (a separate but related project to the Business Plan)

Although forecasts are presented for select design years only, the Integrated Business Model will interpolate interim years based on the underlying ridership growth rate.

Appendix A: Forecasting Methodology

This section describes the forecasting methodology used to update the Caltrain Ridership Model for the Business Plan. It provides an overview of the forecasting approaches considered for updating the Caltrain Ridership Model, including applicable regional models, the approach used for PCEP forecasting, and the approach actually used for Business Plan forecasting.

FORECASTING OPTIONS

Several existing models of Caltrain ridership were considered for updating the Caltrain Ridership Model. These models are described below.

PRIOR CALTRAIN RIDERSHIP MODEL (PCEP FORECASTS)

As part of the PCEP EIR, a Caltrain Ridership Model was developed which was based on a then-current version of the C/CAG-VTA regional travel demand model. This version of the C/CAG-VTA model was well calibrated to system-level ridership, but was relatively insensitive to station-area conditions related to land use and station area circulation. Therefore, the Caltrain Ridership Model used a linear regression "direct ridership model" (DRM) to fine-tune the station-level forecasts to better account for these local conditions. The DRM provided a statistical analysis of the relationship between daily station-level boardings and station-area variables including walkability and land use density. The DRM improved estimates of station boardings at 18 of the 23 Caltrain stations studied, and reduced the percent root mean square error (an indicator that amplifies the importance of large errors and doesn't allow overestimates and underestimates to cancel each other) by 24 percent.

This model was lightly updated in 2018, when the first version of the Caltrain Toolbox was developed. The update made use of a later version of the C/CAG-VTA model and updated Caltrain ridership but used the same data for other explanatory variables.

Both versions of the C/CAG-VTA model used for the PCEP version of the Caltrain Ridership Model used the more conservative land use forecasts present in the 2013 RTP. For this reason, this version of the Caltrain Ridership Model is expected to underestimate Caltrain demand, even with its 2018 update.

MTC TRAVEL MODEL ONE[11]

MTC's Travel Model One was considered both as a potential source of Caltrain ridership forecasts and as a potential replacement for the C/CAG-VTA model in a composite approach such as the one used for the PCEP version of the Caltrain Ridership Model.

As compared to the C/CAG-VTA model, the MTC model network contains less detail in San Mateo and Santa Clara counties – two of the three counties in the Caltrain corridor. Base-year validation of Caltrain ridership is imprecise, with the 2013 model predicting only 20,000 daily Caltrain riders (as compared to 47,000 daily riders observed that year, and 48,000 daily riders predicted by the C/CAG-VTA model.

In addition, the MTC model lacks sensitivity to some station-area factors affecting Caltrain ridership, is less sensitive to auto congestion than is desired for modeling the increasingly-congested corridor along US 101, and lacks sensitivity both to train capacity and to station access capacity constraints such as parking at Caltrain stations.

The MTC model does include land use forecasts consistent with Plan Bay Area 2017. However, this benefit was not sufficient to overcome the shortcomings listed above for using the MTC model either as the forecast of Caltrain ridership, or as a basis from which to build a statistical direct ridership model as was done in the previous version.

[11] MTC's Travel Model Two was still in development, and not yet ready for use, when the approach to Caltrain Ridership Model update was being determined.

C/CAG-VTA MODEL

Several versions of the C/CAG-VTA model were considered for potential use in the updated Caltrain Ridership Model. As compared to the MTC model, the C/CAG-VTA model offers more network detail in San Mateo and Santa Clara Counties, which comprise a substantial portion of the Caltrain corridor. The C/CAG-VTA model also includes, with limited detail, portions of San Joaquin, Santa Cruz, Monterey, and San Benito counties. While these counties make up only a small proportion of overall Caltrain ridership in 2017, it is nevertheless useful to account for longer-distance inter-regional travel. Finally, the C/CAG-VTA model is better calibrated to Caltrain corridor transit ridership in general, and Caltrain ridership in particular, than the MTC model is.

However, the C/CAG-VTA model also has some limitations for applications to Caltrain in the Business Plan. The C/CAG-VTA model does not account for planned land use changes represented in the 2017 RTP (the 2017 version of Plan Bay Area). Moreover, several jurisdictions have moved forward with major land use plans since completion of the 2017 RTP; consequently, some land use projections may be overly conservative.

The C/CAG-VTA model also does not reflect the origin-destination patterns exhibited by Caltrain riders, overestimates intra-county trips, particularly within Santa Clara and San Francisco counties, and underestimates longer-distance trips. Like the 2013 version, the C/CAG-VTA model lacks sensitivity to some station-area factors affecting Caltrain ridership. It is less sensitive to auto congestion than is desired for modeling the increasingly-congested corridor along US 101, and lacks sensitivity both to train capacity and to station access capacity constraints such as parking at Caltrain stations.

The C/CAG-VTA model was chosen to serve as the base input for the Caltrain Ridership Model, although substantial updates were completed within the model itself by Fehr & Peers and within an expanded Direct Ridership Model (DRM) methodology to arrive at the final Caltrain Ridership Model. The modeling approach is described in the following sections.

CALTRAIN RIDERSHIP MODEL APPROACH

The approach selected for updating the Caltrain Ridership Model is similar in overall concept to the previous version: a regional travel demand model to capture regional land use and origin-destination patterns and transportation system integration, together with a set of regression “direct ridership models” to better capture station-specific characteristics. The update is based on a version of the C/CAG-VTA model, as described in the following section. However, the regression models are more complex than in the prior version of the Caltrain Ridership Model, in the following respects.

- The prior version of the Caltrain Ridership Model focused on station-level boardings as the basis for its regression adjustment. However, this approach over-simplified the relationship between boardings and alightings and does not address the known tendency of the C/CAG-VTA model to overestimate the number of shorter Caltrain trips and underestimate the number of longer trips. The selected approach focused on station-to-station boarding-alighting pairs in order to capture more fully station-level effects at both ends of the Caltrain trip. Thus, the unit of analysis in the direct ridership model adjustment is the station-pair, rather than the station.
- The prior version of the Caltrain Ridership Model focused on daily ridership totals. Because the station-to-station ridership patterns change significantly over the course of a typical weekday, the updated version of the Caltrain Ridership Model developed a total of 6 regression models, one for each of 5 average weekday time periods (Early AM, AM Peak, Midday, PM Peak, and Evening) together with an all-day weekend model.

Data sources for the updated regression models included model outputs from the updated C/CAG-VTA model, updated (2017) ridership data from Caltrain, the 2014 MTC Caltrain on-board survey, the 2016 Caltrain triennial survey, and a variety of 2015 American Community Survey and LEHD data.

Table A-1 summarizes background transportation project assumptions assumed in the Caltrain Ridership Model.

Table A-1: Background Project Assumptions

Project	Caltrain Business Plan Design Year	Approach	Source
ACE	2022	6 daily ACE roundtrips (+2 from today)	ACE Forward Project Description
	2029	10 daily ACE roundtrips (+4 from today)	ACE Forward Project Description
	2033	Same as 2029	-
	2040	Same as 2033	-
Capitol Corridor: Oakland to San Jose	2022	No change from existing model	Capitol Corridor Vision Plan
	2029	Capitol Corridor shift to Coast Subdivision, 11 daily roundtrips (+4 from today)	Capitol Corridor Vision Plan
	2033	Same as 2029	-
	2040	15 daily Capitol Corridor roundtrips (+8 from today)	Capitol Corridor Vision Plan
Hollister Express Bus	2022	No change	State Rail Plan
	2029	Bi-hourly integrated express bus service between Gilroy and Hollister	State Rail Plan
	2033	Same as 2029	State Rail Plan
	2040	Hourly integrated express bus service between Gilroy and Hollister	State Rail Plan
Salinas Rail	2022	No service	State Rail Plan
	2029	Bi-hourly rail service between Gilroy and Salinas	State Rail Plan
	2033	Same as 2029	-
	2040	Hourly service between Gilroy and Salinas; hub station at Pajaro/Watsonville providing hourly connections to Santa Cruz; hub station at Castroville providing hourly connections to Monterey.	State Rail Plan
Dumbarton Rail	2022	Not included	Cross Bay Transit Partners
	2029	Rail shuttle from Union City BART station to Redwood City Caltrain station: 4 trains per hour per direction peak, 2 trains per hour per direction off-peak.	Cross Bay Transit Partners
	2033	Same as 2029	-
	2040	Same as 2033	-
US-101 Managed Lanes	2022	Add HOT lane in San Mateo County south of I-380	SMCTA US-101 Managed Lanes Project Description
	2029	Convert a northbound lane to a HOT lane between I-380 and San Francisco County Line; convert a southbound lane to a HOT lane from I-280 terminus to I-380 via US-101.	SFCTA US-101 Managed Lanes Project Description
	2033	Same as 2029	-
	2040	Same as 2033	-
SamTrans Express Bus	2022	Four express routes between the Peninsula and San Francisco	SamTrans Express Bus Study

Table A-1: Background Project Assumptions

Project	Caltrain Business Plan Design Year	Approach	Source
	2029	Ten express routes between the Peninsula and San Francisco	SamTrans Express Bus Study
	2033	Same as 2029	
	2040	Same as 2033	

LAND USE MODIFICATIONS

Several updates were made to the land use assumptions in the updated C/CAG-VTA model. First, the model base year was updated from 2013 to 2015, and existing land use was updated using 2015 ACS and LEHD data. Second, the model land use projections for 2040 were updated to be consistent with the 2017 version of Plan Bay Area. Finally, additional projects not included in Plan Bay Area forecasts but nevertheless approved by the relevant cities were included in the 2040 population and employment forecasts. The list of additional projects, which was reviewed by Caltrain staff prior to the beginning of forecasting, accounts for an additional 12,000 population and 115,000 jobs as shown below.

Table A-2 summarizes background land use assumptions assumed in the Caltrain Ridership Model.

Table A-2: Background Land Use Assumptions

City	Plan	Population Added beyond Plan Bay Area	Employment Added beyond Plan Bay Area	Notes
San Francisco	Central SoMa	12,000	38,000	Approved by Planning Commission; Board of Supervisors has not approved yet
South San Francisco	East of 101 employment	-	11,000	Approved / Under construction. ~13 individual biotech projects approved/under construction totaling 7 MSF
San Bruno	Transit Corridors Plan	-	3,000	Approved
Millbrae	Station Plan	-	3,000	Approved
Redwood City	Stanford Healthcare Campus	-	4,000	Approved
Palo Alto / Stanford	Stanford Research Park expansion and Stanford Hospital expansion	-	6,000	Approved
Mountain View	North Bayshore Precise Plan	-	21,000	Approved
Sunnyvale	Peery Park Specific Plan	-	10,000	Approved
	Moffett Towers	-	3,000	Approved
Santa Clara	City Place	-	8,000	Approved
	Total	**12,000**	**115,000**	

Notes:

Several development plans are underway on the Caltrain Corridor but were not approved prior to this analysis and therefore have been omitted from land use forecasts. This list of pending projects includes large developments in South San Francisco (Genentech Master Plan and other East of 101 and Lindenville developments), San Bruno (Bayhill Specific Plan), Menlo Park (Facebook Willow Village project), Palo Alto (Stanford General Use Permit update), Mountain View (East Whisman Precise Plan), San Jose (Google Diridon development and Downtown Strategy EIR), and Gilroy (Station Area Plan). Combined, these would result in an additional 12,000 people and 80,000 jobs along the study corridor. If these developments are realized, they are likely to further increase demand on the Caltrain corridor and exacerbate capacity challenges for the Baseline and Moderate Growth Scenarios.
Housing and employment plans consistent with Plan Bay Area are not noted in this table. Examples of such plans include but are not limited to the Diridon Station Plan, Lawrence Station Area Specific Plans in Santa Clara and Sunnyvale, housing growth in North Bayshore, Redwood City's Downtown Precise Plan, Millbrae's Station Area Specific Plan, Brisbane Baylands, Candlestick Point-Hunters Point Redevelopment, and Pier 70 redevelopment.

OTHER VTA-C/CAG MODEL MODIFICATIONS

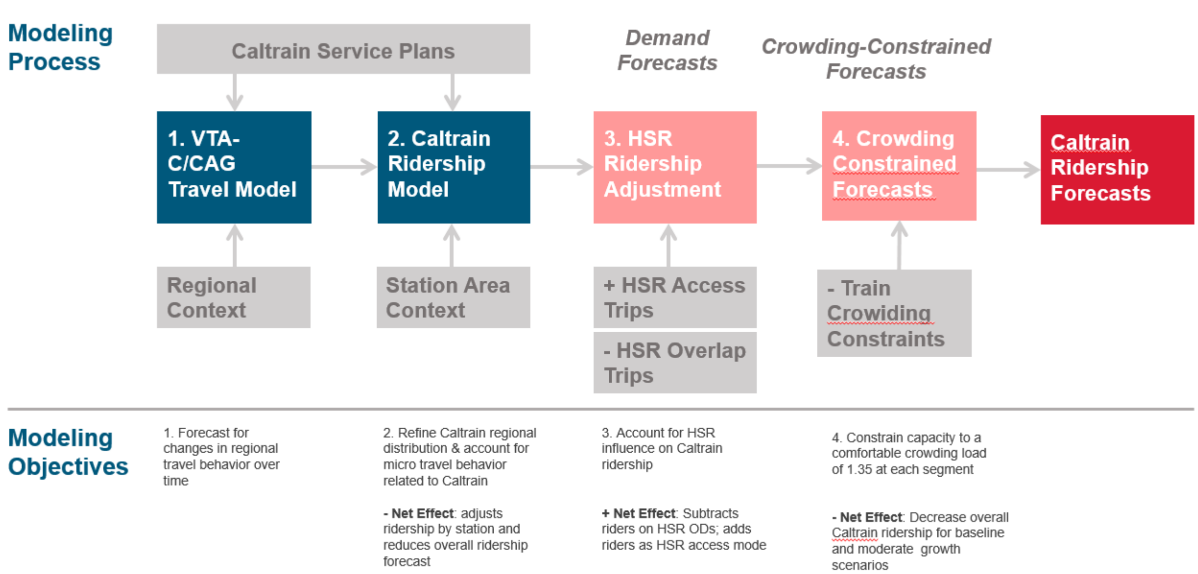
This Caltrain Ridership Model includes two additional updates to Caltrain's features in the C/CAG-VTA Model. First, it standardizes the definition of station catchment areas across Caltrain stations in order to achieve more consistent results. Second, it updates the Caltrain service pattern to reflect current and future schedules.

As a result of these changes and modifications to transportation and land use conditions, the C/CAG-VTA Model outputs tends to overestimate systemwide ridership and shorter-distance trips. These overestimates were adjusted by the Caltrain Ridership Model.

CALTRAIN RIDERSHIP MODEL APPROACH

This section describes the model development process used to arrive at the updated Caltrain Ridership Model. The development process included the development of a large pool of potential independent (explanatory) variables to test in each ridership model, the process of selecting a set of variables that both fit existing Caltrain operations and can reasonably be forecast for future scenarios, and some final "post-process" adjustments. The overall model approach is shown schematically below on **Figure A-1**.

FIGURE A-1: CALTRAIN RIDERSHIP MODEL FRAMEWORK



VARIABLE DEVELOPMENT

The Caltrain Ridership Model considered a range of variables based not only on the current availability of data but also on the ability to reasonably forecast them; variables which could not reasonably be forecast were excluded from the list. The variables developed and tested in this process included both variables which operate at the level of station pairs (e.g. Caltrain in-vehicle time) and variables which operate at the level of stations (e.g. population within half-mile). Station-level variables were generally tested both as characteristics of the boarding station and as characteristics of the alighting station. Some variables of both types included different variants by time of day (e.g. AM versus midday connecting public shuttles), while others did not vary over the course of the day (e.g. Caltrain fare).

Table A-3 indicates the types of variables tested, along with examples of specific variables.

Table A-3: Example Ridership Variables

Variable Category	Example Variables
VTA Model outputs	Modeled Caltrain ridership (PNR, KNR, non-Auto access), Modeled person-trips (Caltrain and total) within ½ mile buffer (2-mile buffer, 15-minute walk/bike/transit/drive sheds)
Caltrain Service	Caltrain frequency (with and without transfers, segmented by train speed), Caltrain in-vehicle time (with and without transfers, segmented by train speed), Caltrain vs auto speed (difference, ratio)
Other Caltrain	Fare, usage of GoPass
Land Use	Population, households, high-income households within ½ mile & within 2 miles; Employment, tech sector employment within ½ mile & within 2 miles; Station area parking cost
Drive Accessibility	Station parking supply & cost, decay-weighted population & jobs within station drive-shed (with and without accounting for congestion)
Transit Accessibility	Frequency of connecting transit (by time of day), frequency of connecting public and private shuttles (by time of day); decay-weighted population & jobs within station transit-shed (with and without accounting for more difficult transit access along busy arterials)
Bike Accessibility	Bike parking, bike share, bike lockers, decay-weighted population & jobs within station bike-shed (with and without accounting for level of traffic stress)
Walk Accessibility	Decay-weighted population & jobs within station walk-shed (with and without accounting for reluctance to walk along busy arterials)

VARIABLE SELECTION

The initially large list of potential independent variables was first screened using Random Forest methods, allowing the analysts to quickly screen a large set of variables and identify the variables most strongly correlated with Caltrain ridership. Once an initial set of promising variables was identified for each time-of-day model, variable strength was tested based on several factors including statistical significance, reasonable magnitude and direction of regression coefficients, and reasonable behavior in long-range forecasts. This process allowed the analysts to arrive at models which best fit existing Caltrain operations and which provide reasonable future forecasts.

Table A-4 shows the final list of variables selected for inclusion in the Caltrain Ridership Model.

Table A-4: Caltrain Ridership Model Variables

Variable Category	Variable	Time Periods
VTA Model Outputs	Modeled AM peak Caltrain ridership, non-auto access	AM peak, PM peak (reversed)
	Modeled AM peak Caltrain ridership, auto access	AM peak, PM peak (reversed)
	Modeled off-peak Caltrain ridership	Early AM, Midday, Evening, Wknd
Caltrain Service	Caltrain frequency in relevant time period (all service)	Wknd
	Caltrain frequency in relevant time period (excluding slowest trains)	AM peak, Midday, PM peak, Evening
	Average Caltrain in-vehicle time in relevant time period	Early AM, AM peak, Midday, PM peak, Evening, Wknd
	Origin station has worse frequencies than its neighbors	AM peak
	Destination station has worse frequencies than its neighbors	PM peak
Other Caltrain	Caltrain fare	Early AM, AM peak, Midday, Evening, PM peak, Wknd
	Percentage of go-pass users accessing origin station	PM peak
	Percentage of go-pass users egressing at destination station	AM peak
Land Use	High-income households within 2 miles of origin station	AM peak
	High-income households within 2 miles of destination station	PM peak
Drive Accessibility	Parking supply at origin station	Early AM
Walk Accessibility	Decay-weighted population within origin station walk-shed	Early AM, AM peak
	Decay-weighted population within destination station walk-shed	PM peak
	Decay-weighted jobs within origin station walk-shed	Midday
	Decay-weighted jobs within destination station walk-shed	Early AM, AM peak, Midday, Wknd

FORECAST ADJUSTMENTS

A final set of steps were applied to post-process the results of the C/CAG-VTA model together with the direct ridership models described in the previous section. These post-processes further fine-tuned the forecast results by adjusting the distribution pattern slightly, applying a standard “difference method” to prevent unreasonable discrepancies between observed data and forecasts, accounting for ridership shifts related to California High-Speed rail, and applying capacity constraining.

Distribution and Scale Adjustments

Although the results of the statistical models came closer than the C/CAG-VTA model forecasts to the observed distribution of intra versus inter-county trips on Caltrain, they still tended to overestimate the number of riders within Santa Clara and San Francisco counties, and to underestimate the number of longer-distance riders, especially between Santa Clara and San Francisco counties. Scaling factors were developed which adjusted county-to-county ridership flows. This step also adjusted the system wide Caltrain ridership, to remove the consistent over-estimate introduced by standardizing the station catchment areas in the C/CAG-VTA model.

Difference Methods

A standard technique in travel modeling is to apply a “difference method” to avoid unreasonable discrepancies between observed data and forecasts, particularly near-term forecasts. Differences between observed and base-year modeled station-level boardings and alightings were calculated, and these differences were distributed across station-to-station forecasts.

HSR Ridership

High-Speed Rail has the potential to affect Caltrain Ridership in two ways: as a competing mode between Transbay, 4th/King, Millbrae, San Jose Diridon, and Gilroy stations which reduces Caltrain ridership; and as a complementary mode in which Caltrain serves as a mode of access to (or egress from) HSR, which adds to Caltrain ridership.

Estimates of HSR as a competing mode to Caltrain compared HSR ridership forecasts by station pair, travel times by both HSR and Caltrain, and estimated fares for both HSR and Caltrain. San Francisco (both stations) to San Jose Diridon represented the majority of these trips in all scenarios, with fewer trips attracted away from Caltrain in the 2040 Moderate and High Growth scenarios because of improved Caltrain service.

Estimates of HSR as a complementary mode to Caltrain were based on HSR forecasts of Caltrain as a mode of access to HSR. For each HSR station, the estimated access and egress trips using Caltrain were distributed as Caltrain trips between the HSR station and neighboring Caltrain stations, using the same proportions as the forecast among the relevant station pairs.

Capacity Constraints

The final post-processing step was to incorporate information about the size and capacity of trains, and to constrain ridership based on an occupancy threshold of 135% of seated capacity. Constraining was applied to the busiest two hours of each five-hour peak period, with the assumption that the peak hour contained 35 percent of the peak period ridership, and the second-peak hour contained 25 percent of the peak period ridership, based on a review of existing Caltrain and BART data.

To constrain ridership for these two hours, station-to-station ridership was converted to passenger loads for each segment of the corridor. Working from north to south for southbound trains, and south to north for northbound trains, segment loading was compared against the 135% threshold. If the modeled loading for a segment exceeded 135%, then boardings at the relevant station were reduced sufficiently to keep segment loading under 135%. These “denied boardings” were distributed among destinations based on the proportion of each destination among that station’s boardings.

For the baseline, moderate growth, and high growth service plans, capacity constraining was applied to each train type separately, to consider whether certain skip-stop patterns would potentially be more prone to capacity problems than others, and to consider whether express trains would be potentially more prone to capacity problems than local trains.

Table A-5 displays systemwide ridership forecasts over time.

Table A-5: Systemwide Ridership Forecasts over Time

Station	2017	2022		2029		2033			2040		
	Observed	Existing Service	PCEP	PCEP	PCEP with DTX	Baseline (Valley to Valley HSR)	Baseline (Valley to Valley HSR)	Baseline (Phase 1 HSR)	Baseline	Moderate	High
VTA-C/CAG Model	86,300	85,800	103,900	148,400	153,200	171,800	188,300	188,300	220,700	273,700	277,100
Caltrain Ridership Model	62,100	69,500	85,100	103,100	130,600	132,800	141,400	141,400	158,300	181,200	202,700
Caltrain Ridership Model with HSR Adjustments	62,100	69,500	85,100	103,100	130,600	133,100	141,700	143,700	161,200	184,700	207,200
Caltrain Ridership Model with HSR and Capacity Adjustments	62,100	69,500	85,100	103,100	130,600	133,100	141,700	143,700	151,700	177,200	207,200

Note: 2017 forecasts were developed by interpolating land use forecasts between the 2015 base year and 2040 horizon year, then applying a difference method to align observed data and forecasts.

Appendix B: Greenhouse Gas Emissions Methodology

This section describes the methodology used to develop the greenhouse gas emissions estimates for the Baseline, Moderate, and High Growth Scenarios. It provides an overview of California Air Resources Board (CARB) Transit and Intercity Rail Capital program (TIRCP) Calculator Tool, outlines the inputs and assumptions made for each time period, and presents the full results.

CARB CALCULATOR TOOL

The California Air Resources Board (CARB) provides the quantification methodology and calculator tool to estimate the GHG emission reductions and other non-GHG outcomes from projects receiving funding from the Greenhouse Gas Reduction Fund. The methodology uses calculations to estimate the reduction in auto vehicle miles traveled and associated GHG emission reductions based on transportation characteristics of specific transit projects. This methodology has been adapted from its original purpose to calculate the GHG and non-GHG emissions from Caltrain electrification and expanded ridership.

The methodology includes four Quantified Components, or project types; these are New/Expanded Service, System and Efficiency Improvements, Cleaner Vehicles/Technology/Fuels, and Fuel Reductions. Each Quantified Component requires project-specific inputs that are used in calculating the difference in emissions from a baseline year. This analysis used the New/Expanded Service and Cleaner Vehicles/Technology/Fuels components:

- The New/Expanded Service project type refers to the expansion of transit service through new service or additional routes.
- The Cleaner Vehicles/Technology/Fuels project type refers to the use of cleaner vehicles, technologies, or fuels that result in GHG emission reductions.

The full methodology, including the equations and calculator tool, is available at the California Air Resources Board website.

INPUTS

Five time periods (2022-2029, 2029-2040, 2040-2070 (Baseline), 2040-2070 (Moderate), and 2040-2070 (High) were considered, based on electrification timelines. These were analyzed separately and then combined to produce cumulative emissions reductions for the Baseline, Moderate, and High Growth Scenarios.

The New/Expanded Service project type requires inputs on year 1 and final year ridership, adjustment factor, length of average trip, fuel type, and annual fuel required for new service. The Cleaner Vehicles/Technology/Fuels project type requires inputs on new fleet fuel type and annual fuel required, as well as displaced fleet fuel type and annual fuel required. The Caltrain project will replace the diesel fleet with an Electric Multiple Unit (EMU) fleet. The inputs used are presented in **Table A-6.**

Table A-6: Greenhouse Gas Emissions Calculations Assumptions

Scenario	Year 1 Ridership	Year Final Ridership	Adj. factor	Length of Average Trip	New/Expanded Service		Cleaner Vehicles/Technology/Fuels		
					New Train Miles	Annual fuel for new service (kwh)	Diesel miles replaced by EMU miles	Annual fuel for new EMU service	Annual fuel for replaced diesel service (kwh)
2022-2029	4,730,000	16,940,000	0.83	20.1	0.74	43,225,000	1.28	74,841,666	3,788,699
2029-2040	4,380,000	11,570,000	0.83	19.3	0.95	63,600,000	0.11	7,200,000	318,924
2040-2070 (Baseline)	1,890,000	3,484,000	0.83	19.3	-	-	-	-	-
2040-2070 (Moderate)	7,390,000	9,610,000	0.83	18.4	2.96	143,947,747	-	-	-
2040-2070 (High)	15,490,000	18,380,000	0.83	17.9	4.09	200,607,825	-	-	-

RESULTS

The Calculator Tool provided estimates for reductions in greenhouse gas (GHG), reactive organic gas (ROG), nitrogen oxide (NOx), fine particulate matter (PM2.5), and diesel particulate matter (Diesel PM) emissions. The full results are presented in the **Table A-7.**

Table A-7: GHG and non-GHG Emissions Reductions, Moderate and High Growth Scenarios

Time Period	GHG Emission Reductions (MTCO2e)	ROG Emissions Reductions (lbs)	NOx Emissions Reductions (lbs)	PM2.5 Emissions Reductions (lbs)	Diesel PM Emissions Reductions (lbs)
2022-2029	516,575	355,792	6,118,596	215,213	228,839
2029-2040	200,729	59,865	881,521	30,699	33,170
2040-2070 (baseline)	390,741	11,313	65,578	1,838	2,579
2040-2070 (moderate)	1,181,026	34,473	199,549	5,623	7,880
2040-2070 (high)	2,288,724	67,004	387,707	10,941	15,326
2029-2070 (baseline)	**1,108,045**	**426,970**	**7,065,695**	**247,750**	**264,588**
2029-2070 (moderate)	**1,898,330**	**450,131**	**7,199,666**	**251,535**	**269,889**
2029-2070 (high)	**3,006,028**	**482,662**	**7,387,824**	**256,854**	**277,336**

Existing Property Value and Fiscal Benefits of Caltrain Memo

Prepared for:

Caltrain

October 2019

OK18-0254.00

Prepared by:

STRATEGIC ECONOMICS

FEHR PEERS

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1. INTRODUCTION

This report, which was prepared for the Caltrain Business Plan, examines Caltrain's existing fiscal benefits for local jurisdictions and property value benefits for properties located near its stations.[1]

1.1 OVERVIEW OF THE CALTRAIN BUSINESS PLAN

Caltrain is currently engaged in the Caltrain Business Plan, an in-depth technical and policy process that will set the vision for how Caltrain service, and the Caltrain corridor as a whole, should grow to meet current and future ridership demand over the next 20 to 30 years. This study is a joint effort between agency partners and communities along the corridor. One of the main goals of the Caltrain Business Plan process is to evaluate the various benefits, costs, and impacts of three different rail service growth scenarios for 2040: a Baseline Growth Scenario, a Moderate Growth Scenario, and a High Growth Scenario. Based on this evaluation, the Caltrain Business Plan builds the case for investing in and implementing an agreed upon 2040 Long Range Service Vision for the Caltrain corridor, which includes proposed service improvements, infrastructure needs, and associated costs and benefits.

Strategic Economics was retained as part of the consultant team developing the Caltrain Business Plan, led by Fehr & Peers, to prepare the following tasks:

1. **An analysis of the current fiscal and property value benefits of existing Caltrain service,** including an analysis of whether benefits vary by station service levels. The methods and findings of this analysis are summarized in this report.
2. **An estimation of the potential future property value impacts of the Caltrain Business Plan Growth Scenarios**, based on the results of this report and a broader literature review. The methods and findings of this second task are provided in a separate report.

1.2 OVERVIEW OF PURPOSE AND APPROACH

A substantial body of literature exists on the property value benefits of transit investments. In particular, many studies have demonstrated that proximity to transit confers a value premium to properties located nearby, thereby also providing fiscal benefits for the local jurisdictions in which transit investments occur.[2] The literature generally concludes that household and firm preferences for transit-served locations result in higher residential and office property values near transit stations; however, transit premiums vary significantly depending on the context, and the magnitude of the premium depends largely on the quality of service and accessibility provided, as well as the strength of the local real estate market.

In order to estimate the property value impacts of existing Caltrain service near its stations in San Francisco, San Mateo, and Santa Clara Counties, two types of analyses were conducted:

- **Analysis of assessed property values near Caltrain stations.[3]** The analysis focused on assessed values within a half-mile of Caltrain stations, and results are summarized by county and by city. An analysis of the assessed

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[1] This report was prepared by Nadine Fogarty, Alison Nemirow, Evelyne St-Louis, and Emery Reifsnyder from Strategic Economics. The authors would like to thank Jacob Wegmann, Assistant Professor at the University of Texas at Austin, and Jesus Barajas, Assistant Professor at the University of Illinois Urbana-Champaign, for their valuable contributions throughout the research and writing of the report.

[2] Several cities have examined this question in the Bay Area specifically as well. A summary of the literature review conducted by Strategic Economics on this topic is provided in the second technical report.

[3] In California, assessed property values must be interpreted in the context of California's Proposition 13, which works to keep the assessed value of properties below their market value (i.e., the value if sold on the open market). Therefore, in this report, assessed property values obtained from County Assessor data differ significantly from market values obtained from sale price and rental data.

value contribution of properties near Caltrain relative to the land area they occupy was also conducted, to assess the impact of Caltrain on local jurisdictions' tax base.

- **Analysis of the property value benefits of Caltrain focusing on three property types: for-sale residential, rental apartments, and office properties.**[4] The analyses compared property values within a half-mile of Caltrain stations to values further away, and differentiated stations based on their service levels. For each land use type, the most statistically robust method possible was chosen depending on data availability. Hedonic price modeling (a statistical method that controls for the effect of other variables) was tested for each land use type, but ultimately was only used for the for-sale residential properties. The apartment and office analyses relied on simple descriptive statistics. Note that the statistically significant premiums obtained for the for-sale residential properties were used to inform the analysis of the potential future property value impacts of the Caltrain Business Plan Growth Scenarios.

1.3 KEY DEFINITIONS

1.1.3. PROXIMITY TO CALTRAIN STATIONS

In this report, proximity to Caltrain stations is measured using network distances, which are distances calculated based on the street network (in contrast to Euclidian distances, also known as straight line or "as the crow flies" distances.) The resulting network distance service areas are shown in Figure 1-1. Throughout this report, proximity to Caltrain generally refers to the half-mile network area from Caltrain stations.

1.2.3. CALTRAIN STATION TRAIN FREQUENCY CLASSIFICATION

In this report, Caltrain stations are classified into three levels of service based on the station's frequency of trains, listed below and summarized in Figure 1-2 and Table 1-1.

- Low frequency stations are typically served by 1-2 trains per hour per direction during peak periods;
- Medium frequency stations are typically served by 3 trains per hour per direction during peak periods;
- High frequency stations are typically served by 4-5 trains per hour per direction during peak periods.

These service frequency levels are highly simplified. In reality, Caltrain's schedule is rather complex. Given that Caltrain's existing passenger service is oriented towards peak commuter periods, service varies by time of day and by train type, with a mix of local, zone express, skip stop and regional express (Baby Bullets) trains. For example, travel times between 4th & King (San Francisco) and Diridon (San José) at peak periods can vary from 62 to 95 minutes. Caltrain operates up to five trains per hour per direction during peak periods, and hourly service in the off-peak periods. Service patterns also vary by peak direction (northbound AM and southbound PM) versus reverse-peak direction (southbound AM and northbound PM). For example, Sunnyvale receives four trains per hour in the peak direction and one train per hour in the reverse peak direction. For these reasons, riders typically plan their travel around a handful of trains, and experience long and irregular wait times if they do not plan ahead. The system can be complicated to navigate for both seasoned and occasional riders.

[4] Ibid.

1.4 REPORT ORGANIZATION

Following this introduction, the report is organized by the chapters listed below:

- A summary of key findings (Chapter 2);
- An evaluation of assessor's data to understand the importance of Caltrain for the local property tax base (Chapter 3);
- An estimate of the property value premiums associated with proximity to Caltrain for single-family homes and condominium (Chapter 4), rental apartments (Chapter 5), and office properties (Chapter 6);
- Detailed methodology (Appendices A and B).

FIGURE 1-1. CALTRAIN STATION NETWORK SERVICE AREAS

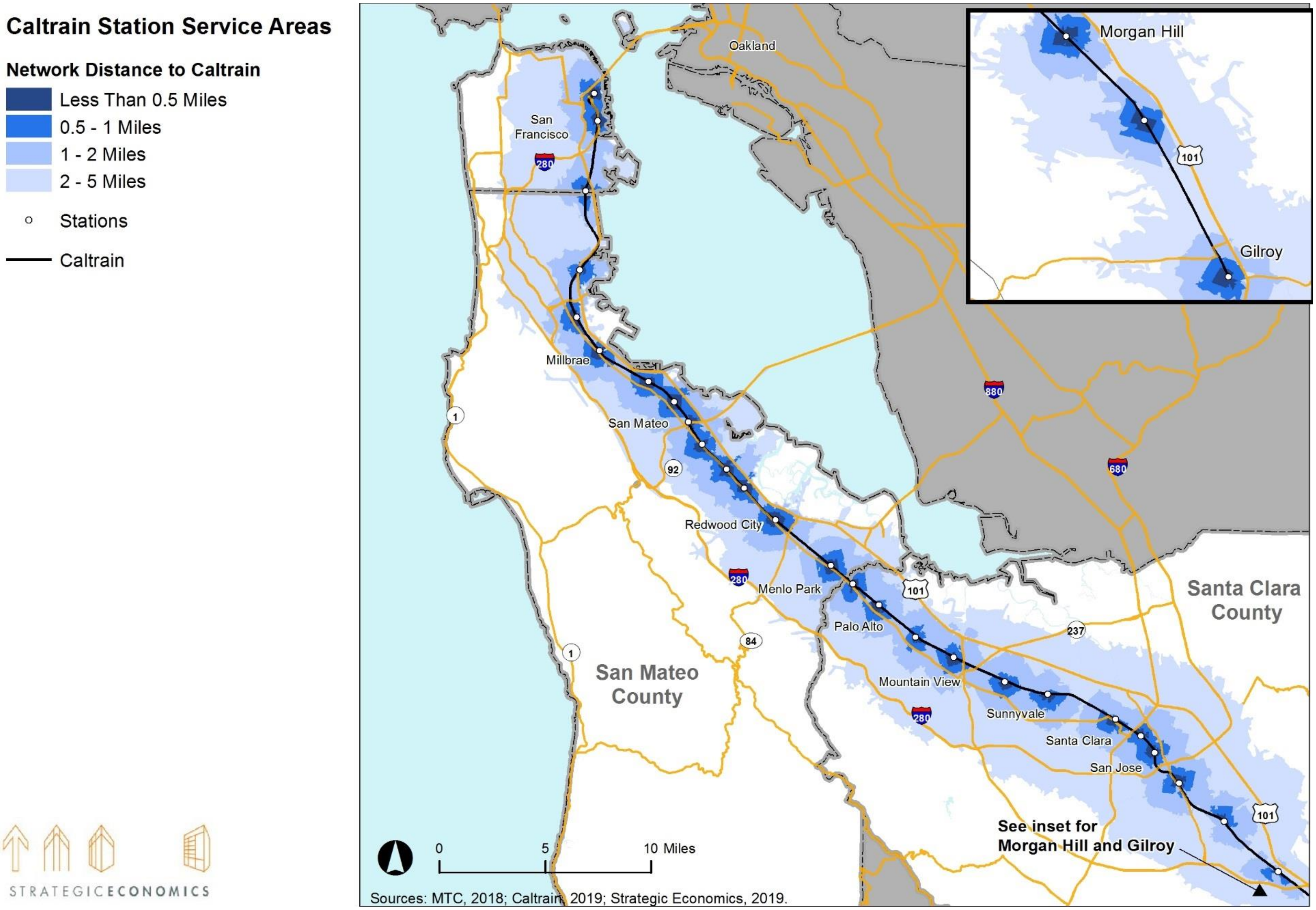


FIGURE 1-2. CALTRAIN STATION TRAIN FREQUENCY CLASSIFICATION

Caltrain Station Train Frequency Levels*

Frequency Levels

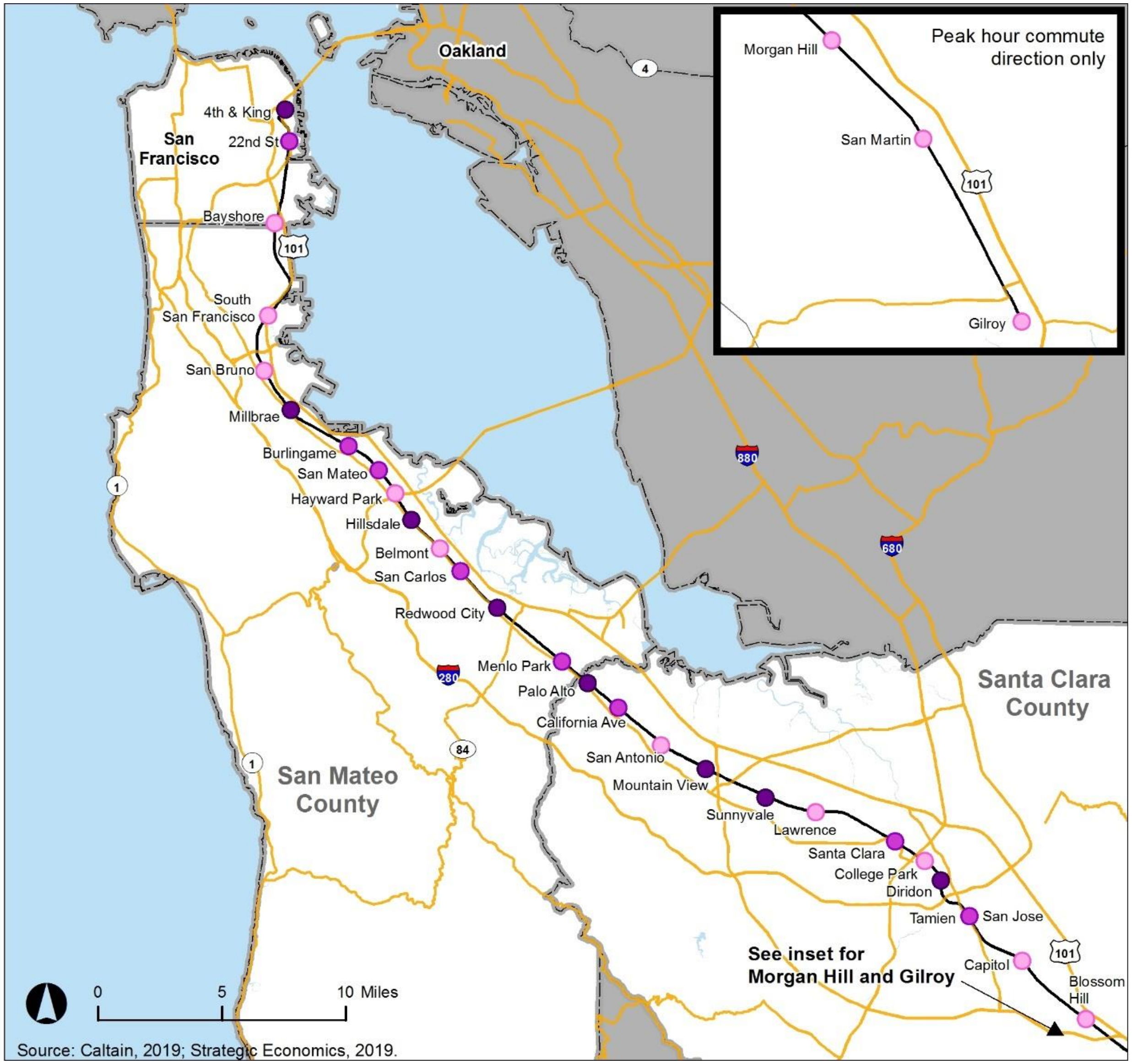
- High
- Medium
- Low

*Caltrain station frequency levels are defined as follows:

High frequency stations are typically served by 4-5 trains per hour per direction during peak periods.

Medium frequency stations are typically served by 3 trains per hour per direction during peak periods.

Low frequency stations are typically served by 1-2 trains per hour per direction during peak periods.



STRATEGICECONOMICS

TABLE 1-1. CALTRAIN STATION CLASSIFICATION

Low Frequency Caltrain Stations	Medium Frequency Caltrain Stations	High Frequency Caltrain Stations
Bayshore	22nd Street	4th and King
South San Francisco	Burlingame	Millbrae
San Bruno	San Mateo	Hillsdale
Hayward Park	San Carlos	Redwood City
Belmont	Menlo Park	Palo Alto
San Antonio	California Ave	Mountain View
Lawrence	Santa Clara	Sunnyvale
Capitol	Tamien	Diridon
Blossom Hill		
Morgan Hill		
San Martin		
Gilroy		

Stations excluded from the analysis due to very infrequent or inexistent service: Broadway, Atherton, Stanford Stadium, and College Park. Low frequency: station typically served by served by 1-2 trains per hour per direction during peak periods. Medium frequency: station is typically served by 3 trains per hour per direction during peak periods. High frequency: station is typically served by 4-5 trains per hour per direction during peak periods. Source: Caltrain, 2019.

2. SUMMARY OF KEY FINDINGS

This section summarizes the importance of Caltrain for the tax base of local jurisdictions (fiscal benefits) and the value that Caltrain confers to condominiums, single-family homes, apartment properties, and office properties located in proximity to Caltrain stations (property value benefits).

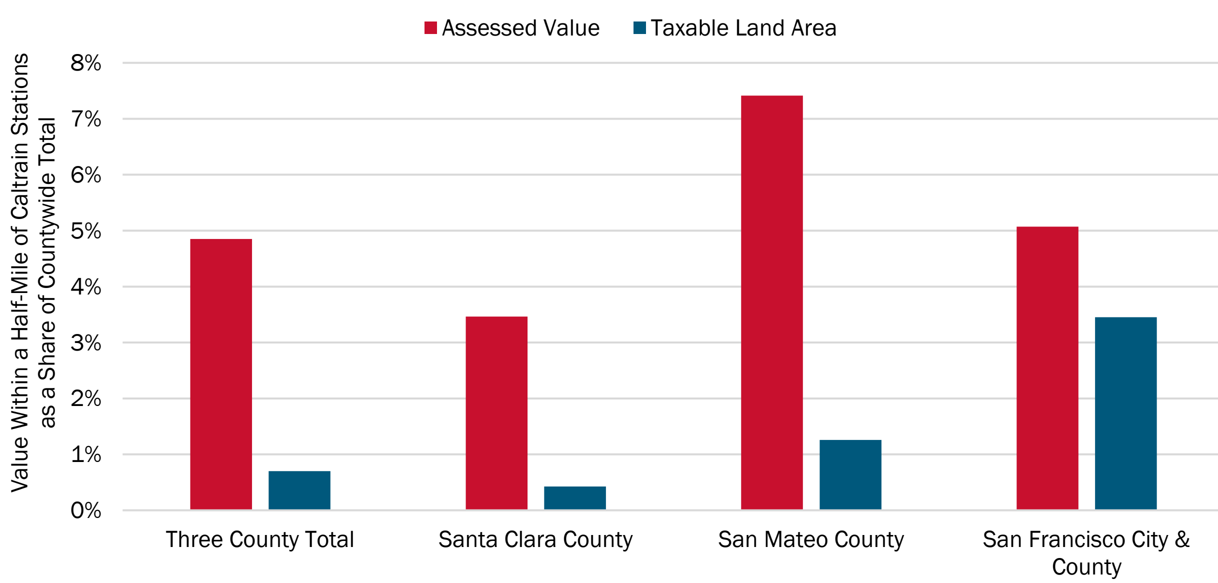
2.1 FISCAL BENEFITS OF CALTRAIN

Properties located within a half-mile of Caltrain stations have a combined total assessed property value of $42 billion; together these properties generate an estimated $419 million annually in property tax revenue. In California, one percent of assessed property values is collected as property tax and allocated to county government, municipal government, and other taxing entities. Given that the tax revenue apportionment to these taxing entities varies significantly across jurisdictions and tax rate areas, property tax revenues are summarized at the county-level.

The combined assessed value of properties located near Caltrain stations total over $1 billion in 9 out of 19 cities in San Mateo or Santa Clara Counties. For instance, the total assessed value within a half-mile of Caltrain stations exceeds $5 billion in Palo Alto (two Caltrain stations) and San Mateo (three stations). In contrast, for cities such as Brisbane and San Martin, the total assessed value within a half-mile of Caltrain stations is less than $200 million.

Compared to the land area they account for, properties near Caltrain stations are relatively more valuable to the property tax base of most of the communities Caltrain serves. To understand the *relative* contribution of properties near Caltrain stations to the tax base of local jurisdictions, the share of assessed value located within a half-mile of stations is compared to the share of total taxable land in the same area, at the county and city-level (Figure 2-1). This gives a sense of the relative "density" of value near Caltrain compared to other parts of the region. Across the three-county area, properties in the half-mile area contribute 5 percent of total assessed value, but account for only 0.7 percent of overall land area. This pattern is consistent in each county, and in 17 out of 19 cities analyzed.

FIGURE 2-1. ASSESSED VALUE AND LAND AREA NEAR CALTRAIN STATIONS BY COUNTY



Source: City of San Francisco Assessor, 2019; San Mateo County Assessor, 2019; Santa Clara County Assessor, 2019; CoreLogic, 2018; Strategic Economics, 2019.

2.2 PROPERTY VALUE BENEFITS OF CALTRAIN

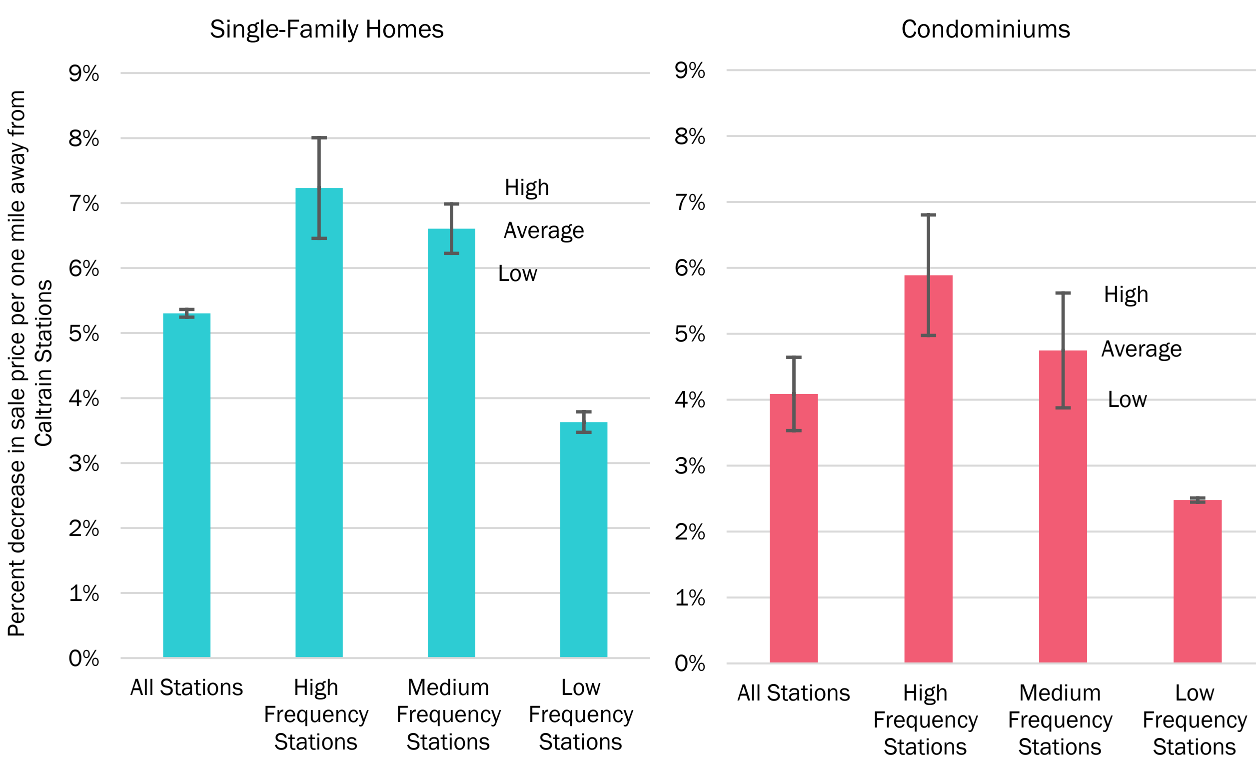
2.1.2. SINGLE-FAMILY HOMES AND CONDOMINIUMS

The results shown in Figure 2-2 are statistically significant. They are based on hedonic price modeling, a statistical regression method that breaks the value of a property into its constituent parts, allowing the researcher to isolate the value associated with each specific attribute. Hedonic price modeling is considered a best practice method for analyzing the effect of transit on property values. Results are based on a large sample of single-family home and condominium sale transactions recorded between 2013 and 2018 in San Mateo and Santa Clara Counties.

Proximity to Caltrain station confers a property value benefit to single-family homes and condominiums. On average across the Caltrain corridor, every mile farther away from Caltrain stations is associated with a 5.3 percent decrease in single-family home sale price, all else being equal. For condominiums, every mile farther away from Caltrain stations is associated with a 4.1 percent decrease in sale price, all else being equal.

The property value benefits of Caltrain for single-family homes and condominiums vary by station service level: proximity to a high frequency Caltrain station confers a *higher* property value benefit than proximity to a medium or low frequency Caltrain station. High frequency stations are associated with the highest benefit and are closely followed by medium frequency stations. Properties located near low frequency stations experience a significantly lower property value benefit. For single-family homes, the benefit ranges from 7.2 percent (high frequency stations) to 3.6 percent (low frequency stations). For condominiums, the benefit ranges from 5.9 percent (high frequency stations) to 2.5 percent (low frequency stations).

FIGURE 2-2. PERCENT DECREASE IN SALE PRICE PER MILE AWAY FROM CALTRAIN, BY STATION FREQUENCY LEVEL



Note: Results are based on single-family home and condominium transactions in Santa Clara County and San Mateo County. The brackets represent the two coefficients obtained from the Ordinary Least Square model and the Spatial Error Model. The bar shows the average of these two coefficients. For the single-family homes chart, values shown for "All Stations" summarize the results of Models 1 and 2, and values shown for different station type summarize the results of Models 3 and 4. For the condominium chart, value shown for "All Stations" summarize the results of Models 5 and 6; and values shown for different station types summarize the results of Models 7 and 8. See Appendix B for a detailed description of the different models tested. Source: Strategic Economics, 2019.

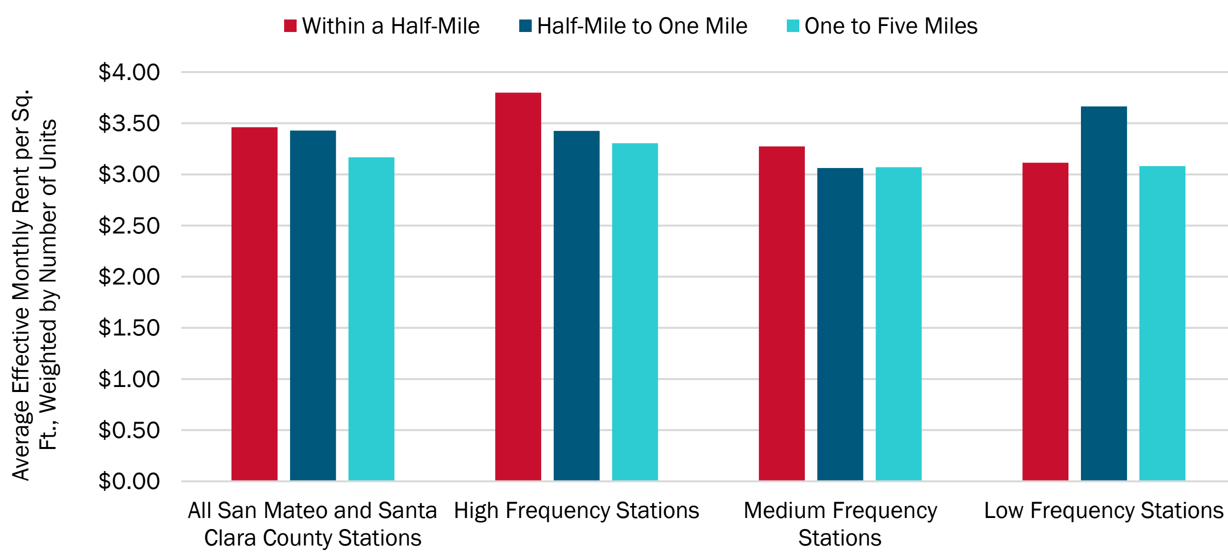
2.2.2. APARTMENTS

The results shown in Figure 2-3 are descriptive statistics, based on apartment rental data from the CoStar Group.

Apartment rents within a half-mile of Caltrain stations are generally higher than apartments rents further away. Across all stations in San Mateo and Santa Clara Counties, apartment rents average around $3.46 per square foot, which is 1 percent higher than those located between a half-mile to one-mile from stations, and 9 percent higher compared to rents between one and five miles from stations. This relationship is also consistent for apartment rents within a half-mile of the 4th & King and of 22nd Street stations in San Francisco, but results are more limited due to data availability.

Proximity to Caltrain appears to have the most impact on apartment rents for high frequency Caltrain stations, followed by medium frequency stations. Apartment rents within a half-mile of high frequency stations average around $3.80 per square foot, which is the highest average value of all the distance and service level combinations. This value is 11 percent higher than rents between a half-mile and one mile of high frequency stations, and 15 percent higher than rents between one to five miles of high frequency stations. Apartment rents near medium frequency stations display a similar trend. However, this pattern is inconsistent for low frequency stations.

FIGURE 2-3. AVERAGE APARTMENT RENTS, SAN MATEO AND SANTA CLARA COUNTIES



Source: CoStar, 2018; Strategic Economics, 2019.

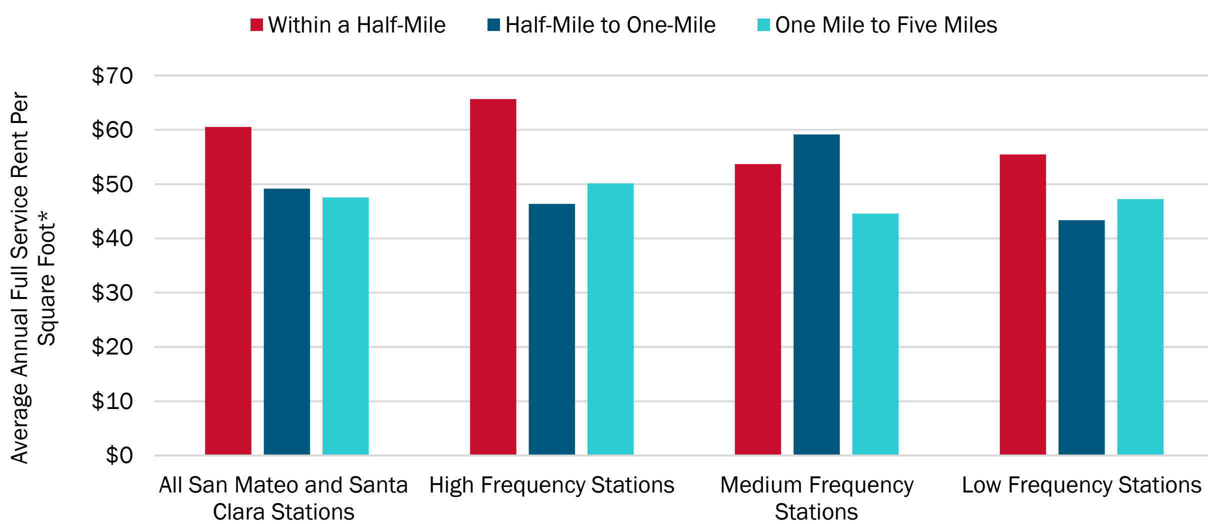
2.3.2. OFFICE

The results shown in Figure 2-4 are descriptive statistics, based on office rental data obtained from the CoStar Group.

Office rents within a half-mile of Caltrain stations are generally higher than office rents further away. Across all stations in San Mateo and Santa Clara Counties, office rents average around $60.50 per square foot (annually, full service), which is 23 percent higher than office rents within a half-mile to one-mile from stations, and 27 percent higher than office rents between one and five mile from stations.

Proximity to Caltrain appears to have the most impact on office rents for high frequency Caltrain stations; the impact of Caltrain is not as consistent for medium frequency stations. Properties located within a half-mile of high frequency Caltrain stations command the highest rents, averaging around $65.70 per square foot (annually, full-service). This is 42 percent higher than office rents between a half-mile and one mile from high frequency stations, and 31 percent higher than office rents between one to five miles from high frequency stations. For low frequency stations, rents within the half-mile are also higher than rents further away, but this pattern is inconsistent for medium frequency stations.

FIGURE 2-4. AVERAGE OFFICE RENTS, SAN MATEO AND SANTA CLARA COUNTIES



*Average rent per square foot refers to annual full service gross rents per square foot weighted by the building's rentable building area.
Source: Costar, 2018; Strategic Economics, 2019.

3. ASSESSED PROPERTY VALUES AND PROPERTY TAX NEAR CALTRAIN

This chapter summarizes the analysis of Caltrain's impact on assessed values and local jurisdictions' property tax base. The chapter includes an overview of the data and methodology used and a discussion of key findings.

3.1 APPROACH

This analysis examined the assessed values of properties located within a half-mile of Caltrain stations. The analysis was based on 2018 County Assessor data obtained from the City and County of San Francisco (for San Francisco) and purchased from commercial vendor CoreLogic (for Santa Clara and San Mateo Counties).

These assessed property value estimates were also used to estimate property tax revenues generated within a half-mile of Caltrain stations. Per California's Proposition 13, the base property tax rate is assumed to be one percent of assessed property value. Note that this does not include special assessments.

Tax-exempt land uses and parcels missing recorded assessed values were excluded from the analysis.[5] In San Francisco, a high proportion (29 percent) of taxable land area in Caltrain's half-mile service area had missing data. This may be due to high levels of development activity within a half-mile of San Francisco Caltrain stations. New development creates new parcels, which take time to be assessed and included in the assessor's data. Therefore, assessed values were interpolated for the missing portion of data based on existing land use patterns and typical market values.[6]

UNDERSTANDING ASSESSED PROPERTY VALUES IN LIGHT OF CALIFORNIA'S PROPOSITION 13

The assessed values presented in Chapter 3 differ from the market values presented in Chapters 4-6. Assessed values must be interpreted in the context of California's Proposition 13, which generally works to keep the assessed value of properties below their market value (i.e., the value if sold on the open market).

Passed by voters in 1978, Proposition 13 rolled property assessments back to their estimated value in 1975 and limited the reassessment of real property (land, buildings, and other property improvements). Prior to Proposition 13, county assessors reappraised real property at least once every five years. As a result, assessed values were kept relatively close to market values. However, under Proposition 13, properties are reassessed to current market value only when the property changes ownership or undergoes new construction; otherwise, real property valuations may only increase at a factor tied to the rate of inflation, but by no more than 2 percent each year. As a result, property assessments in California often reflect the length of time that an individual or entity has owned a property, rather than current market values.

Analyzing assessed values near transit is important from a fiscal perspective because local property tax revenues are tied to assessed values rather than market values.

[5] Certain types of property are exempt from property taxation under California law, including most government-owned property and property owned, irrevocably dedicated to, and used for religious, hospital, scientific, and/or charitable purposes.

[6] To interpolate the missing assessed values, Strategic Economics first calculated the total area of parcels with missing assessed value data. The proportion of land uses within those parcels was then estimated using both trends in development activity and existing land uses in parcels within Caltrain service areas for which data was available. Price per square foot values for existing land uses were then applied to the interpolated missing land values by use to arrive at the total interpolated value.

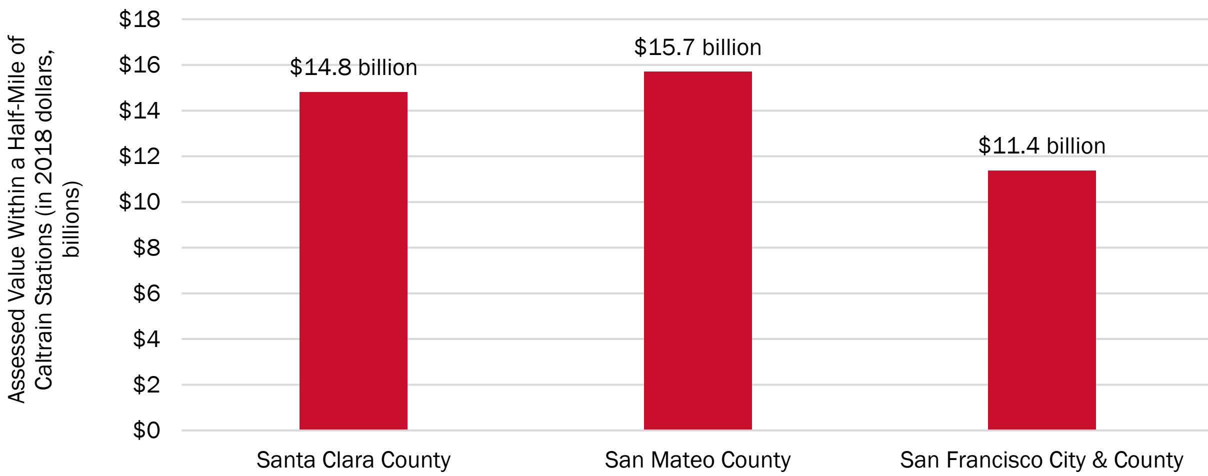
3.2 KEY FINDINGS

Key findings are described below and summarized in Figures 3-1 through 3-5. Detailed results are also provided in Appendix A.

Properties located within a half-mile of Caltrain stations have a combined total assessed value of $42 billion. The half-mile network distance service areas were used for this analysis, as explained in Chapter 1. Findings by county are listed below, and shown in Figure 3-1:

- In Santa Clara County, properties within a half-mile of Caltrain stations have a total assessed value of $14.8 billion.
- In San Mateo County, properties within a half-mile of Caltrain stations have a total assessed value of $15.7 billion.
- In San Francisco City and County, properties within a half-mile of Caltrain stations are estimated to have a total assessed value of $11.4 billion.

FIGURE 3-1. ASSESSED VALUE NEAR CALTRAIN STATIONS BY COUNTY

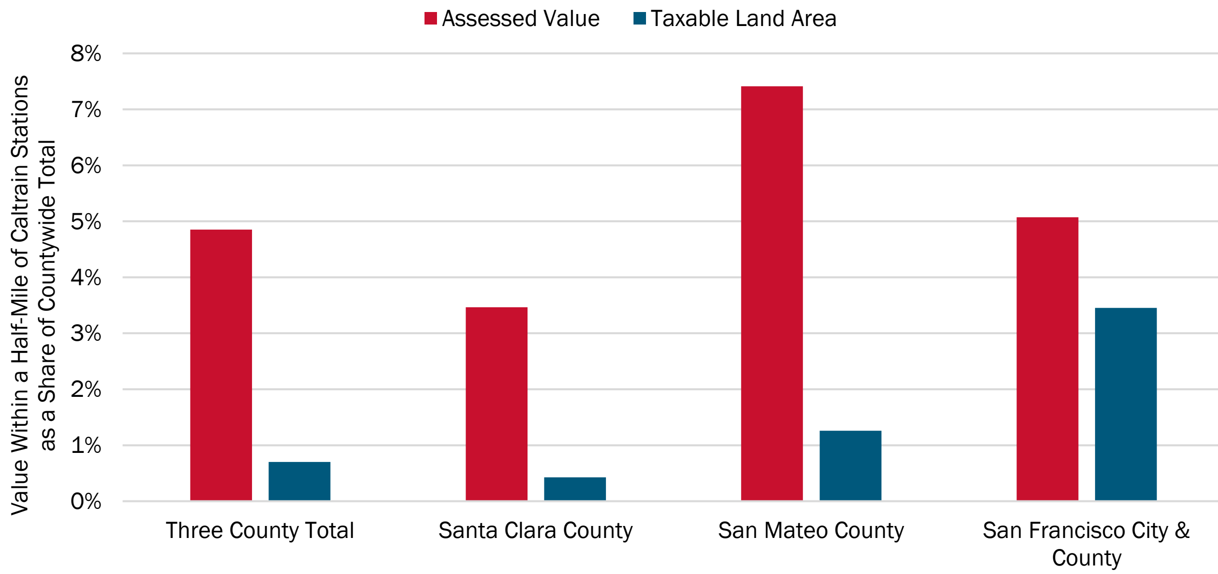


Source: City of San Francisco Assessor, 2019; San Mateo County Assessor, 2019; Santa Clara County Assessor, 2019; CoreLogic, 2018; Strategic Economics, 2019.

Overall, properties near Caltrain stations are disproportionately valuable to the property tax base of most of the communities Caltrain serves. To understand the relative contribution of the Caltrain half-mile area to the tax base of local jurisdictions, the share of assessed property value located within a half-mile of Caltrain stations is compared to the share of total taxable land in the same area, by county (Figure 3-2). This gives a sense of the relative "density" of value near Caltrain compared to other parts of the region. Findings are below and shown in Figure 3-2.

- Together, properties within a half-mile of all Caltrain stations in San Francisco, San Mateo, and Santa Clara Counties represent 4.9 percent of total assessed value, and account for 0.7 percent of overall land area.
- In Santa Clara County, properties within a half-mile of Caltrain represent 3.5 percent of total assessed value, and account for 0.4 percent of total land area.
- In San Mateo County, properties within a half-mile of Caltrain stations represent 7.4 percent of total assessed value, and account for 1.3 percent of total land area.
- In San Francisco City and County, properties within a half-mile of Caltrain stations represent 5.1 percent of total assessed value, and account for 3.5 percent of total land area.

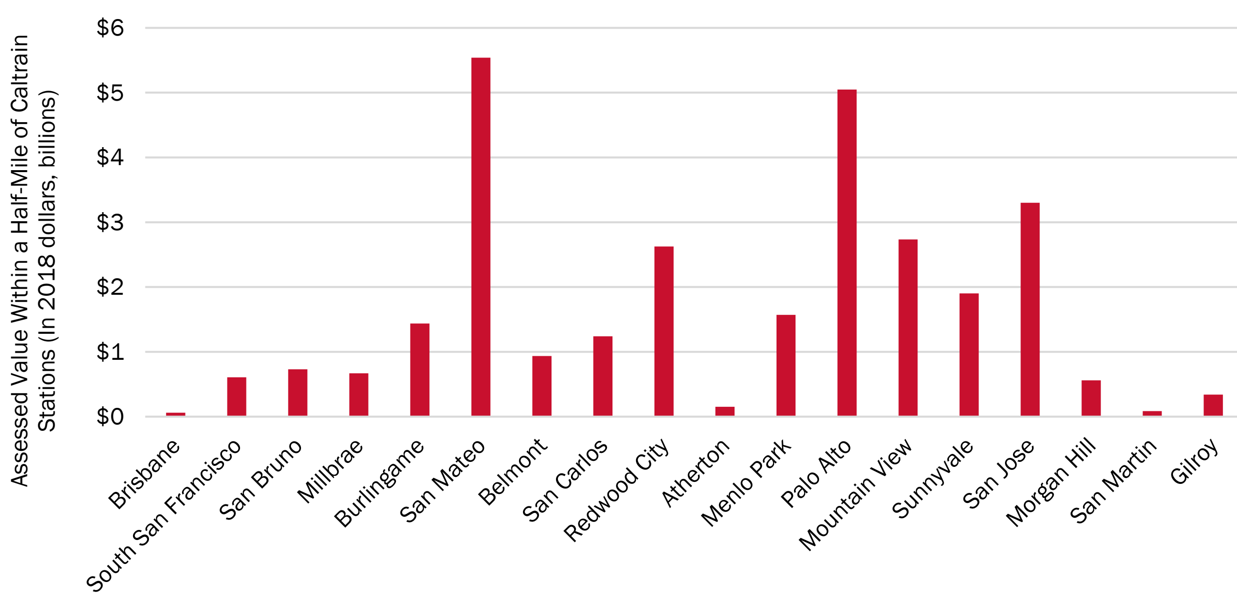
FIGURE 3-2. ASSESSED VALUE AND LAND AREA NEAR CALTRAIN STATIONS BY COUNTY



Source: City of San Francisco Assessor, 2019; San Mateo County Assessor, 2019; Santa Clara County Assessor, 2019; CoreLogic, 2018; Strategic Economics, 2019.

Assessed values within a half-mile of Caltrain stations total over $1 billion in 9 out of 19 cities in San Mateo or Santa Clara Counties (Figure 3-3). However, assessed values within a half-mile of Caltrain stations do vary significantly across cities. For instance, the total assessed value within a half-mile of Caltrain stations exceeds $5 billion in Palo Alto (two Caltrain stations) and San Mateo (three stations). In contrast, for cities such as Brisbane and San Martin, the total assessed value within a half-mile of Caltrain stations is less than $200 million.

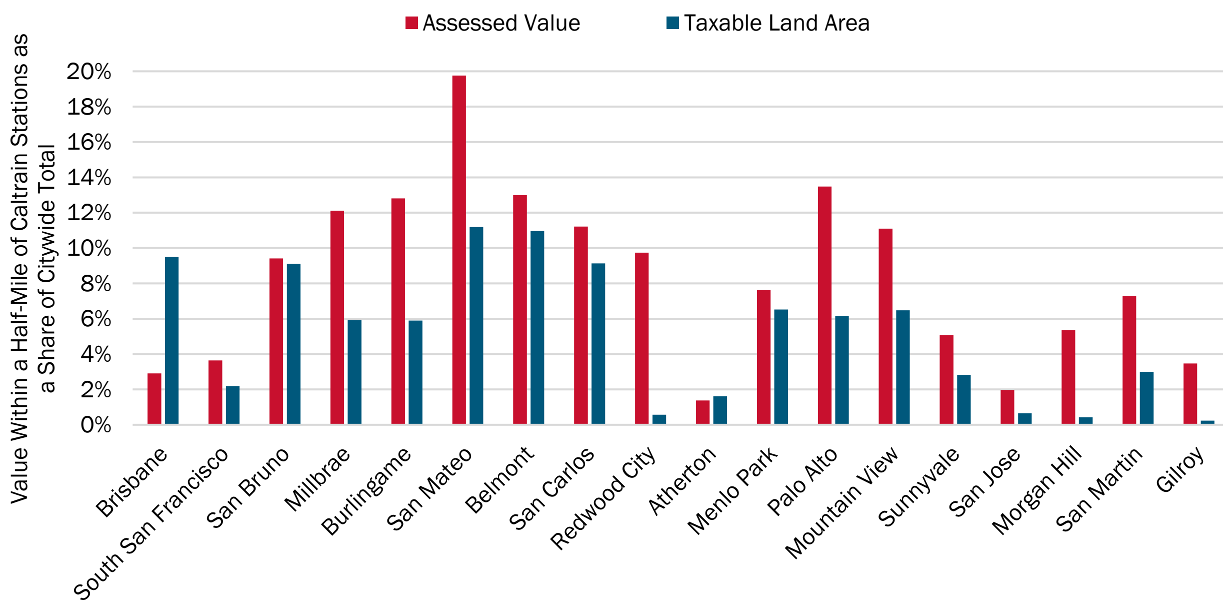
FIGURE 3-3. ASSESSED VALUE NEAR CALTRAIN STATIONS BY CITY



Source: San Mateo County Assessor, 2019; Santa Clara County Assessor, 2019; CoreLogic, 2018; Strategic Economics, 2019.

Properties located within a half-mile of Caltrain stations are disproportionately valuable in most cities in Santa Clara and San Mateo Counties. As seen in Figure 3-4, the share of citywide assessed value within a half-mile of Caltrain is higher than the corresponding share of taxable land area in 17 out 19 cities included in the analysis. For example, parcels within a half-mile of Caltrain stations in Mountain View account for 11 percent of the city's total assessed value, but only 6.5 percent of the city's total taxable land area. In Santa Clara County, assessed values within a half-mile of Caltrain stations were disproportionately valuable in all nine cities analyzed. In San Mateo County, assessed values within a half-mile of Caltrain stations were disproportionately valuable in eight out of ten cities.

FIGURE 3-4. ASSESSED VALUE AND LAND AREA NEAR CALTRAIN STATIONS BY CITY

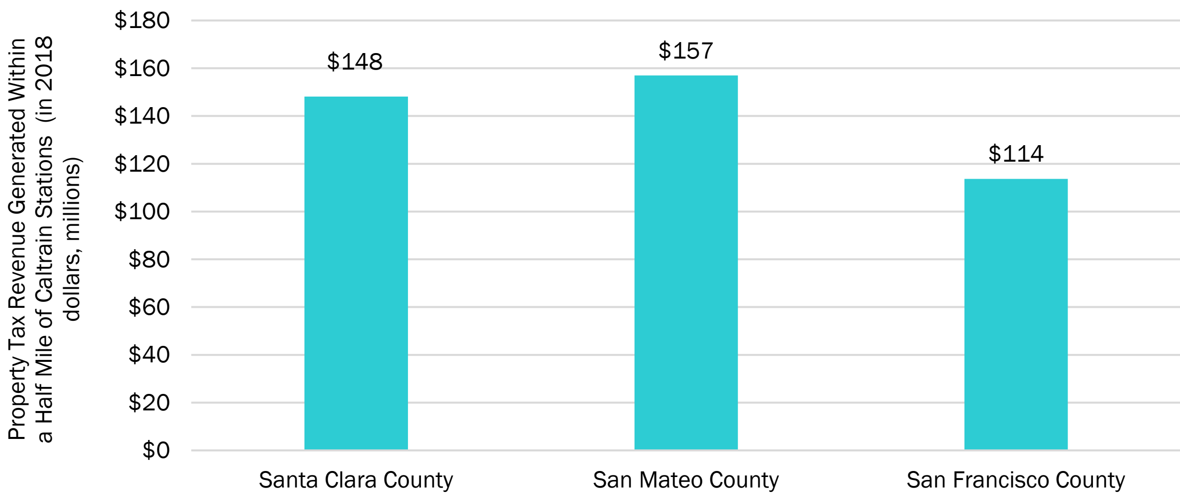


Source: San Mateo County Assessor, 2019; Santa Clara County Assessor, 2019; CoreLogic, 2018; Strategic Economics, 2019.

Properties located within a half-mile of Caltrain stations in San Francisco, San Mateo, and Santa Clara Counties together generate about $419 million annually in property tax revenue. As referenced above, in California one percent of assessed property values is collected as property tax and allocated to county government, municipal government, and other taxing entities. Given that the tax revenue apportionment to these various taxing entities varies significantly across jurisdictions and tax rate areas, property tax revenues were summarized by county, as shown in Figure 3-5. Findings by county are listed below:

- In Santa Clara County, properties within a half-mile of Caltrain stations are estimated to generate $148 million annually in property tax revenue.
- In San Mateo County, properties within a half-mile of Caltrain stations are estimated to generate $157 million annually in property tax revenue.
- In San Francisco City and County, properties within a half-mile of Caltrain stations are estimated to generate $114 million annually in property tax revenue.

FIGURE 3-5. ANNUAL PROPERTY TAX REVENUE GENERATED NEAR CALTRAIN STATIONS



Source: City of San Francisco Assessor, 2019; San Mateo County Assessor, 2019; Santa Clara County Assessor, 2019; CoreLogic, 2018; Strategic Economics, 2019.

4. CALTRAIN'S IMPACT ON SINGLE-FAMILY HOME AND CONDOMINIUM PROPERTY VALUES

This chapter presents the results of a statistical analysis of Caltrain's impact on single-family and condominium sale prices. The chapter includes an overview of the methods used, and a discussion of key findings. Appendix B provides more detail on the data, methodology, and results. A short section at the end of this chapter also describes how these regression results informed the analysis of the future property value benefits of the Caltrain Business Plan growth scenarios.

4.1 APPROACH

Caltrain's impact on single-family and condominium sales prices was analyzed using hedonic price modeling. Hedonic price modeling is a statistical regression method that breaks the value of a property into its constituent parts, allowing the researcher to isolate the value associated with each specific attribute. Hedonic price modeling is considered one of the best practices methods for analyzing the effect of transit on property values.

The hedonic price models developed for this study estimate the effect of proximity to Caltrain stations on single-family home and condominium sale prices. These models also incorporate information on frequency of Caltrain service to test whether there is a different value premium associated with different station service levels.

In addition to testing the effect of proximity to Caltrain stations by service level, the models also incorporate additional variables to control for the numerous other factors that influence property values. These include: (1) additional transportation accessibility variables (e.g. distance to freeway on-ramps); (2) property attributes (e.g. unit size); (3) neighborhood demographics (e.g. percent homeowners); and (4) neighborhood amenities/disamenities and other control variables (e.g. density of nearby retail). The full list of variables is available in Appendix B.

The analysis uses a dataset of all single-family home and condominium sales in Santa Clara and San Mateo Counties between January 2013 and August 2018, purchased from the commercial vendor CoreLogic. Other data sources were also collected, as explained in Appendix B. San Francisco was not included in the models because of the significant challenges involved in isolating Caltrain's impact in a city where Caltrain is only one of many rail transit options. Furthermore, the areas served by Caltrain in San Francisco (particularly SOMA) have received significant public and private investment in recent years, adding to the challenge of distinguishing the effects of Caltrain from other factors.

To confirm the validity and consistency of results, Strategic Economics tested various regression techniques. In addition to Ordinary Least Square modeling, which is the most common type of hedonic price analysis, spatial autocorrelation models were also developed.[7] Spatial autocorrelation modeling is generally considered a more appropriate model choice

[7] There exist many different types of spatial autocorrelation models. In this analysis, a Spatial Error Model (SEM) was used. The Appendix includes a more detailed discussion of these various regression methods.

for hedonic price analysis because it has the advantage of controlling for the spatial dependencies often found in real estate data.[8] Results are reported as ranges, with estimated averages, to reflect these two different methods.

4.2 KEY FINDINGS

Key findings are described below and summarized in Figure 4-1. Full results of the regression analyses are available in Appendix B.

For single-family homes in San Mateo and Santa Clara Counties, every mile farther away from Caltrain stations is associated with a 5.3 percent decrease in sale price, all else being equal. The regression models found that every additional mile farther from Caltrain stations is associated with a decrease in single-family home sale price ranging from 5.2 to 5.4 percent, holding all other variables constant. As mentioned above, this property value benefit is reported as a range to account for the different regression methods tested (see Appendix B for further discussion).

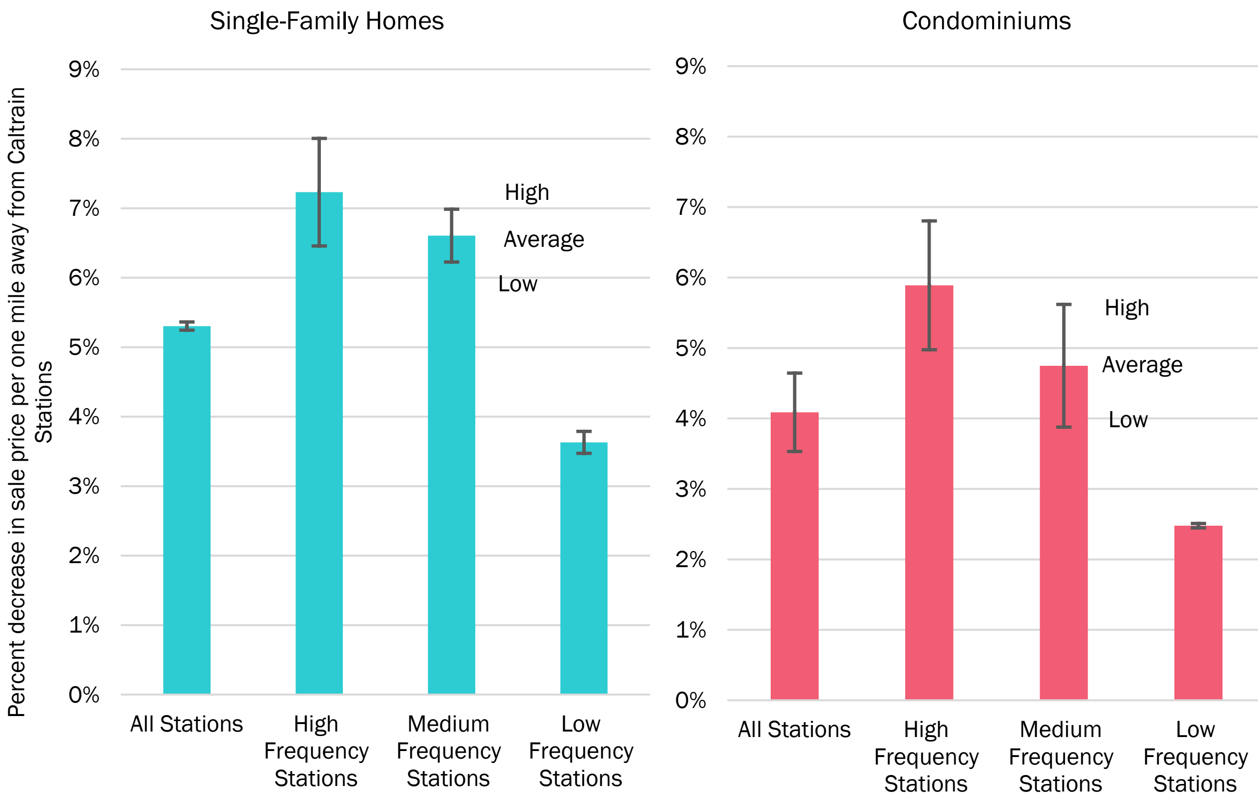
For condominiums in San Mateo and Santa Clara Counties, every mile farther away from Caltrain stations is associated with a 4.1 percent decrease in sale price, all else being equal. The regression models found that condominium sale prices were 3.6 to 4.5 percent lower for every additional mile away from Caltrain, all else being equal.

In San Mateo and Santa Clara Counties, proximity to a high frequency Caltrain station confers a higher property value benefit than proximity to a medium or low frequency Caltrain station. Holding all other variables constant, the regression models suggest that different service levels are associated with different property value benefits. High frequency stations are associated with the highest benefit and are closely followed by medium frequency stations. Properties located near low frequency stations experience a significantly lower property value benefit. As shown in Figure 4-1:

- Every mile farther from a **high frequency Caltrain station** is associated with a decrease in average sale price of 7.2 percent for single-family homes, and 5.9 percent for condominiums, all else being equal.
- Every mile farther from a **medium frequency Caltrain station** is associated with a decrease in sale price of 6.6 percent for single-family homes, and 4.7 percent for condominiums, all else being equal.
- Every mile farther from a **low frequency Caltrain station** is associated with a decrease in sale price of only 3.6 percent for single-family homes, and 2.5 percent for condominiums, all else being equal.

[8] To be statistically valid, a regression model must conform to certain criteria, including the random (and spatially random) distribution of residuals. Spatially clustered residuals indicate that the model is missing spatial variables (i.e., spatial fixed effects such as elevation, or neighborhood median income), or, as is often the case with real estate data, that spatial autocorrelation (or spatial dependencies) are present in the data. Spatial autocorrelation is defined as the "the phenomenon by which a value observed in one location depends on the values in neighboring locations" in a way that cannot be easily controlled for by spatial variables. See Appendix B for further explanation.

FIGURE 4-1. PERCENT DECREASE IN SALE PRICE PER MILE AWAY FROM CALTRAIN, BY STATION FREQUENCY LEVEL



Note: Results are based on single-family home and condominium transactions in Santa Clara County and San Mateo County. The brackets represent the two coefficients obtained from the Ordinary Least Square model and the Spatial Error Model. The bar shows the average of these two coefficients. For the single-family homes chart, values shown for "All Stations" summarize the results of Models 1 and 2, and values shown for different station type summarize the results of Models 3 and 4. For the condominium chart, value shown for "All Stations" summarize the results of Models 5 and 6; and values shown for different station types summarize the results of Models 7 and 8. See Appendix B for a detailed description of the different models tested.
Source: Strategic Economics, 2019.

4.1.2. A NOTE ABOUT THE DIFFERENCE BETWEEN SINGLE-FAMILY HOMES AND CONDOMINIUMS

The slightly higher property value benefit found for single-family homes compared to condominiums differs from findings in the literature. Researchers have hypothesized that condominium homebuyers usually consist of smaller households with few or no children, which simplifies their transportation needs. These households may therefore place a higher value on transit accessibility than other household types, such as families with children buying single-family homes.[9] Only a small number of studies have explicitly compared transit premiums for single-family homes versus condominiums, but results generally corroborate this hypothesis. For instance, a 2015 study examining the impact of

[9] Keith Wardrip, Center for Housing Policy and Reconnecting America (2011), Public Transit's Impact on Housing Costs: A Review of the Literature, available at: http://www.reconnectingamerica.org/assets/Uploads/TransitImpactonHsgCostsfinal-Aug1020111.pdf

BART on residential property values in the San Francisco Bay Area found a higher premium for condominiums than for single-family homes, and a 2008 study in San Diego found a similar pattern.[10]

The higher values for single-family homes found in these Caltrain regression models may partly be a result of the extremely tight housing market in San Mateo and Santa Clara Counties, especially for single-family homes, over the time period evaluated (2013 to 2018). It is also possible that the relative difference between single-family homes and condominiums is skewed due to the limited number of sale transactions recorded in very close proximity to Caltrain stations (see Table 7-5 in Appendix B).[11]

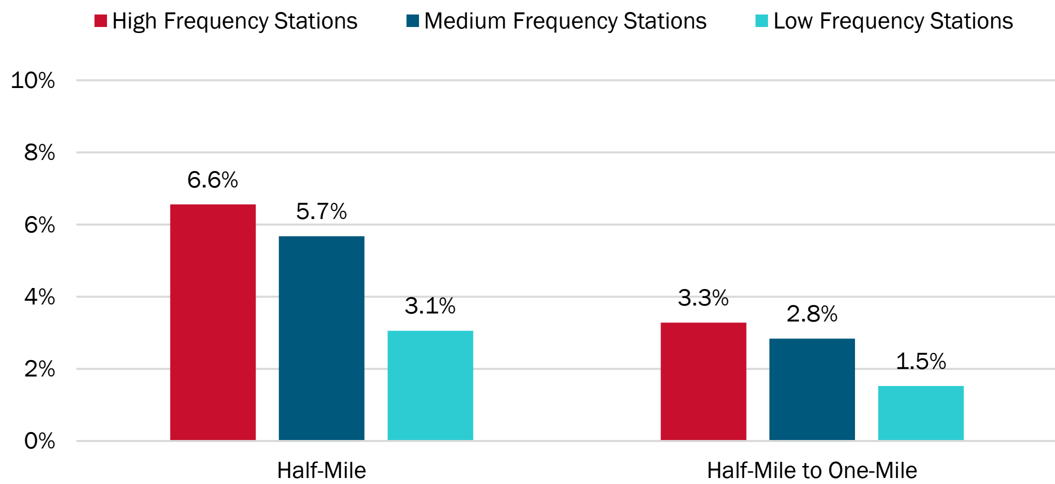
4.2.2. INTERPRETATION OF RESULTS FOR THE ANALYSIS OF THE FUTURE BENEFITS OF CALTRAIN

For the purposes of estimating the future property value benefits of the Caltrain Business Plan growth scenarios, the regression results described above were translated into the residential property value premiums shown in Figure 4-2. In the analysis of the future benefits of Caltrain, Caltrain's "property value premium" is defined as the share of property value that is attributable to Caltrain. These premiums were calculated based on the assumption that, for residential properties, Caltrain's impact tails off at one mile from the stations, which is a conservative estimate. The premiums for properties located within a half-mile of Caltrain stations were calculated as the average of the single-family home and condominium regression coefficients of the Ordinary Least Square and Spatial Error models. The premiums for properties located between a half-mile and one-mile of Caltrain stations represent half the value of the half-mile premiums (see Figure 4-2).

[10] Strategic Economics conducted an analysis for BART in 2015, which found a 15.0 percent premium for condominiums and a 10.7 percent premium for single-family homes locate within a half-mile of BART stations, as compared to being more than five miles from a station, in Alameda, Contra Costa, and Northern San Mateo Counties. See: Strategic Economics (2014), Property Value and Fiscal Benefits of BART, available at: https://www.bart.gov/sites/default/files/docs/2014-08%20BARTPropValues_Final_0.pdf as well as Strategic Economics (2015), Benefits of BART to Single-Family and Condominium Property Values by County, available at: https://www.bart.gov/sites/default/files/docs/1%20-%20BART%20Single%20Family%20and%20Condo%20Analysis_0.pdf. The San Diego study is summarized in: Duncan (2008), Comparing Rail Transit Capitalization Benefits for Single-Family and Condominium Units in San Diego, California, Transportation Research Record Vol 2067-1, https://doi.org/10.3141/2067-14.

[11] Other potential explanations could be explored. For instance, the correlation between proximity to Caltrain and the density of retail and entertainment amenities may make it difficult to tease out the impact of proximity to Caltrain stations, especially for condominiums, which tend to be located in more compact, walkable districts near Caltrain (as opposed to lower density single family home neighborhoods in the hills, for example). This would mean that the condominium models may be attributing some of Caltrain's value to the characteristics of the surrounding neighborhoods, and therefore slightly underestimating the value of Caltrain.

FIGURE 4-2. RESIDENTIAL PROPERTY VALUE PREMIUMS USED FOR THE ANALYSIS OF FUTURE BENEFITS OF CALTRAIN



Source: Strategic Economics, 2019.

5. APARTMENT RENTS NEAR CALTRAIN

This chapter summarizes the analysis of Caltrain's impact on multifamily apartment rents. The chapter includes a brief overview of the data and methodology, and a discussion of key findings.

5.1 APPROACH

This analysis examined the relationship between apartment rents and proximity to Caltrain in San Francisco, San Mateo, and Santa Clara Counties, using data obtained from the Costar Group. The analysis compared average effective rents per square foot,[12] weighted by the total number of units in each apartment building, at different network distances from Caltrain stations and for different Caltrain station frequency levels.

Figures 5-1 and 5-2, and Tables 5-1 and 5-3 summarize the sample of apartment buildings included in the analysis. In San Mateo and Santa Clara Counties, all market-rate apartment buildings with rent data located within five miles of a Caltrain station were analyzed. Data in San Mateo and Santa Clara Counties were evaluated together in order to include sufficient observations in each combination of distance category and station type.

San Francisco apartments were analyzed separately from San Mateo and Santa Clara apartments to account for San Francisco's unique real estate market.[13] For San Francisco, apartment buildings within a one mile network radius from 4th and King and 22nd Street stations were analyzed, as shown in Figure 5-2. Note that Bayshore station, in San Francisco, was excluded from the analysis due to a lack of data. In order to restrict the analysis to areas with similar market conditions, Highway 101 and Market Street were used as geographic boundaries for the sample.

It should be noted that many factors influence apartment rents, and this analysis does not control for the impact of individual variables on apartment rents. In addition to proximity to Caltrain, factors such as building quality, proximity to amenities, accessibility to employment centers, market conditions, and other variables may influence the difference in rents described in the following section. Alternative methodologies, such as a hedonic price modeling or a more detailed comparison of rents by station area, were explored but found not to be possible given the extent and quality of the data.[14]

5.2 KEY FINDINGS

Major findings from the analysis are summarized below and in the following figures and tables.

In San Mateo and Santa Clara Counties, apartment rents within a half-mile of Caltrain stations are 1 percent higher than apartment rents farther away. Across all station types, apartment rents within a half-mile from Caltrain stations averaged around $3.46 per square foot (Table 5-2 and Figure 5-3). Rents within a half-mile of Caltrain stations are 1 percent higher than rents in apartments located between a half and one mile from Caltrain, and 9 percent higher than rents in apartments located one to five miles from Caltrain.

Apartments rents within a half-mile of high frequency Caltrain stations are 11 percent higher than rents located between a half-mile to one mile of high frequency stations, and 15 percent higher than rents between one to five miles from high frequency stations (Table 5-2 and Figure 5-3). At $3.80 per square foot, apartment rents within a half-mile of high frequency stations represent the highest average rents of any grouping of distance and frequency categories.

[12] Average effective rent is a metric provided by the Costar Group. Average effective rent is the average monthly rent paid by a tenant adjusted downward for concessions paid by a landlord, and upward for extra costs a tenant might incur.

[13] To account for differing inclusionary housing policies across municipalities in San Mateo and Santa Clara Counties, only buildings with all market rate units were analyzed. In San Francisco, buildings with some affordable units were also included in the data.

[14] The data obtained from CoStar were not detailed enough to adequately control for building and unit quality; many properties had missing rent information; and several Caltrain stations had too few data points.

In San Francisco, apartment rents within a half-mile of Caltrain stations are 8 percent higher than to rents between a half-mile to one mile from Caltrain stations. At the 4th & King Caltrain station, rents within a half-mile of the station averaged $5.10 per square foot, which is 9 percent higher than rents in apartments between a half-mile and one mile away from the station. At 22nd Street station, rents within a half-mile averaged $5.20 per square foot, about 4 percent higher than rents a half-mile to one mile away from the station (see Table 5-4 and Figure 5-4).

FIGURE 5-1. APARTMENTS WITHIN FIVE MILES OF CALTRAIN STATIONS

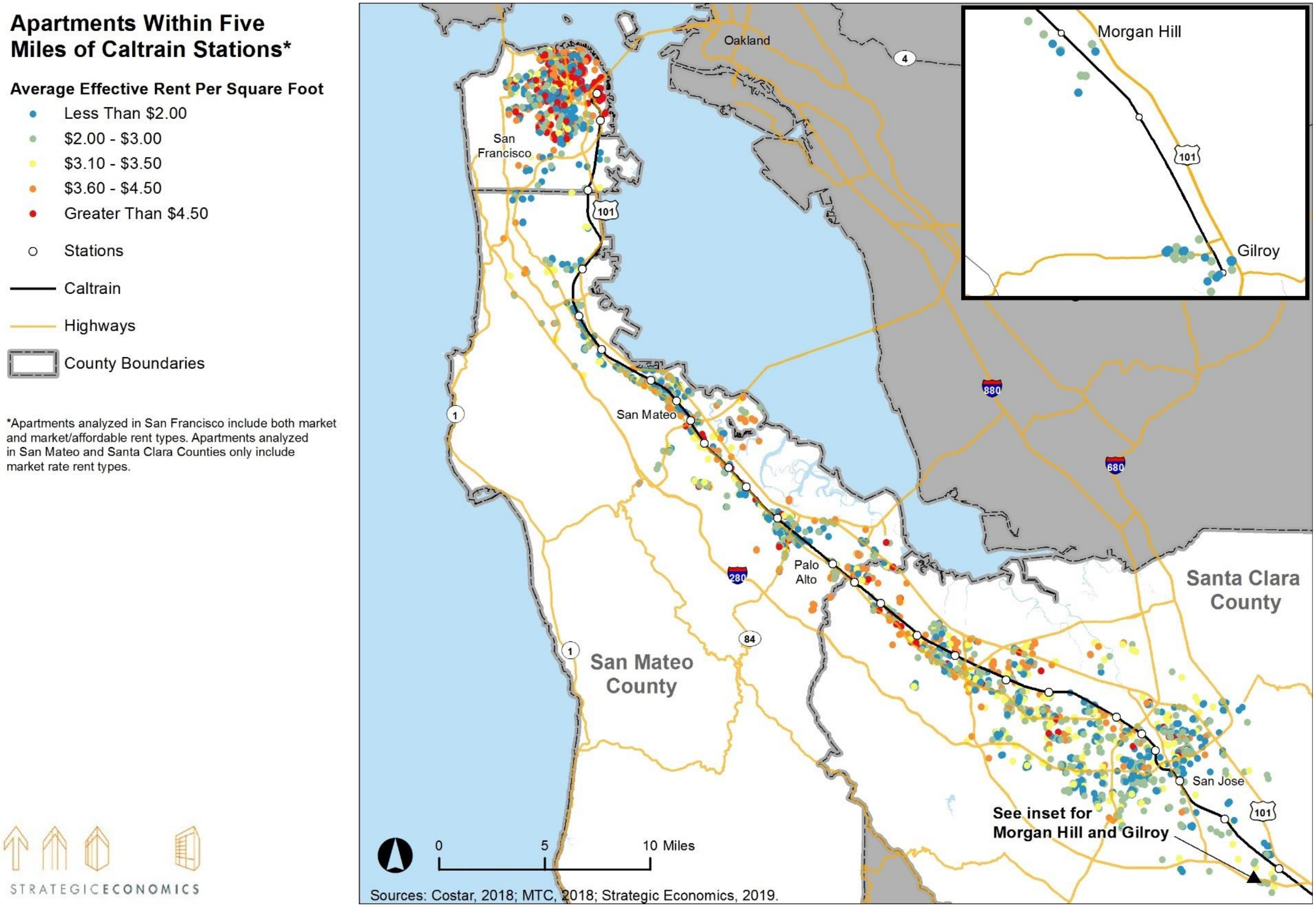


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FIGURE 5-2. SAN FRANCISCO APARTMENTS

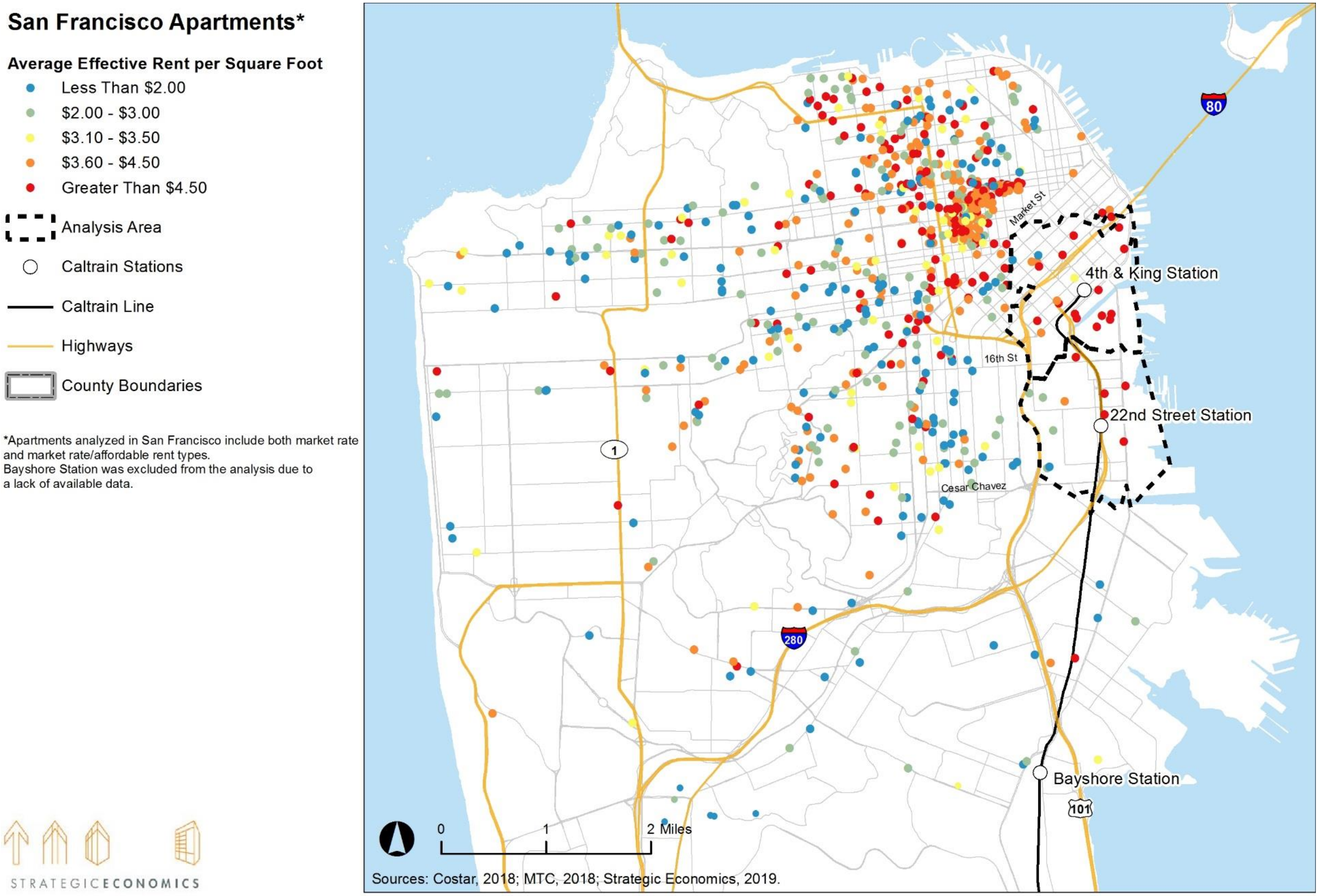


TABLE 5-1. APARTMENTS SAMPLE SIZE, SAN MATEO AND SANTA CLARA COUNTIES

	Number of Apartment Buildings			
	Within a Half-Mile	**Half-Mile to One Mile**	**One to Five Miles**	**Total**
High Frequency Stations	33	113	617	763
Medium Frequency Stations	47	130	393	570
Low Frequency Stations	41	81	412	534
All San Mateo and Santa Clara Stations	**121**	**324**	**1,422**	**1,867**

Source: Costar, 2018; Strategic Economics, 2019.

TABLE 5-2. AVERAGE APARTMENT RENTS, SAN MATEO AND SANTA CLARA COUNTIES

	Average Rent Per Square Foot*			Percent Difference in Average Rents Compared to Rents within the Half-Mile	
	Within a Half-Mile	**Half-Mile to One Mile**	**One to Five Miles**	**Compared to Rents in the Half-Mile to One Mile**	**Compared to Rents in One to Five Miles**
High Frequency Stations	$3.80	$3.42	$3.30	10.9%	14.9%
Medium Frequency Stations	$3.27	$3.06	$3.07	6.9%	6.6%
Low Frequency Stations	$3.11	$3.66	$3.08	-15.0%	1.1%
All San Mateo and Santa Clara Stations	**$3.46**	**$3.43**	**$3.17**	**1.0%**	**9.3%**

*Note: Average rent per square foot refers to average effective monthly rent per square foot, weighted by the total number of units in the building. Source: Costar, 2018; Strategic Economics, 2019.
Source: Costar, 2018; Strategic Economics, 2019.

FIGURE 5-3. AVERAGE APARTMENT RENTS, SAN MATEO AND SANTA CLARA COUNTIES

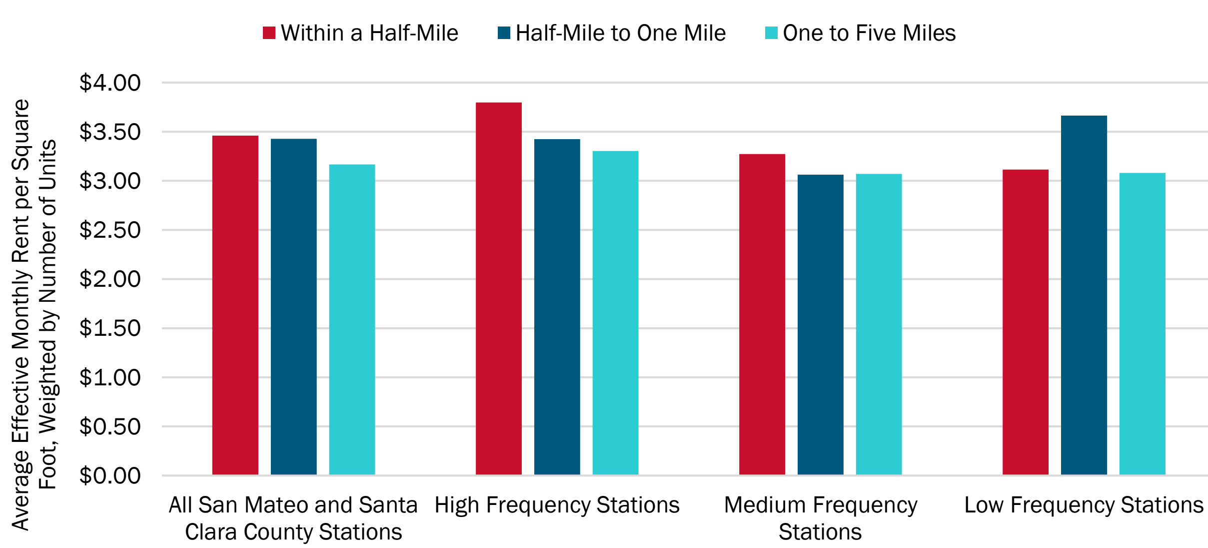


TABLE 5-3. APARTMENTS SAMPLE SIZE, SAN FRANCISCO

	Number of Apartment Buildings		
	Within a Half-Mile	Half-Mile to One Mile	Total
4th & King Station	15	14	29
22nd Street Station	3	10	13
All Stations	**18**	**24**	**42**

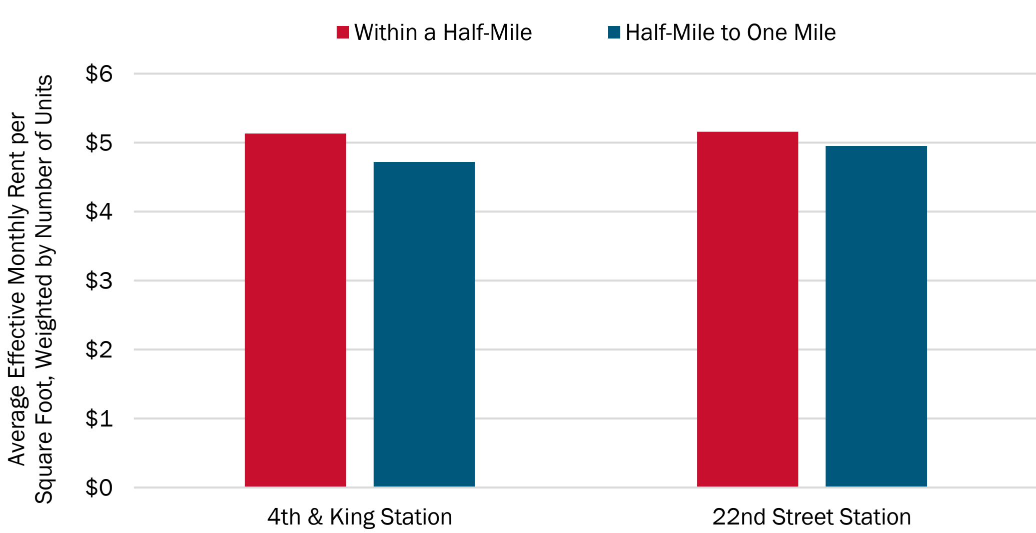
Note: Bayshore station was excluded from the analysis due to a lack of data.
Source: Costar, 2018; Strategic Economics, 2019.

TABLE 5-4. AVERAGE APARTMENT RENTS, SAN FRANCISCO

	Average Rent Per Square Foot*		
	Within a Half-Mile	Half-Mile to One Mile	Percent Difference in Average Rent
4th & King Station	$5.13	$4.72	8.7%
22nd Street Station	$5.16	$4.95	4.2%
All Stations	**$5.14**	**$4.76**	**7.8%**

*Note: Average rent per square foot refers to average effective monthly rent per square foot, weighted by the total number of units in the building. Bayshore station was excluded from the analysis due to a lack of data.
Source: Costar, 2018; Strategic Economics, 2019.

FIGURE 5-4. AVERAGE APARTMENT RENTS, SAN FRANCISCO



Note: No data was available for the one to five mile area from the 22nd St Caltrain station. 4th & King is a High Frequency station, and 22nd Street is Medium Frequency station. Bayshore station was excluded from the analysis due to a lack of data.
Source: Costar, 2018; Strategic Economics, 2019.

6. OFFICE RENTS NEAR CALTRAIN

This chapter summarizes the analysis of Caltrain's impact on office rents. The chapter includes a brief overview of the data and methodology, and a discussion of key findings.

6.1 APPROACH

This analysis examined the relationship between office rents and proximity to Caltrain in San Mateo and Santa Clara Counties. The analysis used data provided by the Costar Group. San Francisco office properties were excluded from the analysis because of a lack of sufficient rent data.

The analysis compared average annual rents per square foot at different distances from Caltrain and for different Caltrain station frequency levels.[15] The analysis only included office properties located within five miles of Caltrain stations for which full-service gross rents were available. The resulting dataset is summarized in Figure 6-1 and Table 6-1. Average rents within a half-mile of Caltrain stations were compared to rents within a half-mile to one mile, and one to five miles from stations.

It should be noted that many factors influence office rents, and this analysis does not control for the impact of individual variables on rents. In addition to proximity to Caltrain, factors such as building quality, proximity to amenities, proximity to other employers, market conditions, and other variables may influence the difference in rents described in the following section. Alternative methodologies, such as a hedonic price modeling or a more detailed comparison of rents by station area, were explored but found not to be possible given the extent and quality of the data.[16]

6.2 KEY FINDINGS

Key findings are described below and summarized in Table 6-2 and Figure 6-2.

In San Mateo and Santa Clara Counties, rents in office properties located within a half-mile of Caltrain stations are more than 20 percent higher than those in office properties farther away. The overall average weighted rent for office buildings within a half-mile of Caltrain stations in San Mateo and Santa Clara Counties is $60.50 per square foot (full-service), 23 percent higher than rents in the half-mile to one mile distance category. This difference increases to 27 percent when comparing rents within the half-mile to those located one to five miles away from Caltrain stations. The trend is slightly inconsistent for medium frequency level stations, where rents in the half-mile to one mile distance category are ten percent higher than rents within the half-mile.

Properties located within a half-mile of high frequency Caltrain stations command the highest rents. Office properties within a half-mile of high frequency stations averaged rents around $65.70 per square foot (full-service). In comparison, office rents between a half-mile and one mile from high frequency stations are 42 percent lower, averaging around $46.37 per square foot. In office buildings one to five miles from high frequency stations, rents are average about $50.13 per square foot, which is 31 percent less than office rents closest to Caltrain stations.

[15] Full service office rents provided by CoStar are weighted based on the square footage of individual office spaces for rent within each building. Strategic Economics then weighted these rents by the total rentable building area in San Mateo and Santa Clara Counties.

[16] The data obtained from CoStar were not detailed enough to adequately control for building quality, and many properties had missing rent information.

FIGURE 6-1. OFFICE BUILDINGS WITH FULL-SERVICE GROSS RENTS WITHIN FIVE MILES OF CALTRAIN STATIONS

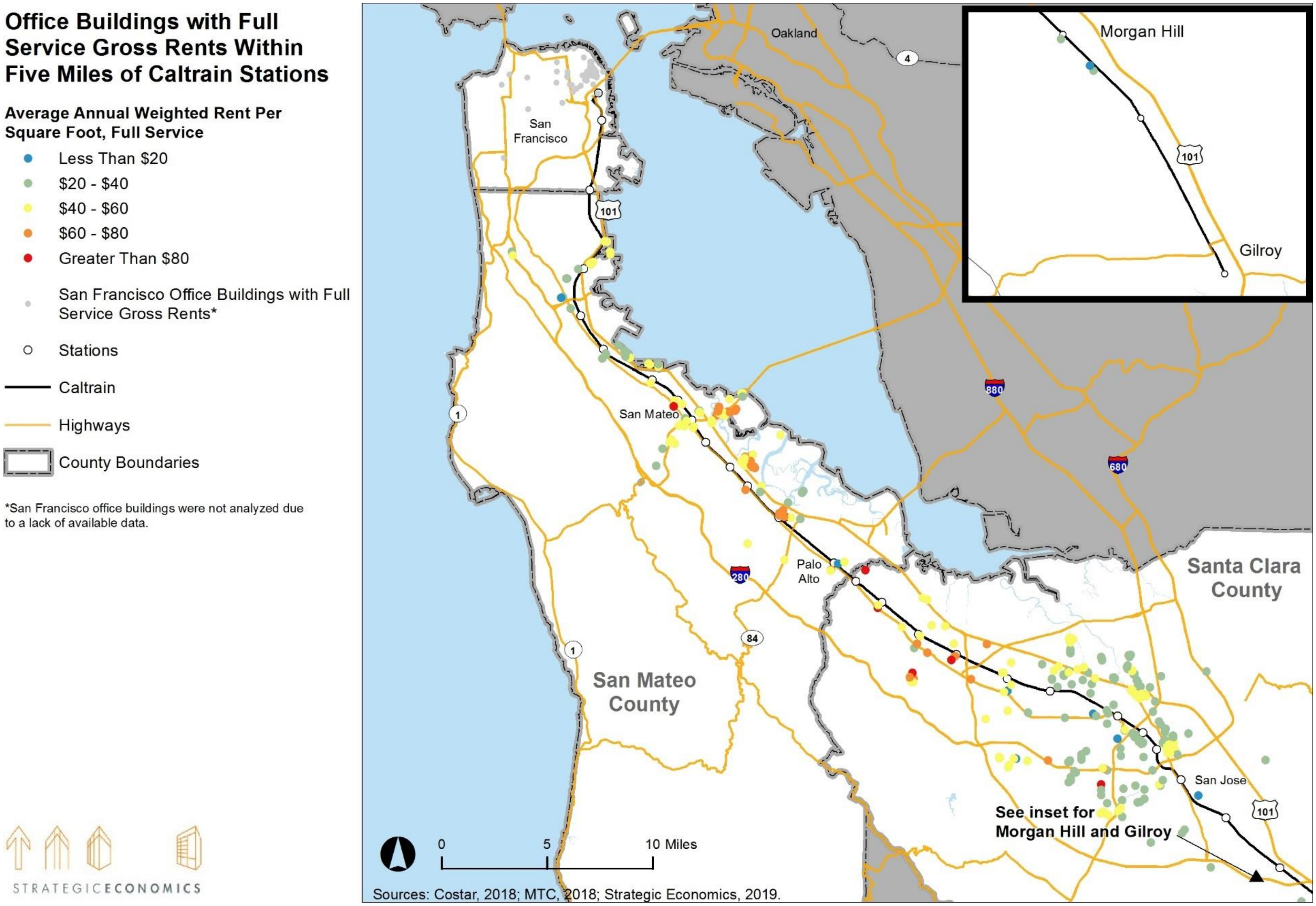


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TABLE 6-1. OFFICE BUILDINGS SAMPLE SIZE, SAN MATEO AND SANTA CLARA COUNTIES

	Number of Office Buildings			
	Within a Half-Mile	Half-Mile to One-Mile	One Mile to Five Miles	Total
High Frequency Stations	11	16	74	101
Medium Frequency Stations	7	20	81	108
Low Frequency Stations	9	20	122	122
All Stations	**27**	**56**	**277**	**360**

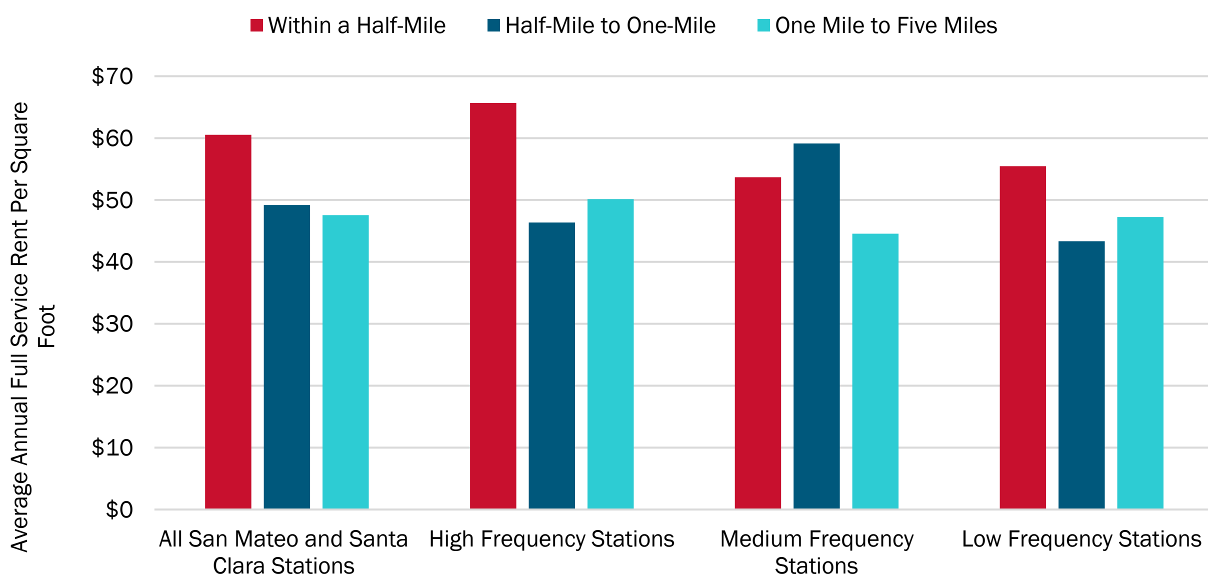
Source: Costar, 2018; Strategic Economics, 2019.

TABLE 6-2. AVERAGE OFFICE RENTS, SAN MATEO AND SANTA CLARA COUNTIES

	Average Rent Per Square Foot*			Percent Difference in Average Rents Compared to Rents within the Half-Mile	
	Within a Half-Mile	Half-Mile to One-Mile	One Mile to Five Miles	Compared to Rents in the Half-Mile to One Mile	Compared to Rents in One to Five Miles
High Frequency Stations	$65.67	$46.37	$50.13	41.6%	31.0%
Medium Frequency Stations	$53.69	$59.14	$44.56	-9.2%	20.5%
Low Frequency Stations	$55.47	$43.35	$47.24	28.0%	17.4%
All Stations	**$60.53**	**$49.17**	**$47.55**	**23.1%**	**27.3%**

*Average rent per square foot refers to annual full service gross rents per square foot weighted by the building's rentable building area.
Source: Costar, 2018; Strategic Economics, 2019.

FIGURE 6-2. AVERAGE OFFICE RENTS, SAN MATEO AND SANTA CLARA COUNTIES



*Average rent per square foot refers to annual full service gross rents per square foot weighted by the building's rentable building area.
Source: Costar, 2018; Strategic Economics, 2019.

7. APPENDICES

Appendix A: Assessed Property Value Near Caltrain Stations

Table 7-1. Assessed Property Value and Taxable Land Area Near Caltrain Stations by City

	ASSESSED VALUE			LAND AREA		
	Assessed Value within a Half-Mile of Caltrain Stations (2018 $)	Citywide Assessed Value (2018 $)	Assessed Value Within a Half-Mile of Caltrain Stations as a Percentage of Citywide Assessed Value	Land Area of Caltrain Station Half-Mile Network Service Area, Taxable Portion Only (Square Feet)	Land Area Citywide, Taxable Portion Only (Square Feet)	Land Area Within a Half-Mile of Caltrain Stations as a Percentage of Citywide Land Area
San Francisco	$11,369,253,389	$224,162,168,240	5.1%	27,006,166	782,290,831	3.5%
Brisbane	$60,138,941	$2,066,663,743	2.9%	6,648,797	70,015,031	9.5%
South San Francisco	$606,489,678	$16,648,713,888	3.6%	4,276,072	195,415,624	2.2%
San Bruno	$730,760,374	$7,764,529,631	9.4%	9,247,813	101,448,724	9.1%
Millbrae	$668,939,198	$5,522,505,008	12.1%	3,449,964	58,263,298	5.9%
Burlingame	$1,437,817,655	$11,225,482,033	12.8%	9,179,306	155,666,094	5.9%
San Mateo	$5,540,883,201	$28,040,731,159	19.8%	28,020,790	250,372,083	11.2%
Belmont	$935,883,073	$7,202,203,395	13.0%	10,082,370	91,988,541	11.0%
San Carlos	$1,240,677,558	$11,065,250,678	11.2%	10,697,472	117,206,289	9.1%
Redwood City	$2,625,323,124	$26,955,443,298	9.7%	8,848,674	1,544,849,513	0.6%
Atherton	$152,270,840	$11,053,369,859	1.4%	1,903,457	117,990,824	1.6%
Menlo Park	$1,571,046,447	$20,612,524,852	7.6%	9,533,621	146,166,594	6.5%
Palo Alto	$5,048,078,606	$37,457,902,269	13.5%	14,811,349	240,493,040	6.2%
Mountain View	$2,736,134,161	$24,652,854,185	11.1%	11,588,266	178,912,481	6.5%
Sunnyvale	$1,902,543,628	$37,505,297,774	5.1%	10,020,426	354,519,753	2.8%
Santa Clara	$840,087,382	$33,030,070,810	2.5%	6,245,227	312,857,392	2.0%
San Jose	$3,301,181,104	$166,975,825,619	2.0%	32,871,492	5,024,407,767	0.7%
Morgan Hill	$560,903,931	$10,473,990,722	5.4%	8,861,757	2,066,036,613	0.4%
San Martin	$85,083,739	$1,166,237,962	7.3%	9,806,693	326,796,407	3.0%
Gilroy	$339,601,422	$9,791,224,372	3.5%	9,020,949	3,879,160,066	0.2%

Source: CoreLogic, 2018; DataSF, 2018; Strategic Economics, 2019.

Appendix B: Single-Family Home and Condominium Property Value Analysis Methodology

Appendix B provides a detailed review of the data and methodology developed for the hedonic regression analysis presented in Chapter 3. Complete regression results are also provided.

OVERVIEW OF HEDONIC PRICE MODELING

The hedonic regression analyses developed for this study model the transaction price of a single-family home or condominium as a function of four types of attributes: transportation accessibility variables, property attributes, neighborhood demographics, and other control variables. The model's general form can be summarized as:

$P_i = f\,(\mathrm{T, A, N, C})$

Where

P_i = the sales price of a given property (property *i*)

T = transportation accessibility variables, including among other variables, the network distance from property *i* to the nearest Caltrain station.

A = attributes of property *i*, such as living area, lot size, and number of bedrooms.

N = neighborhood demographic factors, based on the Census Tract in which property *i* is located.

C = controls for spatiotemporal effects, such as the year when property *i* was sold, the city where it is located, and other neighborhood amenities or disamenities.

Note that separate models were developed for single-family home sales and condominiums sales, respectively, as property values for these product types are typically affected by different factors.

DATA

The analysis uses a dataset of all single-family home and condominium sales in Santa Clara and San Mateo Counties between January 2013 and August 2018. This dataset was purchased from the commercial vendor CoreLogic. The data include information on each transaction (e.g., sale date, sale price, seller and buyer names, etc.) and the characteristics of each property sold (e.g., size of living area, size of lot, number of bedrooms, etc.) that CoreLogic assembles from County Recorders' and Assessors' offices. ArcGIS was used to geocode the sales dataset and to join various other data sources to it, as explained later in this appendix.

The sales data were filtered using the following criteria, in order to eliminate missing and erroneous data and other outliers, and obtain a dataset appropriate for analysis.

- **Distance from Caltrain stations.** The network distance from each property to the nearest Caltrain station was calculated, as described in more detail in the following section. Properties located more than five miles from a Caltrain station were excluded from the analysis. This excluded properties in San Mateo County's coastal cities (Pacifica, Half Moon Bay, El Granada, Moss Beach, Montara, Loma Mar, Pescadero, and some parts of Daly City), in central San Mateo County (La Honda, Portola Valley, and parts of Woodside) and in southwestern Santa Clara County (Saratoga, Los Gatos, and unincorporated Santa Clara County).

- **Non-arms-length and distressed transactions.** Non-arms-length transactions and distressed sales (including foreclosure auctions, short sales, and REO liquidations) were identified using flags provided by CoreLogic and removed from the dataset.
- **Missing and incorrect data.** Transactions with no listed sale price or other important missing property attributes (e.g. year built, living area, or number of bedrooms) were excluded from the dataset. Properties that were not successfully geocoded or attributed a network distance were excluded, as were properties with other errors, such as a mismatch in the land use codes or in the recorded versus actual sale dates. Properties built before 1900 in the case of single-family homes, and before 1960 in the case of condominiums, were also excluded as the exploratory analysis indicated that such entries were often errors.
- **Extreme values.** Properties with extremely large or small values for sale price, sale price per square foot, living area, number of bedrooms, or lot size (for single-family homes only) were excluded from the analysis. These filters were applied in order to ensure that extremely large/luxury or small/low-quality properties would not unduly influence the model. The filters were chosen based on an analysis of each variable's distribution and the lowest and highest 0.1 to 1 percentiles. General market conditions in the South Bay from the last few years were also taken into consideration. A summary of the extreme value thresholds applied to the data is provided in Table 7-2.

The initial dataset included 160,500 non-null single-family and condominium sales. After applying the filters described above, the dataset was reduced to 93,770 sales, including 26,280 condominium sales and 67,736 single-family home sales. Note that this includes repeat sales of properties that sold multiple times between 2013 and 2018 (about 18 percent of single-family home sales and 17 percent of condominium sales were repeat sales).

Table 7-2. Property Characteristics Excluded from the Analysis

Variable	Single-family homes	Condominiums
Sale price	More than $10 million and less than $150,000	More than $2.25 million and less than $150,000
Sale price per square foot	More than $3,100 per square foot	More than $2,000 per square foot
Living area	More than 7,000 square feet and less than 500 square feet	2,500 square feet or more
Number of bedrooms	0 bedrooms and 7 bedrooms	5 bedrooms or more
Lot size	More than 87,000 square feet and less than 600 square feet	n/a

Source: Strategic Economics, 2019.

VARIABLES AND DESCRIPTIVE STATISTICS

Table 7-3 lists all the dependent and independent variables included in the analysis and their respective data sources. Table 7-4 summarizes the descriptive statistics for each variable (the mean value for continuous variables and the proportion of total sales for categorical variables). Figure 1-2 and Table 1-1 (Chapter 1) provides detailed information on the Caltrain station train frequency classification, and Table 7-5 provides a more detailed summary of sales by distance to nearest Caltrain.

In both the single-family home and the condominium models, the dependent variable is the sale price adjusted to 2018 dollars, using the Consumer Price Index for all Urban Consumers (CPI-U). The independent variables are summarized below and in Table 7-3:

- **Transportation accessibility variables.** The ArcGIS Network Analyst tool was used to calculate the network distance (i.e., the shortest route using the street network) between each property and the nearest Caltrain station.[17] This way, each property was assigned to one Caltrain station, and stations were classified into three levels of service based on train type and frequency[18] (see Figure 1-2 and Table 1-1 in Chapter 1). ArcGIS was used to calculate the network distance to the nearest freeway on-ramp, and to determine whether properties were located within a half-mile network service area around VTA light-rail stations and/or within a one mile network service area around BART stations. All else being equal, it is expected that properties with good access to key transportation infrastructure – Caltrain stations, freeway interchanges, BART stations, and VTA light-rail stations – will benefit from a value premium.
- **Property attribute variables.** The CoreLogic database provided information on property attributes, such as unit living area, number of bedrooms, year built, and lot size (for single-family homes). Properties were grouped into different categories based on year built to capture building quality and the architectural styles associated with different time periods.[19] For example, pre-World War II single-family homes in the Bay Area are often valued for their architectural features and high-quality building materials, and new, recently completed condominiums are often valued at a higher premium than older development projects.
- **Neighborhood demographic characteristics.** Data from the 2012-2016 U.S. Census American Community Survey (ACS) was used to obtain demographic information on the census tract in which each property is located. Variables include: median household income, percent of housing units occupied by homeowners, Hispanic/Latino residents as a percent of total population, and percent of residents above the poverty line.
- **Amenities and disamenties.** Data from the 2015 U.S. Census Longitudinal Employment Household Dynamics (LEHD) was used to calculate retail, arts, and entertainment employment density around each property; this is used as a proxy for access to local retail and entertainment amenities. Given the importance of the tech industry in the Bay Area economy, Strategic Economics also developed a gravity-based accessibility model to measure accessibility to tech jobs within a 10-mile radius, at the level of Traffic Analysis Zones (TAZs). All else being equal, it is expected that properties with good access to tech jobs and local retail would benefit from higher property values. Finally, ArcGIS was used to determine whether properties were located within a quarter-mile buffer from Caltrain tracks and freeway right-of-ways (Euclidian distance). Proximity to the train tracks or to the freeway could mean higher exposure to noise, vibration, or poor air quality, which could have a negative effect on sale price.
- **Other control variables.** Dummy variables were included in the analysis to control for the year each transaction occurred. A dummy variable controlling for high income cities is also included to control for the unique "premium" or cachet associated with certain cities in the South Bay.[20] The single-family home models also include elevation and location within a Priority Development Area (PDA)[21] as control variables. Elevation

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[17] Due to low or inexistent service levels, the following stations were excluded: Atherton, Stanford Stadium, College Park, and Broadway.

[18] Low frequency stations offer 1-2 trains per hour per direction (PHPD); medium frequency stations offer 3 trains PHPD; high frequency stations offer 4-5 trains PHPD.

[19] For single-family homes, the categories were: 1900-1945, 1946-1960, 1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2010, and 2010-2018. The categories were the same for condominiums, except that the oldest building category is 1960-1970.

[20] For single-family homes, cities in the "High income city" dummy variable are: Atherton, Cupertino, Emerald Lake Hills CPD, Hillsborough, Los Altos, Los Altos Hills, Palo Alto, and Woodside. For condominiums, cities in the "High income city" dummy variable are Cupertino, Foster City, Los Altos, Mountain View, Palo Alto, and San Carlos (top 80th percentile, or more than $127,000).

[21] As defined by MTC, Priority Development Areas are "areas within existing communities that local city or county governments have identified and approved for future growth. These areas typically are accessible by one or more transit services; and they are often located near established job centers, shopping districts and other services. Plan Bay Area projects that PDAs will accommodate over two-thirds of all housing and employment growth through the year 2040." (MTC, https://mtc.ca.gov/our-work/plans-projects/focused-growth-livable-communities/priority-development-areas)

controls for the fact that some homes may have a premium due to their views or location within more isolated, green neighborhoods in the hills. The PDA variable is an attempt to control for the effect of local reinvestment and redevelopment that may be occurring in PDAs.[22]

- **Interaction term.** It is possible to interact two independent variables to test their combined effect. In this analysis, the network distance to the nearest Caltrain station is interacted with the Caltrain station frequency type to assess whether being in proximity to a higher frequency station is associated with a higher property value premium than being in proximity to a lower frequency station. All else being equal, it is expected that homebuyers will place an increased value on proximity to a high frequency station (e.g., frequent Baby Bullet service), because more frequency means shorter wait times and shorter travel times.[23]

[22] Higgins and Kanaroglou (2016) discuss the need to control not only for transit, but also for associated land use planning efforts such as Transit-Oriented Development.

[23] Based on a literature review, very few studies have incorporated both station proximity and service level (or other accessibility measures) in their analyses. See Higgins, C, and Kanaroglou, P. (2016). Forty years of modelling rapid transit's land value uplift in North America: moving beyond the tip of the iceberg. Transport Reviews 36:5, 610-634, DOI: 10.1080/01441647.2016.1174748

Table 7-3. Variables Included in the Single-Family Home and Condominium Regression Models

Variable	Description and unit of measurement	Source	Single-family home models	Condominium models
Dependent Variable				
Total home sale price, log	Continuous variable, in 2018 dollars (log)	CoreLogic, 2018	X	X
Independent Variables				
Transportation Accessibility Variables				
Network distance to nearest Caltrain station	Continuous variable, in miles	ArcGIS Network Analyst, 2018	X	X
Station train frequency (High, medium, low)	Dummy variables based on train type and frequency (omitted dummy variable: low train frequency)	Caltrain, 2018	X	X
Within a half-mile of a VTA light-rail station	Dummy variable (0=no, 1=yes)	VTA, 2018	X	X
Within a mile of a BART station	Dummy variable (0=no, 1=yes)	BART, 2018	X	X
Network distance to nearest highway on-ramp, log	Continuous variable, in miles (log)	ArcGIS Network Analyst, 2018	X	X
Property Attribute Variables				
Living area, Log	Continuous variable, in square feet (log)	CoreLogic, 2018	X	X
Lot area, Log	Continuous variable, in square feet (log)	CoreLogic, 2018	X	
Number of bedrooms	Dummy variables (omitted dummy variable: 3-bedroom for single-family homes, and 2-bedrooms for condominiums)	CoreLogic, 2018	X	X
Year built	Dummy variables (omitted dummy variable: 1900-1945 for single-family homes; 1960-1970 for condominiums)	CoreLogic, 2018	X	X
Neighborhood Socio-Demographic Variables				
Census tract median household income, log	Continuous variable, in 2018 dollars (log)	ACS 2012-2016 estimates	X	X
Census tract percent Hispanic/Latino Population, log	Continuous variable, percentage (log)	ACS 2012-2016 estimates	X	X
Census tract percent owner-occupied, log	Continuous variable, percentage (log)	ACS 2012-2016 estimates	X	X
Census tract percent above poverty line, log	Continuous variable, percentage (log)	ACS 2012-2016 estimates	X	X

Table 7-3. Variables Included in the Single-Family Home and Condominium Regression Models

Variable	Description and unit of measurement	Source	Single-family home models	Condominium models
Amenity and Disamenity Variables				
Density of retail and entertainment amenities	Continuous variable, density of employment in Retail and Arts, Entertainment, and Recreation (NAICS codes 44-45 and 71) within a half-mile from the property sale location (log)	LEHD, 2015	X	X
Accessibility to tech jobs (gravity-based), log	Continuous variable, employment in Manufacturing and Information (NAICS codes 31-33 and 51) at the Traffic Analysis Zone (TAZ)-level, accessible within 10 miles from the property, weighted by network distance to all other TAZs (log)	LEHD, 2015 and ArcGIS Network Analyst, 2018	X	X
Within a quarter-mile from highway right-of-way	Dummy variable (0=no, 1=yes)	ArcGIS Network Analyst, 2018	X	X
Within a quarter-mile from Caltrain tracks right-of-way	Dummy variable (0=no, 1=yes)	ArcGIS Network Analyst, 2018	X	X
Other Control Variables				
Year sold	Dummy variables (omitted dummy variable: sold in 2013)	CoreLogic, 2018	X	X
High-income city	Dummy variable (0=no, 1=yes)	ACS 2012-2016 estimates	X	X
Priority Development Area (PDA)	Dummy variable (0=no, 1=yes) based on whether the property is located in a PDA	MTC, 2017	X	
Elevation, log	Continuous variable, in meters (log)	ArcGIS, 2018	X	
Interaction Term				
Interaction between network distance to the nearest Caltrain station and the station frequency category			X	X

Dummy variables are used in the case of binary or categorical variables. Coefficients for dummy variables in the regression models should be interpreted in relation to the omitted category.
Source: Strategic Economics, 2019.

Table 7-4. Descriptive Statistics

Variable	Single-family homes	Condominiums
Sample		
Sample Size	62,736	26,280
Dependent Variable		
Total sale price (mean, 2018 dollars)	$1,362,420	$731,849
Independent Variables		
Transportation Accessibility Variables		
Network distance to nearest Caltrain station (mean, miles)	2.42	2.31
Station train frequency category (percent)		
Low train frequency	44%	43%
Medium train frequency	28%	25%
High train frequency	27%	31%
Within a half-mile of a VTA light-rail station (percent)	2.0%	11.4%
Within a mile of a BART station (percent)	1.7%	1.4%
Network distance to nearest highway on-ramp (mean, miles)	0.41	0.28
Property Attribute Variables		
Living area (mean, square feet)	1,862	1,245
Lot area (mean, square feet)	7,918	n/a
Number of bedrooms (percent)		
Studio	n/a	0.3%
1-bedroom	0.4%	15%
2-bedroom	11%	52%
3-bedroom	47%	28%
4-bedroom	32%	5%
5-bedroom	8%	n/a
6-bedroom	1%	n/a
Year built		
1900-1945	14%	n/a
1946-1960	35%	n/a
1961-1970	16%	5%
1971-1980	12%	27%
1981-1990	5%	25%
1991-2000	6%	10%
2001-2009	5%	23%
2010-2018	6%	9%
Neighborhood socio-demographics		
Census tract median household income (mean, 2018 dollars)	$116,186	$98,830
Census tract percent Hispanic/Latino (mean, percent)	24.5%	24.8%

Table 7-4. Descriptive Statistics

Variable	Single-family homes	Condominiums
Census tract percent owner-occupied (mean, percent)	64.7%	49.7%
Census tract percent above poverty line (mean, percent)	93%	91%
Neighborhood amenities and disamenities		
Density of retail and entertainment amenities (mean, jobs)	517	1,010
Accessibility to tech jobs (gravity-based) (mean, jobs)	41,531	56,295
Within a quarter-mile from highway right-of-way (percent)	17%	27%
Within a quarter-mile from Caltrain track right-of-way (percent)	8%	18%
Other Control Variables		
Year sold		
Sold in 2013	18%	18%
Sold in 2014	17%	18%
Sold in 2015	18%	18%
Sold in 2016	17%	18%
Sold in 2017	18%	18%
Sold in 2018	12%	11%
High-income city (percent)	10%	8%
Priority Development Area (percent)	11%	n/a
Elevation (mean, meters)	50.6	n/a

Source: CoreLogic, 2018; Strategic Economics, 2019.

Table 7-5. Single-Family Home and Condominium Sales by Distance to Caltrain Station

	Single-family homes		Condominiums	
Network Distance to Nearest Caltrain Station	Number of Sales	Percent of All Sales	Number of Sales	Percent of All Sales
0 to 0.49 miles	1,018	2%	1,578	6%
0.5 to 0.99 miles	6,556	10%	3,380	13%
1 to 1.49 miles	9,017	14%	4,033	15%
1.5 to 1.99 miles	9,884	16%	3,348	13%
2 to 4.99 miles	36,261	58%	13,941	53%
Total	**62,736**	**100%**	**26,280**	**100%**
Average Distance (miles)	**2.4**		**2.3**	

Source: Strategic Economics, 2019.

REGRESSION METHODS (ORDINARY LEAST SQUARES VERSUS SPATIAL AUTOCORRELATION)

To be statistically valid, a regression model's data and results must conform to certain criteria. One key criterion is whether a model's residuals (the difference between actual and predicted values) are randomly distributed – which must also include a *spatially* random distribution of residuals. Spatially clustered residuals may indicate that the model is missing spatial variables (i.e., spatial fixed effects, such as elevation, neighborhood characteristics, etc.) and/or that spatial autocorrelation is present in the data. Spatial autocorrelation is defined as the "the phenomenon by which a value observed in one location depends on the values in neighboring locations."[24]

Researchers are increasingly recognizing that traditional hedonic price modelling has not adequately accounted for spatial autocorrelation issues.[25] Indeed, real estate data, such as sale prices, are often highly spatially autocorrelated given the "inherently locational and spatial nature of real estate."[26] It makes intuitive sense, for example, that home sales on the same block may affect each other in ways that cannot easily be controlled for by spatial fixed effects. And yet, hedonic price models have conventionally relied on the Ordinary Least Squares (OLS) regression model, which does not account for spatial autocorrelation. OLS models may therefore yield biased or inaccurate results.[27]

In recent years, various solutions have emerged. One common, best-practice approach is the use of a spatial autocorrelation model in place of OLS.[28] In line with this approach, Strategic Economics followed a methodology developed by Luc Anselin to determine the most appropriate spatial autocorrelation model for the Santa Clara/San Mateo residential sales dataset.[29] This involved the following steps:

- First, the standard OLS models were developed, using the variables described in Table 7-3;
- A Moran's I test was conducted on these OLS models' residuals. The Moran's I test confirmed the presence of spatial autocorrelation in the OLS models;
- A Lagrange Multiplier test was also conducted on the OLS models. This test indicated that, of the various spatial autocorrelation model options, a Spatial Error Model (SEM) was the most appropriate;[30]
- A spatial weights methodology, which is required for the SEM, was developed based on prior research examples. The spatial weighting method specified for the SEM consists of a 10-nearest neighbor approach. This means that the SEM model, when predicting a given sale price, takes into account the values of that transaction's 10 nearest neighbors, in addition to all the independent variables already specified in the model.

DETAILED REGRESSION RESULTS AND INTERPRETATION

In summary, the following eight regression models were developed. Table 7-6 and Table 7-7 provide detailed regression results for each model:

- Single-family home OLS and SEM models; no interaction term between network distance to the nearest Caltrain station and station frequency type (Models 1 and 2);
- Single-family home OLS and SEM models; with an interaction term between network distance to the nearest Caltrain station and station frequency type (Models 3 and 4);

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[24] Diao, Mi (2015). Selectivity, spatial autocorrelation and the valuation of transit accessibility. Urban Studies, Vol 52 (1) p. 159-177. https://doi.org/10.1177/0042098014523686

[25] For example, in a literature review of the last forty years of research on the property value impacts of transit, Higgins and Kanaroglou (2016) concluded that a majority of studies either did not incorporate spatial methods, or did so only by including spatial fixed effects.

[26] Wegmann, Jacob (2014). "We Just Built It:" Code Enforcement, Local Politics, and the Informal Housing Market in Southeast Los Angeles County. PhD dissertation for UC Berkeley, City and Regional Planning.

[27] Higgins, C, and Kanaroglou, P. (2016). Forty years of modelling rapid transit's land value uplift in North America: moving beyond the tip of the iceberg. Transport Reviews 36:5, 610-634, DOI: 10.1080/01441647.2016.1174748

[28] Developed by Anselin (2004, 2013), and used by Wegmann (2014). Other options include Geographically Weighted Regression (GWR).

[29] Anselin, Luc (2003). An Introduction to Spatial Regression Analysis in R. University of Illinois, Urbana-Champaign. http://labs.bio.unc.edu/buckley/documents/anselinintrospatregres.pdf

[30] Alternative spatial autocorrelation models include spatial lag models or a spatial Durbin models.

- Condominium OLS and SEM models; no interaction term between network distance to the nearest Caltrain station and station frequency type (Models 5 and 6);
- Condominium OLS and SEM models; with an interaction term between network distance to the nearest Caltrain and station frequency type (Models 7 and 8).

For the OLS models, the adjusted R-squared values range from 0.78 to 0.81, meaning that these models explain between 78 and 81 percent of the variation in sale price. The adjusted R-squared, however, is only one measure of a model's explanatory power. Because spatial autocorrelation was found in the OLS residuals, SEM models were also developed to test the validity of these results.

The SEM models provide a maximum log likelihood statistic instead of an R-squared value. A model's maximum log likelihood cannot be interpreted as an absolute measure of the model fit, but it can be used to compare models to each other: a higher log likelihood usually indicates a better model.

Overall, model coefficients are statistically significant at the 95 or 99 percent confidence level, and most coefficients are in the expected direction, with only a few exceptions or irregularities across the eight models.

In most cases, the shift from OLS to SEM does not lead to changes in the *direction* of key coefficients – only changes in the *magnitude* of specific coefficients, with coefficients usually smaller in the SEM model than the OLS model. This indicates that the OLS models are likely over-estimating the effect of certain variables, but that overall, both the OLS and SEM models tell a relatively consistent and valid story about the effect of proximity to Caltrain on property values.

The coefficients shown in Tables 7-6 and 7-7 can be interpreted in the following manner:

- **Non-log transformed variables.** The coefficient is interpreted as the percent change in sale price for a one-unit change in the independent variable, all other variables being held constant. For example, for condominiums in Model 6, every additional mile away from a Caltrain station is associated with a 3.5 percent decrease in sale price, all else being equal.
- **Log-transformed variables.** The coefficient is interpreted as a partial elasticity, or the percent change in sales price that results from a one percent increase in the given independent variable if all other factors are held constant. For example, for single-family homes in Model 2, a one percent increase in lot area is associated with a 13 percent increase in sale price, all else being equal.
- **Dummy variables.** The coefficients are interpreted as the percent difference in sale price associated with the given variable, compared to the relevant omitted variable. For example, for condominiums in Model 6, a property sold in 2018 is associated with a 49 percent increase in sale price compared to a property sold in 2013, all else being equal.
- **Interaction term.** Given that the interaction is between a continuous variable (distance to Caltrain) and a categorical variable (station type), the interaction term coefficients can be interpreted as the non-log transformed variable, described above. However, these interaction coefficients require an additional interpretation, as explained below using Model 8 as an example:
    - The coefficient shown for the network distance to Caltrain is the coefficient associated with the omitted dummy category, in this case, low frequency stations. In other words, every additional mile away *from a low frequency Caltrain station* is associated with a 2.4 percent decrease in sale price, all else being equal.
    - Every additional mile away from a *medium frequency Caltrain station* is associated with a 3.9 percent decrease in sale price (-0.024 + (-0.014)), all else being equal.
    - Every additional mile away from a *high frequency Caltrain station* is associated with a 5 percent decrease in sale price (-0.024 + (-0.025)), all else being equal.

Table 7-6. Single-Family Home Regression Models: Full Results

Variable	Single-family homes Model 1: Ordinary Least Square, No Interaction	Model 2: Spatial Error Model, No Interaction	Model 3: Ordinary Least Square, With Interaction	Model 4: Spatial Error Model, With Interaction
Overall Statistics				
Sample Size	62,736	62,736	62,736	62,736
Adjusted R^2	0.8042	n/a	0.8056	n/a
Maximum Log Likelihood	n/a	10,345.03	n/a	10,367.42
Independent Variables – Coefficients				
Intercept	4.45***	5.58***	4.63***	5.59***
Transportation Accessibility Variables				
Network distance to nearest Caltrain station (mi)	-0.052***	-0.054***	-0.035***	-0.038***
Station train frequency category (a)				
Medium frequency stations	0.093***	0.113***	0.163***	0.192***
High frequency stations	0.110***	0.126***	0.217***	0.191***
Within a half-mile of a VTA light-rail station	-0.085***	-0.033***	-0.089***	-0.035***
Within a mile of a BART station	0.053***	*0.016*	0.036***	*0.009*
Network distance to highway on-ramp, Log	-0.025***	0.024***	-0.027***	0.023***
Property Attribute Variables				
Living area square feet, Log	0.516***	0.378***	0.516***	0.378***
Lot area square feet, Log	0.131***	0.132***	0.133***	0.133***
Number of bedrooms (b)				
1-bedroom	*0.014*	-0.036***	*0.015*	-0.036***
2-bedroom	-0.007*	-0.018***	-0.008**	-0.019***
4-bedroom	-0.030***	-0.006***	-0.029***	-0.006***
5-bedroom	-0.048***	*-0.006*	-0.048***	-0.006*
6-bedroom	-0.036***	*-0.007*	-0.039***	*-0.008*
Year built (c)				
1946-1960	0.013***	0.006*	0.024***	0.008**
1961-1970	-0.021***	-0.014***	-0.010**	-0.012**
1971-1980	-0.074***	-0.022***	-0.067***	-0.021***
1981-1990	-0.057***	0.012*	-0.050***	0.012*
1991-2000	0.014***	0.085***	0.019***	0.086***
2001-2009	0.032***	0.136***	0.039***	0.137***
2010-2018	0.027***	0.031***	0.034***	0.032***
Neighborhood socio-demographics				
Census tract median household income, Log	0.277***	0.254***	0.262***	0.250***
Census tract percent Hispanic/Latino, Log	-0.203***	-0.191***	-0.205***	-0.191***
Census tract percent owner-occupied, Log	-0.139***	-0.137***	-0.135***	-0.136***

Table 7-6. Single-Family Home Regression Models: Full Results

	Single-family homes			
Variable	**Model 1: Ordinary Least Square, No Interaction**	**Model 2: Spatial Error Model, No Interaction**	**Model 3: Ordinary Least Square, With Interaction**	**Model 4: Spatial Error Model, With Interaction**
Census tract percent above poverty line, Log	0.424***	0.438***	0.410***	0.435***
Neighborhood amenities and disamenities				
Within quarter-mile from highway right-of-way	-0.032***	-0.013**	-0.028***	-0.013**
Within quarter-mile from Caltrain right-of-way	-0.019***	-0.019**	-0.019***	-0.019***
Density of retail/entertainment amenities, Log	0.007***	0.003*	0.006***	0.003*
Accessibility to tech jobs, Log	0.045***	0.044***	0.044***	0.044***
Other Control Variables				
High-income city	0.261***	0.256***	0.273***	0.259***
Priority Development Area	-0.014***	*-0.010*	-0.012***	-0.011*
Elevation	-0.032***	-0.028***	-0.032***	-0.027***
Year sold (d)				
Sold in 2014	0.099***	0.104***	0.099***	0.104***
Sold in 2015	0.225***	0.234***	0.226***	0.234***
Sold in 2016	0.280***	0.288***	0.280***	0.288***
Sold in 2017	0.362***	0.372***	0.362***	0.372***
Sold in 2018	0.483***	0.492***	0.483***	0.492***
Interaction Term				
Network distance to nearest Caltrain station x Medium frequency stations	n/a	n/a	-0.028***	-0.032***
Network distance to nearest Caltrain station x High frequency stations	n/a	n/a	-0.045***	-0.027***

***Significant at a 99 percent confidence level (p-value is less than 0.01)
**Significant at a 95 percent confidence level (p-value is between 0.01 and 0.05)
*Significant at a 90 percent confidence level (p-value is between 0.05 and 0.1)
Coefficients that are italicized are not statistically significant (p-value is greater than 0.1)
(a) Compared to Low train frequency stations
(b) Compared to 3-bedrooms properties.
(c) Compared to properties built between 1900 and 1945.
(d) Compared to properties sold in 2013.
Source: Strategic Economics, 2019.

Table 7-7. Condominium Regression Models: Full Results

Variable	Condominiums			
	Model 5: Ordinary Least Square, No Interaction	Model 6: Spatial Error Model, No Interaction	Model 7: Ordinary Least Square, With Interaction	Model 8: Spatial Error Model, With Interaction
Overall Statistics				
Sample Size	26,280	26,280	26,280	26,280
Adjusted R^2	0.7805	n/a	0.7834	n/a
Maximum Log Likelihood	n/a	14,118	n/a	14,133
Independent Variables – Coefficients				
Intercept	6.14***	7.13***	6.08***	7.14***
Transportation Accessibility Variables				
Network distance to nearest Caltrain station (mi)	-0.046***	-0.035***	-0.025***	-0.024***
Station train frequency category (a)				
Medium train frequency	0.060***	0.036***	0.136***	0.072***
High train frequency	0.100***	0.066***	0.195***	0.121***
Within a half-mile of a VTA light-rail station	-0.062***	-0.043***	-0.074***	-0.047***
Within a mile of a BART station	0.087***	0.048*	0.066***	*0.038*
Network distance to highway on-ramp, Log	-0.010***	*0.008*	-0.012***	*0.008*
Property Attribute Variables				
Living area square feet, Log	0.701***	0.567***	0.699***	0.567***
Number of bedrooms (b)				
Studio	-0.091***	-0.181***	-0.078***	-0.180***
1-bedroom	-0.067***	-0.104***	-0.066***	-0.104***
3-bedroom	0.009**	0.038***	0.012***	0.038***
4-bedroom	-0.055***	0.031***	-0.053***	0.031***
Year built (c)				
1971-1980	0.037***	0.067***	0.039***	0.067***
1981-1990	0.036***	0.080***	0.036***	0.079***
1991-2000	0.098***	0.137***	0.096***	0.137***
2001-2009	0.081***	0.169***	0.078***	0.168***
2010-2018	0.140***	0.196***	0.139***	0.195***
Neighborhood demographics				
Census tract median household income, Log	0.172***	0.175***	0.173***	0.172***
Census tract percent Hispanic/Latino, Log	-0.113***	-0.105***	-0.108***	-0.104***
Census tract percent owner-occupied, Log	-0.075***	-0.107***	-0.078***	-0.108***
Census tract percent under poverty line, Log	-0.040***	-0.054***	-0.041***	-0.055***
Neighborhood amenities and disamenities				
Within quarter-mile from highway right-of-way	0.010***	*-0.004*	0.007**	*-0.005*
Within quarter-mile from Caltrain right-of-way	*0.006*	0.025***	*0.004*	0.024***

Table 7-7. Condominium Regression Models: Full Results

	Condominiums			
Variable	**Model 5: Ordinary Least Square, No Interaction**	**Model 6: Spatial Error Model, No Interaction**	**Model 7: Ordinary Least Square, With Interaction**	**Model 8: Spatial Error Model, With Interaction**
Density of retail/entertainment amenities, Log	0.022***	0.007**	0.021***	0.006**
Accessibility to tech jobs, Log	0.064***	0.068***	0.065***	0.068***
Other Control Variables				
High-income city	0.196***	0.190***	0.211***	0.199***
Year sold (d)				
Sold in 2014	0.084***	0.096***	0.085***	0.096***
Sold in 2015	0.231***	0.241***	0.231***	0.242***
Sold in 2016	0.292***	0.305***	0.293***	0.305***
Sold in 2017	0.362***	0.376***	0.363***	0.376***
Sold in 2018	0.524***	0.534***	0.524***	0.534***
Interaction Term				
Network distance to nearest Caltrain station x Medium frequency stations	n/a	n/a	-0.031***	-0.014**
Network distance to nearest Caltrain station x High frequency stations	n/a	n/a	-0.043***	-0.025***

***Significant at a 99 percent confidence level (p-value is less than 0.01)
**Significant at a 95 percent confidence level (p-value is between 0.01 and 0.05)
*Significant at a 90 percent confidence level (p-value is between 0.05 and 0.1)
Coefficients that are italicized are not statistically significant (p-value is greater than 0.1)
(a) Compared to Low train frequency stations
(b) Compared to 2-bedrooms properties.
(c) Compared to properties built between 1960 and 1970.
(d) Compared to properties sold in 2013.
Source: Strategic Economics, 2019.

Future Property Value Benefits of the Caltrain Business Plan Growth Scenarios Memo

Prepared for:

Caltrain

October 2019

OK18-0254.00

Prepared by:

STRATEGIC ECONOMICS

FEHR PEERS

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1. INTRODUCTION

This report, which was prepared for the Caltrain Business Plan, estimates the future property value impacts of the proposed Caltrain Business Plan Growth Scenarios.

1.1 OVERVIEW OF THE CALTRAIN BUSINESS PLAN

Caltrain is currently engaged in the Caltrain Business Plan, an in-depth technical and policy process that will set the vision for how Caltrain service, and the Caltrain corridor as a whole, should grow to meet current and future ridership demand over the next 20 to 30 years. This study is a joint effort between agency partners and communities along the corridor. One of the main goals of the Caltrain Business Plan is to evaluate the various benefits, costs, and impacts of three different rail service growth scenarios for 2040: a Baseline Growth Scenario, a Moderate Growth Scenario, and a High Growth Scenario. Based on this evaluation, the Caltrain Business Plan builds the case for investing in and implementing an agreed upon 2040 Long Range Service Vision for the Caltrain corridor, which includes proposed service improvements, infrastructure needs, and associated costs and benefits.

Strategic Economics was retained as part of the consultant team developing the Caltrain Business Plan, led by Fehr & Peers, to prepare the following tasks:

1. **An analysis of the current fiscal and property value benefits of existing Caltrain service,** including an examination of whether benefits vary by station service levels. The methods and findings of this analysis are summarized in a separate deliverable.
2. **An estimation of the potential future property value impacts of the Caltrain Business Plan Growth Scenarios,** based on the results of the task above and an extensive literature review. The methods and findings for this second task are summarized in this report.

1.2 OVERVIEW OF PURPOSE AND APPROACH

The purpose of this report is to estimate and compare the potential future increase in property values in 2040 likely to result from the Caltrain Business Plan Baseline and High Growth Scenario service improvements.

Assumptions for this analysis were developed based on findings from a literature review and a related study conducted by Strategic Economics for Caltrain (task 1, above), which estimated the existing property value impacts of Caltrain for residential and office properties located within five miles of Caltrain stations. This analysis found that properties located in proximity to Caltrain stations generally benefit from a transit value premium, and that this premium is higher for properties located near stations that offer a higher frequency of service.

Therefore, to estimate future increases in property values resulting from the Caltrain Business Plan service improvements, the following assumptions were used: (1) residential and office properties located within a half-mile and/or one mile of Caltrain stations will continue to benefit from existing property value premiums, and (2) residential and office properties located within a half-mile and/or one mile of Caltrain stations *planned for service improvements* will benefit from an *increased property value premium above and beyond existing premiums,* resulting from improved Caltrain service. Residential and office value premiums were estimated based on the literature and Strategic Economics' related study. The analysis relies on land use projections for 2040 obtained from ABAG/MTC, as well as residential and office market data by station area.

1.3 REPORT ORGANIZATION

Following this introduction, the report is organized by the following chapters:

- Summary of findings (Chapter 2);
- Literature review (Chapter 3);
- Approach and methodology (Chapter 4);
- Appendices, including a bibliography (Appendix A) and additional methodology (Appendix B).

2. SUMMARY OF FINDINGS

Key findings from the analysis of the potential future benefits of the Caltrain Business Plan 2040 Growth Scenarios are summarized below and in Figures 2-1 and 2-2.

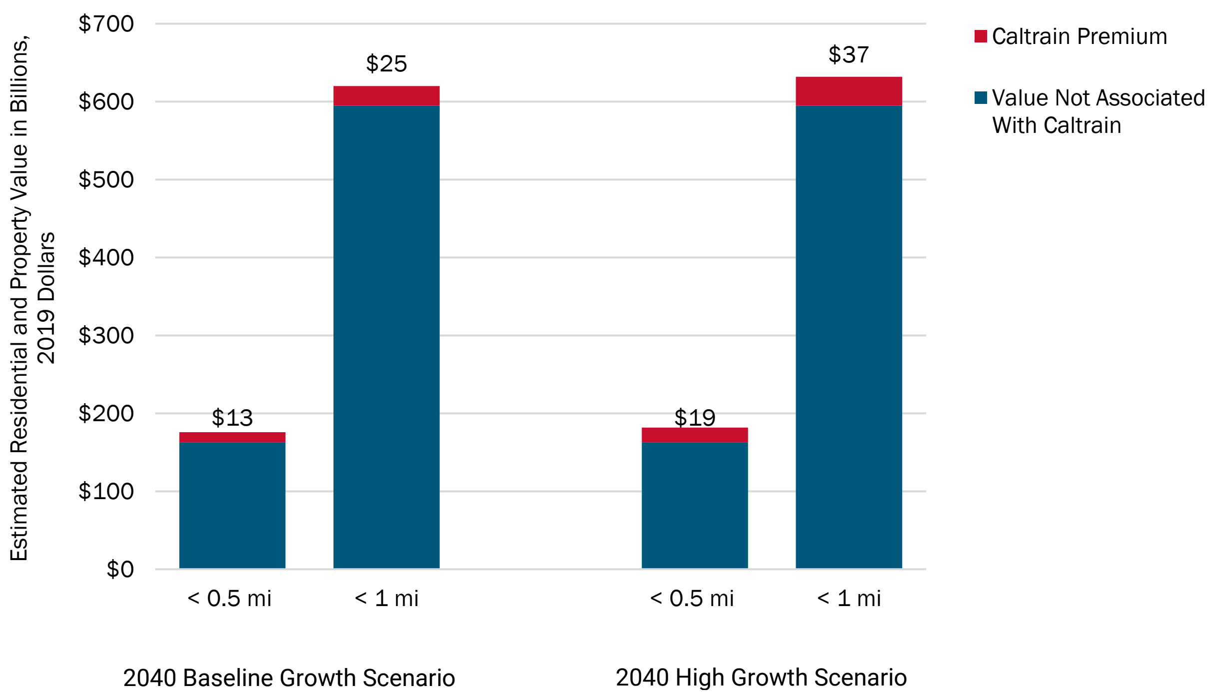
Under both the Baseline and High Growth Scenarios, Caltrain is expected to generate significant property value benefits for nearby residential and office properties, as illustrated in Figure 2-1**:**

- In the 2040 Baseline Growth Scenario, Caltrain will generate an estimated total of $13 billion in property value premium within a half-mile of stations, and $25 billion within one mile of stations.
- In the 2040 High Growth Scenario, Caltrain will generate an estimated total of $19 billion in property value premium within a half-mile of stations, and $37 billion within one mile of stations.

The Caltrain Business Plan Growth Scenarios are expected to generate significant net new value above and beyond what would be achieved with current service levels, as illustrated in Figure 2-2:

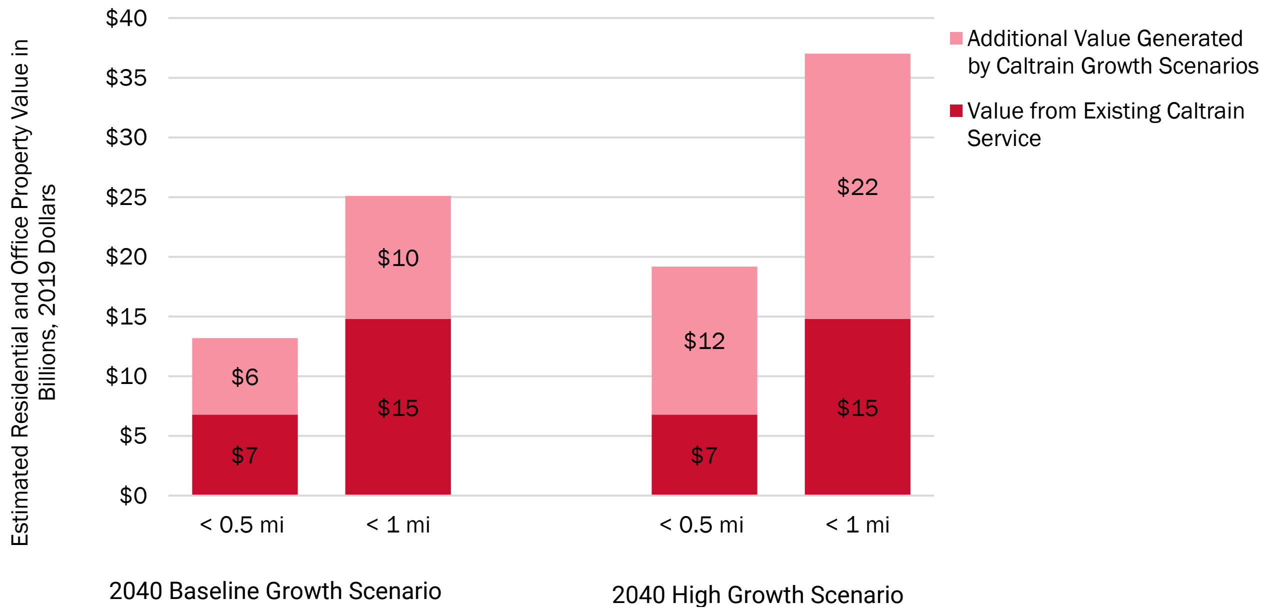
- Compared to what would occur under existing service levels, the 2040 Baseline Growth Scenario could generate up to $6 billion in additional property value within a half-mile of stations, and $10 billion within one mile of stations.
- The 2040 High Growth Scenario could generate up to $12 billion in additional property value within a half-mile of Caltrain stations, and $22 billion within one mile of stations.

FIGURE 2-1. CALTRAIN BUSINESS PLAN GROWTH SCENARIOS: ESTIMATED PROPERTY VALUE NEAR STATIONS



Source: Strategic Economics, 2019.

FIGURE 2-2. CALTRAIN BUSINESS PLAN GROWTH SCENARIOS: ESTIMATED PROPERTY VALUE GENERATED BY CALTRAIN



Source: Strategic Economics, 2019.

3. LITERATURE REVIEW

Strategic Economics conducted a review of the literature on the relationship between property values and access to transit to inform the approach and methodology for this analysis. Many studies have explored the influence of transit investments on property values or rents, with the vast majority of studies finding a positive relationship. Given the breadth of research on this topic, Strategic Economics focused the literature review in three areas:

- Previous studies of Caltrain and other Bay Area transit systems (see Table 3-1);
- Studies that analyzed changes in property value associated with improvements to existing service, different transit technologies, and/or different service frequencies;
- Studies that provided insights on new or innovative methods to model the relationship between transit investments and property values.

A complete bibliography is included in Appendix A, and relevant findings are described below:

Previous research on property value increases associated with improvements to existing transit service is limited. The vast majority of literature focuses on evaluating the influence of transit investments on property values. Only a few studies have examined the property value impacts of improvements to existing systems. The most relevant study evaluated the introduction of Caltrain's Baby Bullet service in 2004, and found that for every one-minute reduction in expected travel time, residential assessed property values within 0.25 miles of a Caltrain station were expected to increase by 1.5 to 2.4 percent. A few other studies have analyzed the impacts of expanding existing transit systems, such as the addition of a second bus rapid transit (BRT) corridor in Eugene, Oregon, or the announcement of a new rail line (Crossrail) in a neighborhood in London (Ealing) that is already served by existing passenger rail; however the results of these studies are not directly applicable to Caltrain.

Studies comparing the effects of different transit technologies (commuter rail, heavy rail, light rail, BRT) have had mixed results. Researchers have hypothesized that higher frequency service has a greater impact on property values. This hypothesis has been tested using comparisons of different transit technologies. However, studies comparing different transit technologies have had varying results. For example, one recent meta-analysis of previous U.S. studies found that both commuter rail and heavy rail had greater positive impacts on property values than light rail, while BRT had a smaller impact. In contrast, a different meta-analysis that included European, Asian, and North American studies found that heavy rail had a substantially lower impact on property values compared to light rail. These conflicting results suggest that transit technology may not be a consistent proxy for service quality, and/or that the effects of different transit technology may vary depending on the local and national context (i.e., Europe versus Asia versus North America).

Very few studies have directly analyzed the relationship between property values and different service frequencies or ridership. Based on Strategic Economics' research, only one study included any direct measure of service frequency or ridership. This study of a regional commuter train system in southern Sweden found that service frequency (number of departures at the nearest station) had a positive impact on residential property values, after controlling for other factors.

The impacts of transit investments on property values are highly dependent on the local context. For example, Strategic Economics has previously found that proximity to BART is associated with a significant property value premium for single-family residential, office, and apartment properties in the East Bay (Alameda and Contra Costa Counties); however, in San Mateo County, there was no significant premium associated with proximity to BART stations. This difference may reflect the fact that most East Bay stations opened 40 years ago. Over the ensuing decades, connectivity improvements, supportive land use and zoning policies, and transit-oriented development have all contributed to making the station areas more attractive and valuable locations. In contrast, the San Mateo County stations are relatively new and the station areas are still more auto-oriented. Additionally, a portion of the BART line in San Mateo County is paralleled by Caltrain, which may mitigate the property value impacts of BART in this area.

TABLE 3-1. LITERATURE ON THE IMPACT OF TRANSIT ON PROPERTY VALUES IN THE SAN FRANCISCO BAY AREA

Study	System/Geography	Property Type	Key Findings
Strategic Economics, 2015	BART Alameda, Contra Costa, San Mateo Counties	Residential (SFR, Condo, Apartment) and Office	East Bay: • + 11-18% premium for single-family residential within a half mile of stations • + 15% premium for condos located within a half mile of stations • + 18% premium for office properties located within a quarter mile of stations • + 20% premium for apartments located within a half mile of stations* San Mateo County: • No significant effects; authors hypothesized that the relatively recent introduction of BART service and auto-oriented character of many of the station areas may be limiting the potential premium associated with transit proximity.
Bay Area Economic Institute, 2012	Caltrain San Francisco, San Mateo, Santa Clara Counties	Residential	• A one-minute reduction in expected travel time resulting from the introduction of Baby Bullet service caused residential assessed property values within 0.25 miles of a Caltrain station to increase by 1.5% to 2.4%
Cervero and Duncan, 2002	Caltrain and VTA Santa Clara County	Commercial	• + 120% premium for properties within a quarter mile of Caltrain stations • + 23% premium for properties within a quarter mile of VTA light rail stations
Landis et al., 1995; Cervero and Landis, 1995	BART, Caltrain, VTA Alameda, Contra Costa, San Mateo, Santa Clara County	Single-Family Residential	• + $2.00 increased sales value per meter closer to BART stations • No effect for properties near Caltrain stations • No consistent effect for properties near VTA light rail stations

4. APPROACH AND METHODOLOGY

This chapter describes the approach and methodology used to model the future property value impacts of Caltrain's proposed growth scenarios.

4.1 APPROACH

The analysis presented in this report projects the future property value increases likely to result from the Caltrain Business Plan Baseline and High Growth Scenarios. The analysis includes residential and office properties near Caltrain stations.

The analysis was developed based on findings from the literature, as described in the previous chapter, and also builds directly on a related study conducted by Strategic Economics for Caltrain. This work estimated the *existing* property value impacts of Caltrain for residential and office properties located within five miles of Caltrain stations. This analysis found that: [1]

- Properties located in proximity to Caltrain stations benefit from a property value premium, and that benefits are generally concentrated within a half-mile or one mile from stations;
- Properties located near stations that offer a higher service level (measured as the typical number of trains per hour) benefit from a higher property value premium.

In light of these results, two key assumptions guide the analysis of the future property value impacts of Caltrain service improvements:

- Properties located within a half-mile and/or one mile of Caltrain stations will continue to benefit from property value premiums; and
- Properties located near stations planned for service improvements will experience increased property value premiums.

4.2 OVERVIEW OF METHODOLOGY

To measure the net increase in property values resulting from the Caltrain Growth Scenarios, this analysis estimates current and future residential and office property values within a half-mile and one mile of Caltrain stations under the 2040 Baseline and High Growth Scenarios. The methodology is summarized in the steps below, and described in greater detail in the following subsections in this chapter.

1. Define the half-mile and half-mile to one-mile network service areas from Caltrain stations.
2. Classify Caltrain stations according to their service level (measured as the typical number of trains per hour per direction) given current conditions and under the Caltrain Business Plan Baseline and High Growth Scenarios.
3. Estimate residential units and office square feet within each station's half-mile and half-mile to one-mile service area, under current conditions and in 2040, based on land use projections provided by ABAG/MTC and adjusted by Fehr & Peers.
4. Estimate the total value of residential and office properties within each station's half-mile and half-mile to one-mile service area, under current conditions and in 2040 *assuming no changes to Caltrain service*, based on average property value estimates and appreciation rates.

[1] Detailed results are available in this report: Strategic Economics, 2019, "Caltrain Business Plan: Property Value and Fiscal Benefits of Caltrain."

5. Develop residential and office property value premiums for different Caltrain station service levels and distances to Caltrain, based on the literature and findings from Strategic Economics' previous analysis of the existing property value benefits of Caltrain.
6. For each station, calculate the difference between the existing premiums and the premiums under the Caltrain Business Plan Baseline and High Growth Scenarios; apply this difference as a percentage increase to the projected value of residential and office properties in 2040 to estimate the net property value increase resulting from Caltrain service improvements.
7. Sum the total residential and office property value increases across all stations to compare the corridor-wide property value benefits of the different Caltrain Business Plan Growth Scenarios.

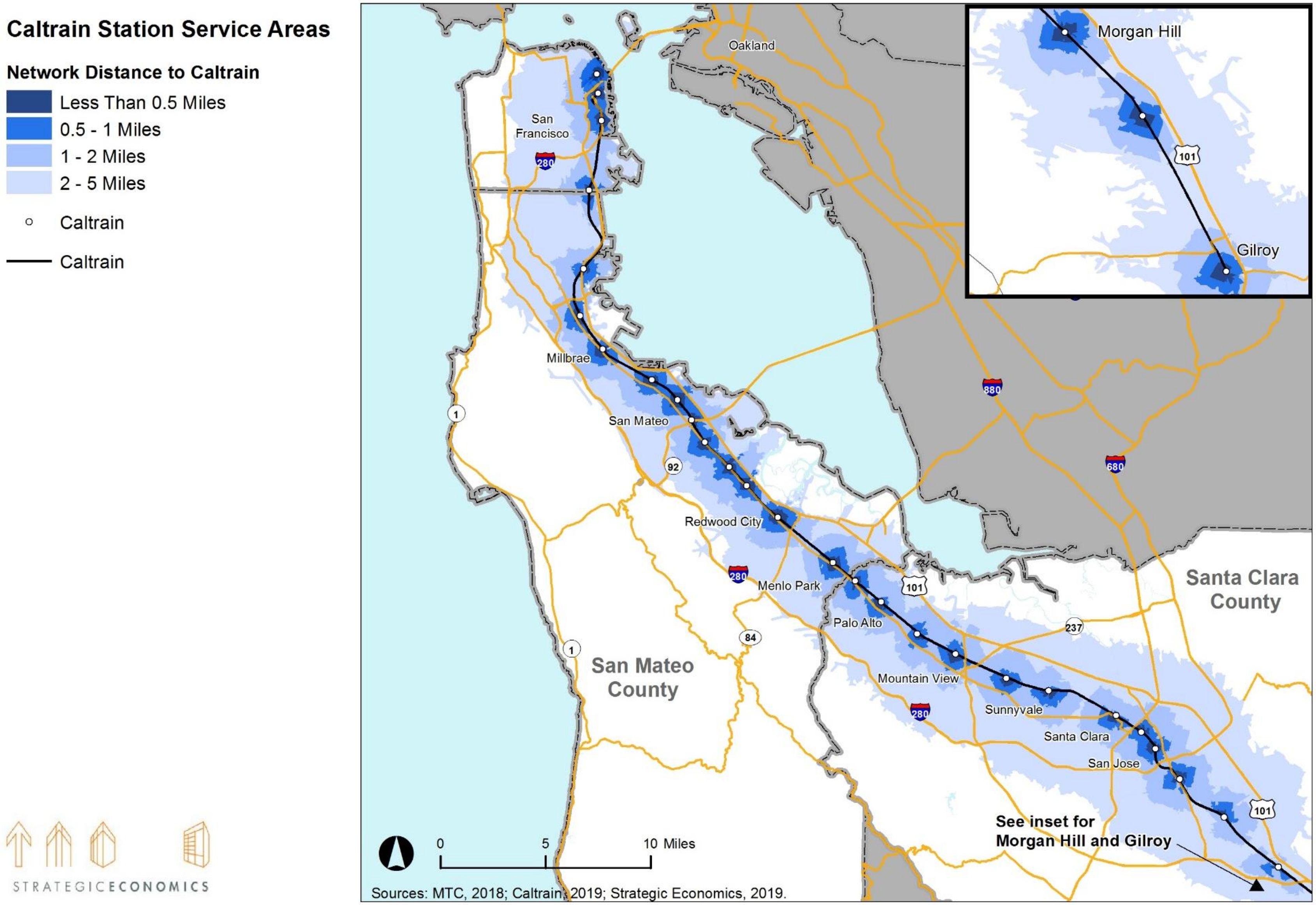
4.3 CALTRAIN STATIONS NETWORK SERVICE AREAS

This analysis models the change in property values within a half-mile and one mile of Caltrain stations. Findings from the literature, and from Strategic Economics' analysis of the existing property value impacts of Caltrain, suggest that the property value premium of transit is highest in close proximity to stations. This is especially the case for office development, as most studies have found a premium within a quarter- or half-mile from stations, with a sharp decrease outside the half-mile area. For residential uses, the premium tends to extend further, in some cases out to five miles, but the premium remains highest closer to the station, usually within a half- or one-mile.[2]

This analysis relies on network distances calculated based on the street network (in contrast to Euclidian distances, also known as straight line or "as the crow flies" distances). The resulting half-mile and one-mile areas, referenced as "network service areas" throughout this report, are illustrated in Figure 4-1.

[2] Significant research has been conducted on this topic. A selection of articles is included here: Debrezion, Pels, and Rietveld, 2017, "The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-Analysis", available at: https://econpapers.repec.org/article/kapjrefec/v_3a35_3ay_3a2007_3ai_3a2_3ap_3a161-180.htm; Ko and Cao, 2013, "Impacts of the Hiawatha Light Rail Line on Commercial and Industrial Property Values in Minneapolis", available at: https://www.nctr.usf.edu/wp-content/uploads/2013/03/16.1_cao_ko.pdf; Nelson et al., 2015, "Office Rent Premiums with Respect to Light Rail Transit Stations in Dallas and Denver", available at: https://pdxscholar.library.pdx.edu/usp_fac/128/; Strategic Economics, prepared for Bay Area Rapid Transit (BART), 2014, "Property Value and Fiscal Benefits of BART", available at: https://www.bart.gov/sites/default/files/docs/2014-08%20BARTPropValues_Final_0.pdf; Strategic Economics, prepared for Bay Area Rapid Transit (BART), 2015, "Benefits of BART to Single-Family and Condominium Property Values by County (Revised)", available at: https://www.bart.gov/sites/default/files/docs/1%20-%20BART%20Single%20Family%20and%20Condo%20Analysis_0.pdf; Cervero and Duncan, 2002, "Transit's Value-Added Effects: Light and Commuter Rail Services and Commercial Land Values", available at: https://journals.sagepub.com/doi/10.3141/1805-02.

FIGURE 4-1. NETWORK DISTANCES TO CALTRAIN STATIONS



STRATEGICECONOMICS

4.4 CALTRAIN STATION SERVICE LEVEL CLASSIFICATION

To compare proposed changes in Caltrain service, stations are classified into five service level categories, based on the typical number of trains per direction per hour at peak periods. Stations are classified based on their current service level, and the same classification is used to classify stations in the 2040 Baseline Growth and High Growth Scenarios, as shown in Table 4-1.

Under current conditions, all Caltrain stations have Low (1-2 trains per hour per direction at peak period), Medium (3 trains), or High (4-5 trains) service levels. In the 2040 Growth Scenarios, several stations see service improvements up to the "Very High" (6-8 trains) or "Highest" (12 trains) levels. Note that the Salesforce Transit Center station is assumed to be operational before 2040.

Note that this classification system is a highly simplified summary of the proposed Caltrain Business Plan service improvements. In reality, service varies by train type (local, express, High Speed Rail), time of day, and day of the week. A more detailed description of the service improvements included in the growth scenarios is available in the Caltrain Business Plan.

TABLE 4-1. CALTRAIN STATION SERVICE LEVEL CLASSIFICATION

Station ID	Station Name	Existing Caltrain Service Level	2040 Caltrain Baseline Scenario Service Level	2040 Caltrain High Growth Scenario Service Level
1	Salesforce Transit Center	n/a	Very High	Highest
2	4th and King	High	Very High	Highest
4	22nd St	Medium	High	Highest
7	Bayshore	Low	Low	High
8	South San Francisco	Low	Low	Very High
9	San Bruno	Low	Low	High
10	Millbrae	High	Very High	Very High
12	Burlingame	Medium	Medium	Medium
13	San Mateo	Medium	Medium	Very High
14	Hayward Park	Low	Low	Very High
15	Hillsdale	High	Very High	Highest
16	Belmont	Low	Low	High
17	San Carlos	Medium	Medium	Very High
18	Redwood City	High	High	Highest
21	Menlo Park	Medium	Medium	Medium
22	Palo Alto	High	Very High	Highest
24	California Ave	Medium	Medium	High
25	San Antonio	Low	Low	High
26	Mountain View	High	Very High	Highest
27	Sunnyvale	High	High	Highest
28	Lawrence	Low	High	Very High
30	Santa Clara	Medium	Medium	High
32	Diridon	High	Very High	Highest

TABLE 4-1. CALTRAIN STATION SERVICE LEVEL CLASSIFICATION

Station ID	Station Name	Existing Caltrain Service Level	2040 Caltrain Baseline Scenario Service Level	2040 Caltrain High Growth Scenario Service Level
33	Tamien	Medium	Very High	Highest
34	Capitol	Low	Low	High
35	Blossom Hill	Low	Low	High
36	Morgan Hill	Low	Low	Low
38	Gilroy	Low	Low	Low

Stations excluded from the analysis due to infrequent or inexistent service: Broadway, Atherton, Stanford Stadium, College Park, and San Martin. This is a simplified classification system, as Caltrain's service quality depends on a variety of factors and varies significantly based on time of day, day of the week, and train type. Service levels are defined as the typical number of trains per hour per direction during peak periods as follows: Low: 1-2 trains; Medium: 3 trains; High: 4-5 trains; Very High: 6-8 trains; Highest: 12 trains.
Source: Fehr & Peers, 2019; Strategic Economics, 2019.

4.5 LAND USE PROJECTIONS

Household and employment growth projections for 2015 and 2040 at the Traffic Analysis Zone (TAZ) level were used to estimate future land use in the station areas. This data was provided by ABAG/MTC and adjusted by Fehr & Peers. Estimates for 2015 are used to approximate current (2019) conditions.

To derive projections for the half-mile and one-mile Caltrain network service areas, the original household and employment values for each TAZ were multiplied by the proportion of that TAZ's area located within the network service areas, using ArcGIS software. These values were then summed for each station's half-mile and one-mile service area.

Because the original dataset only provided household and employment projections, a series of assumptions were developed to derive residential units and office square feet projections (see Table 4-2). To calculate the number of residential units, a 5 percent vacancy rate was applied to the household projections. To calculate office square feet based on total employment, an average employment density and a corridor-wide estimate of the share of office-based jobs were applied, based on typical regional patterns for San Francisco, San Mateo, and Santa Clara counties. A 5 percent office vacancy rate was also applied. Detailed station-level projection results are available in Appendix B.

TABLE 4-2. LAND USE PROJECTIONS: KEY ASSUMPTIONS

Residential Assumptions	
Residential vacancy rate	5%
Office Assumptions	
Percent office-based jobs	75%
Average employment density (net sq. ft. per employee)	275
Office vacancy rate	5%

Source: Strategic Economics, 2019.

4.6 PROPERTY VALUE ASSUMPTIONS

Average residential values within the half-mile Caltrain service areas are summarized in Figure 4-2. Values were estimated using a point-level dataset of all condominium sales in Santa Clara and San Mateo counties between 2013 and 2018, adjusted to 2018 dollars. This data was purchased from the commercial vendor CoreLogic. Condominium market reports, published by a real estate marketing company called Polaris Pacific, provided average sale prices for San Francisco, and also helped confirm more recent sale prices for Santa Clara and San Mateo counties.[3]

Average residential values within the half-mile to one-mile service area of each given station are assumed to be 2 percent lower than values in the half-mile service area of that same station, based on an empirical analysis of the sales price data obtained from CoreLogic.

Average office rents within a half-mile of Caltrain stations are summarized in Figure 4-2. Rents were estimated based on office market reports from Cushman and Wakefield, a commercial real estate brokerage firm which tracks office rents by submarket, including smaller downtown and transit-oriented submarkets.[4] In addition, a point-level dataset of office rents in San Francisco, San Mateo, and Santa Clara counties obtained from the CoStar Group, a real estate information company, provided supplementary rent data. Based on the rents shown in Figure 4-2, average office capitalized values for each station were calculated using the assumptions shown in Table 4-3.

To calculate property values in 2040, values were inflated using the residential and office average annual appreciation rates included in Table 4-3 (developed based on regional longitudinal market data).[5] These estimates were then adjusted to 2019 dollars using an average annual inflation rate of 2.5 percent.[6]

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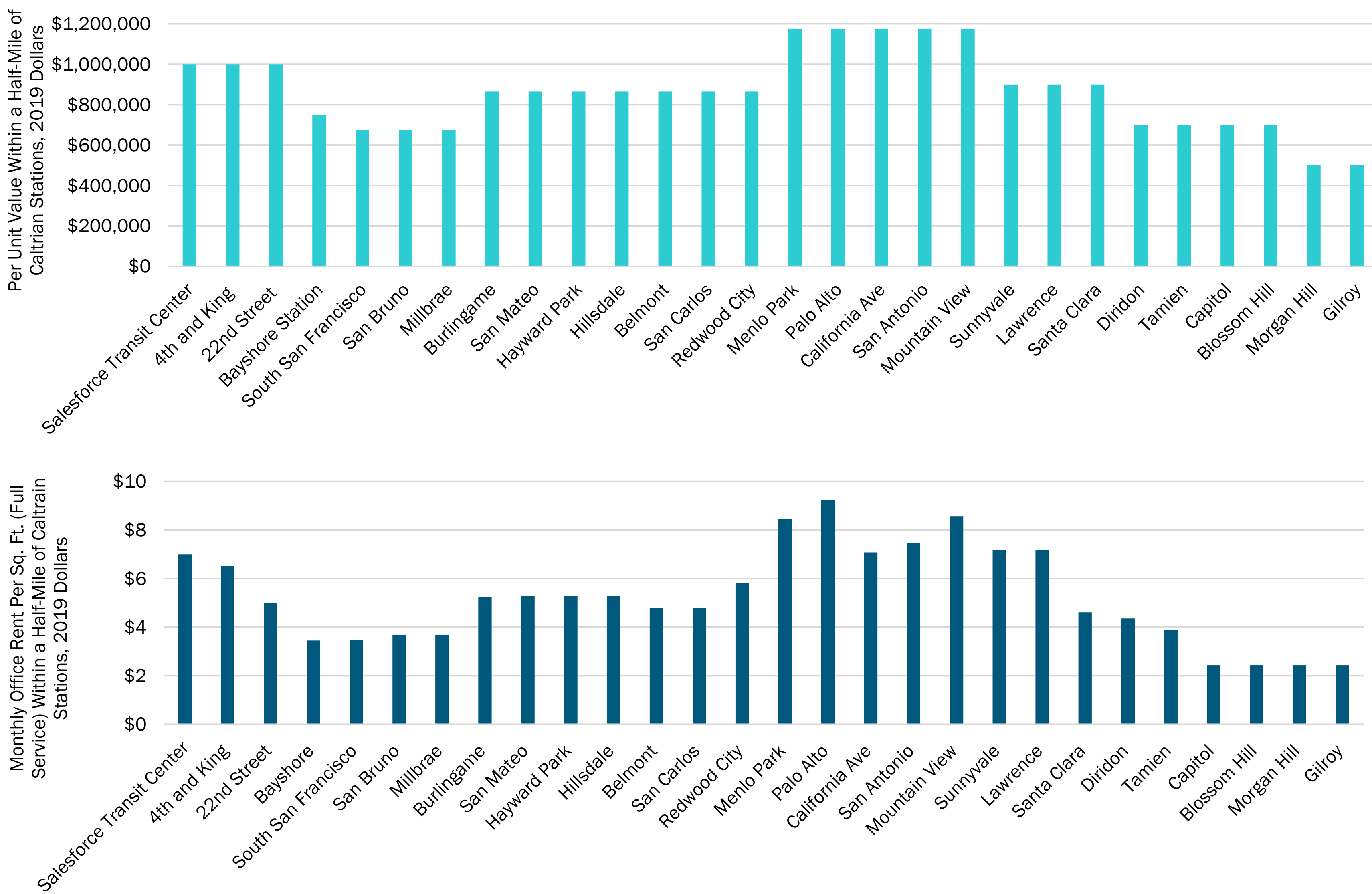
[3] Polaris Pacific, April 2019, "The Polaris Pacific Report: Silicon Valley", and "The Polaris Pacific Report: San Francisco", available at: http://marketing.polarispacific.com/acton/attachment/36076/f-51ea54d3-5c43-41e5-b488-32e7e2cd2b64/1/-/-/-/-/SF%20March%202019.pdf?sid=TV2:isGhwSuMJ and http://marketing.polarispacific.com/acton/attachment/36076/f-a5e0463d-8026-48ef-b79b-4380a9164349/1/-/-/-/-/SV%20March%202019.pdf?sid=TV2:isGhwSuMJ

[4] Cushman and Wakefield, Q4 2018, "The Transit Effect Bay Area: Downtown/Core vs. Overall Market (Office, All Classes)", available at: http://blog.cushwake.com/san-francisco/the-transit-effect-bay-area-rail-centric-markets-generally-outperform-featuring-map.html; Cushman and Wakefield, 2018, "Market Beat Silicon Valley Office Q4 2018", available at: http://www.cushmanwakefield.com/en/research-and-insight/unitedstates/silicon-valley-office-snapshot ; Cushman and Wakefield, 2018, "Market Beat San Mateo County Office & R&D Q4 2018", available at: http://www.cushmanwakefield.com/en/research-and-insight/unitedstates/san-mateo-office-snapshot; and Cushman and Wakefield, 2018, "Market Beat San Francisco Office Q4 2018", available at: http://www.cushmanwakefield.com/en/research-and-insight/unitedstates/san-francisco-office-snapshot

[5] The residential average annual appreciate rate was calculated based on data from the U.S. Federal Housing Finance Agency House Price Index from 1990-2018 for the San José-Sunnyvale-Santa Clara Metropolitan Statistical Area and the San Francisco-San Mateo-Redwood City Metropolitan Division (available at: https://fred.stlouisfed.org/series/ATNHPIUS41940Q#0). The office average annual appreciate rate was calculated using various market reports, including JLL's San Francisco and Silicon Valley office market trends from 2007 to 2016, and Cushman and Wakefield's San Francisco office market trends from 2012 to 2018.

[6] The Bureau of Labor Statistics publishes historical trends of the Consumer Price Index for All Urban Consumers (CPI-U) for different geographic areas. The average 12-month percent change (inflation rate) from 2000 to 2018 for the San Francisco-Oakland-Hayward area was 2.69%, and the average inflation rate for the same period for the U.S. was 2.18%. See: https://www.bls.gov/regions/west/data/cpi_tables.pdf

FIGURE 4-2. ESTIMATED RESIDENTIAL VALUES (TOP) AND OFFICE RENTS (BOTTOM) NEAR CALTRAIN STATIONS



Source: CoreLogic, 2019; Polaris Pacific, 2019; Cushman and Wakefield, 2019; CoStar, 2019; Strategic Economics, 2019.

TABLE 4-3. PROPERTY VALUES: KEY ASSUMPTIONS	
Office Capitalized Value Assumptions	
Vacancy rate	5.0%
Operating expenses	25%
Capitalization rate (a)	7.0%
Property Value Appreciation	
Average annual appreciate rate – residential (b)	5.5%
Average annual appreciate rate – office (c)	4.0%
Annual inflation rate (d)	2.5%

(a) CBRE, North America Cap Rate Survey Second Half of 2018, for San José Office CBD Class A.
(b) U.S. Federal Housing Finance Agency House Price Index, 1990-2018, for the San José-Sunnyvale-Santa Clara Metropolitan Statistical Area and the San Francisco-San Mateo-Redwood City Metropolitan Division.
(c) JLL San Francisco and Silicon Valley office market trends, 2007 to 2016; Cushman and Wakefield, San Francisco office market trends, 2012 to 2018.
(d) Bureau of Labor Statistics Consumer Price Index for All Urban Consumers (CPI-U) 12-Month Percent Change for the San Francisco-Oakland-Hayward area and for the U.S. City Average, 2000-2018.
Source: CBRE, 2019; U.S. Federal Housing Finance Agency, 2019; Strategic Economics, 2019.

4.7 CALTRAIN PROPERTY VALUE PREMIUMS

Caltrain's "property value premium" is defined as the share of property value that is attributable to proximity to Caltrain. As summarized in Figure 4-3, residential and office premiums vary by service level and by distance to Caltrain stations.

The residential property value premiums are based on the following sources:

- The half-mile residential property value premiums for the Low, Medium, and High service levels are based on the analysis of Caltrain's existing property value benefits. In a separate report, Strategic Economics analyzed the residential property value benefits of existing Caltrain service using hedonic price modeling, a statistical regression method that breaks the value of a property into its constituent parts, thus making it possible to isolate the value associated with each specific attribute. It is considered a best practice method for analyzing the effect of transit on property values. The premiums shown in Figure 4-3 represent an average of the single-family home and condominium regression model results. [7]
- The half-mile residential property value premium for the Highest service level is based on a previous study of residential property value premiums of BART in Alameda and Contra Costa counties.[8] These BART premiums were also obtained using statistical hedonic price modeling. Given that BART operates in the same region as Caltrain, and that existing BART peak period frequencies are in line with the Highest service levels, BART was deemed to be an appropriate reference for estimating the future premiums of Caltrain.
- The half-mile residential property value premium for the Very High service level is the mid-point between High and Highest premiums, described above.

[7] The premiums shown in Figure 4-3 are the average of the single-family home and condominium models, for both the Ordinary Least Square and the Spatial Error models. For complete results and methodology, see: Strategic Economics, 2019, "Caltrain Business Plan: Property Value and Fiscal Benefits of Caltrain."

[8] Strategic Economics, prepared for Bay Area Rapid Transit (BART), August 2014, "Property Value and Fiscal Benefits of BART", available at: https://www.bart.gov/sites/default/files/docs/2014-08%20BARTPropValues_Final_0.pdf; and Strategic Economics, prepared for Bay Area Rapid Transit (BART), July 2015, "Benefits of BART to Single-Family and Condominium Property Values by County (Revised)", available at: https://www.bart.gov/sites/default/files/docs/1%20-%20BART%20Single%20Family%20and%20Condo%20Analysis_0.pdf.

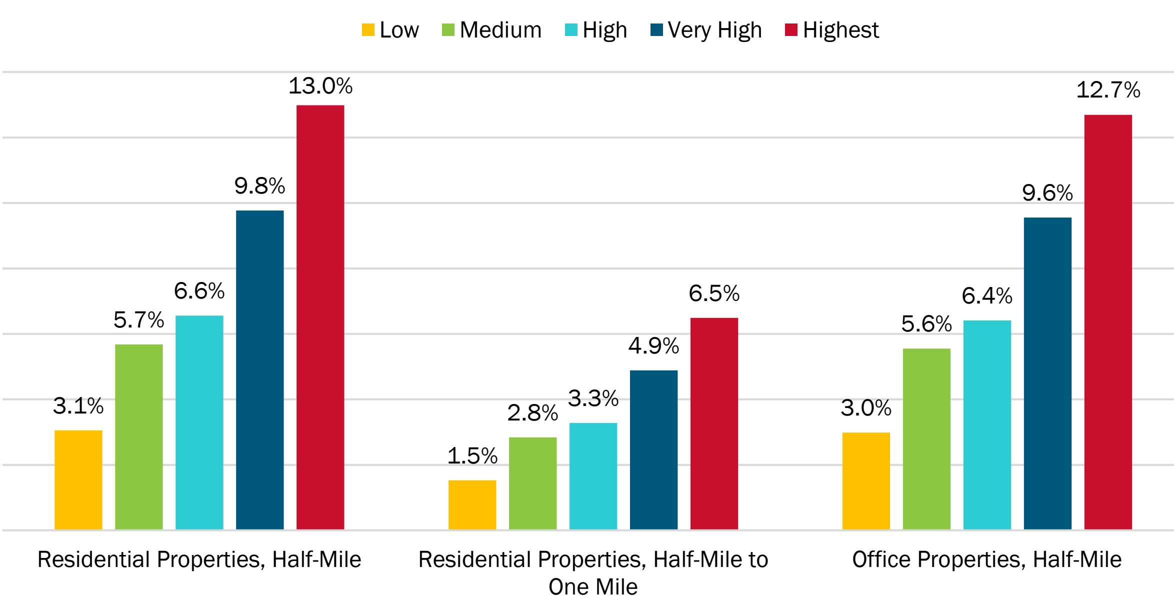
- The half-mile to one-mile residential property value premiums, for all service levels, are estimated at half the value of the premiums within the half-mile area.

The office property value premiums are based on the following sources:[9]

- The half-mile office property value premiums for the Highest service level is estimated as an average of the BART office property value premiums in Alameda and Contra Costa counties.[10] These BART premiums were obtained using statistical hedonic price modeling. The BART premiums are relevant to Caltrain for several reasons: BART operates in a relatively comparable region to Caltrain; Alameda and Contra Costa counties have relatively strong office markets; and existing BART peak period frequencies are in line with the Highest service level.
- The half-mile office property value premiums for all other service levels were scaled down proportionally to the residential premiums (note: this relationship was used as a proxy given that the analysis of existing office premiums was not able to isolate the specific impact of Caltrain.)
- Office properties outside the half-mile Caltrain service area are conservatively assumed to be uninfluenced by Caltrain service improvements, and therefore are not assigned a premium.

For each station, service area, and land use type, Strategic Economics calculated the difference between the existing premium and the potential future premiums under the Baseline and High Growth Scenarios. This difference, applied as a percentage increase, was used to estimate the future net growth in property values resulting from Caltrain service improvements.

FIGURE 4-3. RESIDENTIAL AND OFFICE CALTRAIN PROPERTY VALUE PREMIUMS



Source: Strategic Economics, 2019.

[9] Due to a lack of sufficient office rent data, the analysis of Caltrain's existing property value benefits for office properties relied on descriptive statistics. This analysis found higher office rents near Caltrain, particularly near High service level stations. These results could not be used to develop property value premiums because they are not based on statistical regression methods, which control for the effect of other potential variables.

[10] Strategic Economics, prepared for Bay Area Rapid Transit (BART), July 2015, "Benefits of BART for Office and Apartment Properties", available at: https://www.bart.gov/sites/default/files/docs/2%20-%20BART_OfficeApartmentAnalysis_Final_07-2015_0.pdf.

5. APPENDICES

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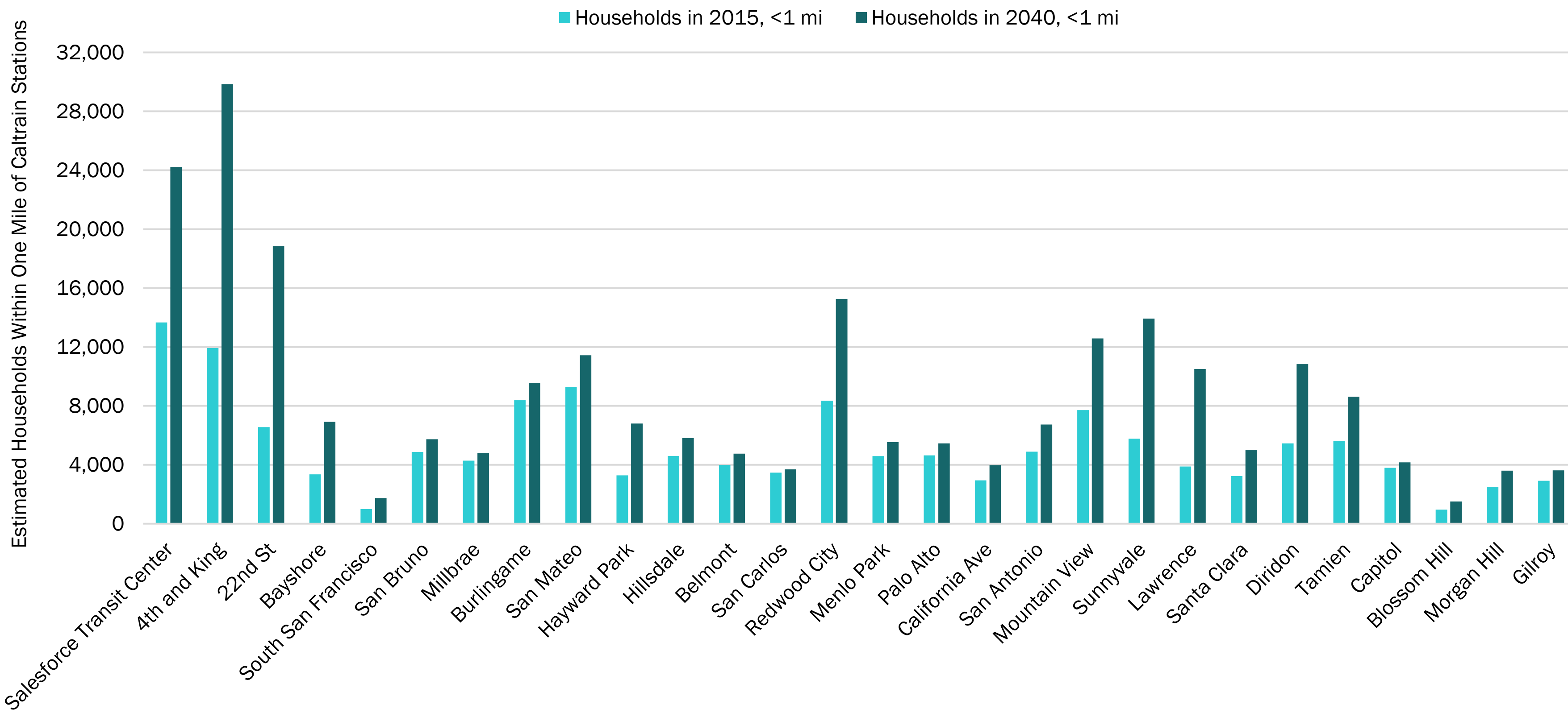
Strategic Economics. "Property Value and Fiscal Benefits of BART." Bay Area Rapid Transit (BART), August 2014. https://www.bart.gov/sites/default/files/docs/2014-08%20BARTPropValues_Final_0.pdf.

Appendix B: Land Use Projections by Station Service Area

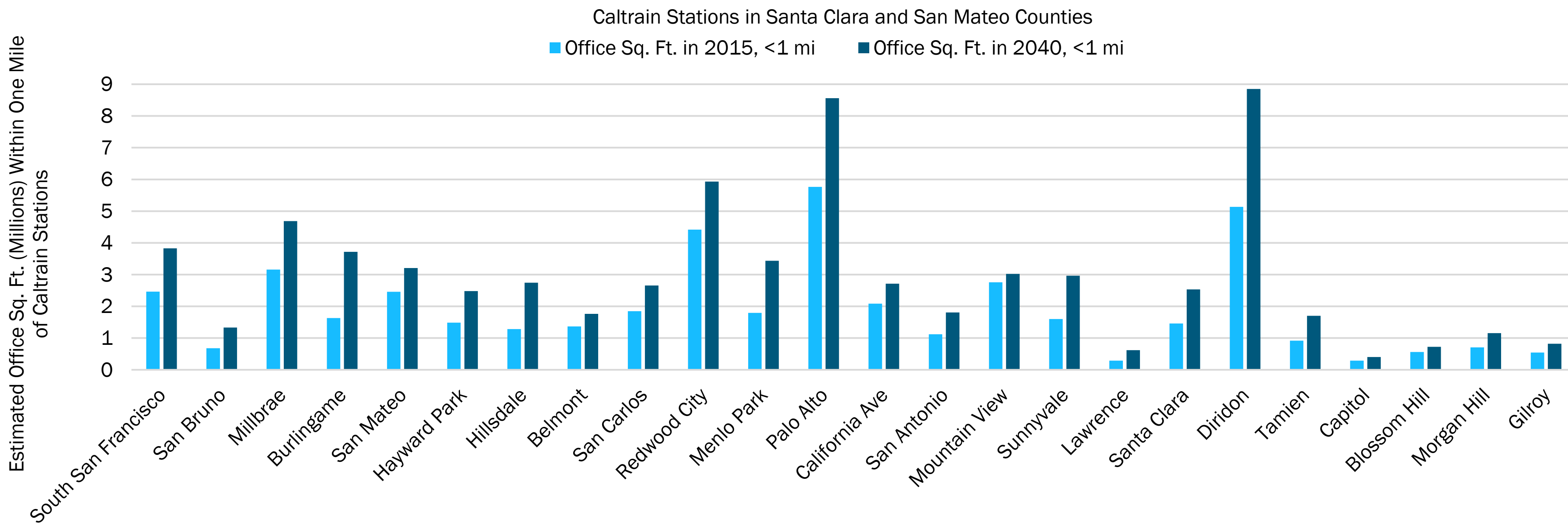
Figure 5-1, Figure 5-2, and Table 5-1 summarize the station-level projections of households and office square footage for the half-mile and one-mile Caltrain network service areas.

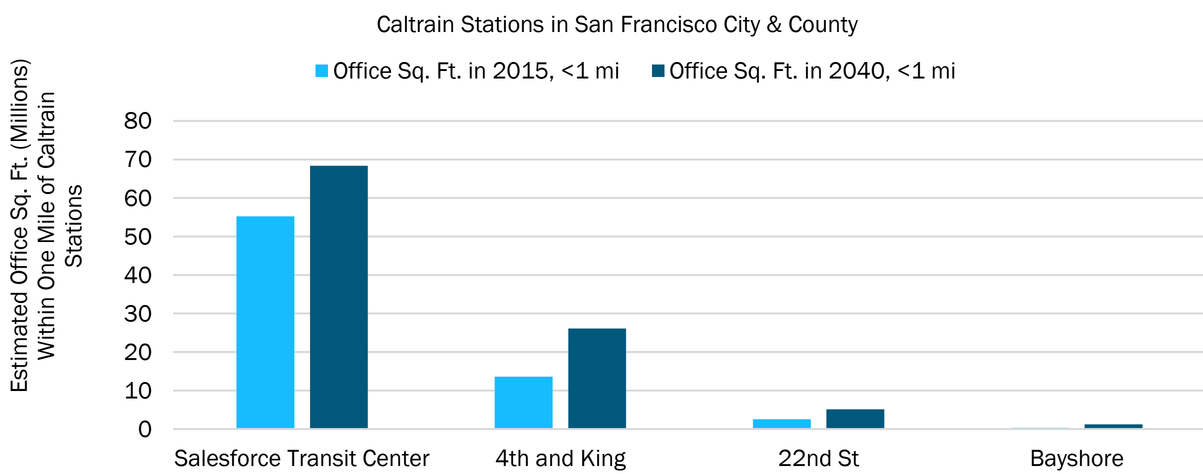
FIGURE 5-1. HOUSEHOLD PROJECTIONS NEAR CALTRAIN STATIONS, 2015 AND 2040



Based on ABAG/MTC's household projections for 2015 and 2040 by Traffic Analysis Zones, modified by Fehr & Peers. TAZ-level projections were weighted by the share of the TAZ's area located within the half-mile or one-mile Caltrain network service area.
Source: ABAG/MTC, 2019; Fehr & Peers, 2019; Strategic Economics, 2019.

FIGURE 5-2. OFFICE SQUARE FOOTAGE PROJECTIONS NEAR CALTRAIN STATIONS, 2015 AND 2040





Based on ABAG/MTC's household projections for 2015 and 2040 by Traffic Analysis Zones, modified by Fehr & Peers. TAZ-level projections were weighted by the share of the TAZ's area located within the half-mile or one-mile Caltrain network service area. It is assumed that 75% of jobs are office-based, and that the average job density is 275 net sq. ft. per employee.
Source: ABAG/MTC, 2019; Fehr & Peers, 2019; Strategic Economics, 2019.

Table 5-1. Household and Office Square Footage Projections Near Caltrain Stations, 2015 and 2040

Station ID	Station Name	Households in 2015, <0.5 mi	Households in 2040, <0.5 mi	Households in 2015, <1 mi	Households in 2040, <1 mi	Office Sq. Ft. in 2015, <0.5 mi	Office Sq. Ft. in 2040, <0.5 mi	Office Sq. Ft. in 2015, <1 mi	Office Sq. Ft. in 2040, <1 mi
1	Salesforce Transit Center	2,059	5,907	13,666	24,224	22,611,392	30,531,947	55,235,135	68,364,967
2	4th and King	2,362	7,202	11,926	29,843	2,341,576	6,057,490	13,612,254	26,099,956
4	22nd St	1,817	5,671	6,561	18,844	606,225	1,316,364	2,553,825	5,116,605
7	Bayshore	486	2,142	3,352	6,917	85,349	320,920	329,724	1,235,900
8	South San Francisco	6	37	990	1,745	317,487	463,213	2,461,901	3,826,613
9	San Bruno	1,261	1,567	4,869	5,736	195,016	406,821	678,395	1,329,612
10	Millbrae	887	1,159	4,280	4,803	758,947	1,109,506	3,159,039	4,686,964
12	Burlingame	2,006	2,191	8,382	9,568	503,995	1,031,313	1,631,736	3,716,771
13	San Mateo	2,710	3,576	9,295	11,436	1,479,179	1,668,004	2,460,013	3,209,017
14	Hayward Park	456	1,156	3,281	6,802	226,023	401,919	1,486,319	2,479,544
15	Hillsdale	606	646	4,600	5,824	152,915	199,174	1,284,792	2,746,610
16	Belmont	1,194	1,383	3,992	4,759	288,910	411,163	1,368,778	1,761,418
17	San Carlos	752	822	3,467	3,692	556,056	788,412	1,845,979	2,657,385
18	Redwood City	2,049	5,268	8,352	15,268	2,016,337	2,553,233	4,419,197	5,933,529
21	Menlo Park	1,521	1,773	4,587	5,543	526,289	1,089,763	1,792,473	3,435,861
22	Palo Alto	767	988	4,643	5,457	2,333,709	2,711,269	5,767,101	8,560,934
24	California Ave	572	697	2,941	3,978	860,456	937,514	2,083,962	2,712,168
25	San Antonio	958	1,317	4,889	6,735	147,555	333,091	1,119,507	1,805,653
26	Mountain View	1,501	3,053	7,714	12,583	983,557	1,187,771	2,757,344	3,022,127
27	Sunnyvale	1,144	3,058	5,774	13,931	422,045	628,767	1,600,211	2,962,726
28	Lawrence	545	1,813	3,880	10,503	28,536	47,191	290,006	617,477
30	Santa Clara	412	782	3,234	4,984	149,725	354,980	1,458,382	2,534,970
32	Diridon	1,258	1,505	5,450	10,837	530,523	961,062	5,133,745	8,849,807
33	Tamien	1,081	1,593	5,617	8,622	207,913	313,611	919,103	1,702,156
34	Capitol	383	531	3,800	4,163	33,456	53,300	288,257	401,678

Table 5-1. Household and Office Square Footage Projections Near Caltrain Stations, 2015 and 2040

Station ID	Station Name	Households in 2015, <0.5 mi	Households in 2040, <0.5 mi	Households in 2015, <1 mi	Households in 2040, <1 mi	Office Sq. Ft. in 2015, <0.5 mi	Office Sq. Ft. in 2040, <0.5 mi	Office Sq. Ft. in 2015, <1 mi	Office Sq. Ft. in 2040, <1 mi
35	Blossom Hill	10	43	953	1,511	35,282	43,243	561,671	722,608
36	Morgan Hill	626	1,075	2,505	3,599	195,294	336,317	705,397	1,155,190
38	Gilroy	494	679	2,917	3,623	125,367	186,402	544,665	820,986
Total		29,923	57,631	145,917	245,528	38,719,112	56,443,761	117,548,909	172,469,234

Stations excluded from the analysis due to very infrequent or inexistent service: Broadway, Atherton, Stanford Stadium, College Park, and San Martin stations. Note that the Salesforce Transit Center station is not currently in service. Estimated 2015 numbers are used as a proxy for current values. The following assumptions were used to estimate office square feet: 75% of all employment is office-based; 275 net square feet per employee. Note that the half-mile and one-mile area are based on network distances, as shown in Figure 4-1.
Source: ABAG/MTC, 2019; Fehr & Peers, 2019; Strategic Economics, 2019.

Operating Cost Memo

Prepared for:

Caltrain

October 2019

OK18-0254.00

Prepared by:

WWW.FCPWORLD.NET
Trusted Advisors in Transport

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1 INTRODUCTION

This report, prepared for the Caltrain Business Plan, documents the operating and maintenance cost estimates for the 2040 Service Vision. This includes estimates of both the direct costs associated with additional Caltrain rail services as well as the overall costs of maintaining a shared corridor including a conceptual approach to how costs could be apportioned and applied to California High-Speed Rail for their proposed use of the corridor at some point in the future. All costs shown are conceptual and will require significant further refinement as plans to incrementally improve service and corridor facilities are refined and as use agreements with High-Speed Rail or other future corridor users are developed and formalized.

1.1 OVERVIEW OF THE CALTRAIN BUSINESS PLAN

Caltrain is currently developing the Caltrain Business Plan, an in-depth technical and policy document that will set the vision for how Caltrain service, and the Caltrain corridor as a whole, should grow to meet current and future ridership demand over the next 20 to 30 years. This study is a joint effort between agency partners and communities along the corridor. One of the main goals of the Caltrain Business Plan is to evaluate the various benefits, costs, and impacts of three different rail service growth scenarios for 2040: a Baseline Growth Scenario, a Moderate Growth Scenario, and a High Growth Scenario. Based on this evaluation, the Caltrain Business Plan builds the case for investing in and implementing an agreed upon 2040 Long Range Service Vision for the Caltrain corridor, which includes proposed service improvements, infrastructure needs, and associated costs and benefits.

First Class Partners (FCP) was retained as part of the consultant team developing the Caltrain Business Plan, led by Fehr & Peers, to prepare a model that allows Caltrain to analyze different growth scenarios to understand how they impact all aspects of its business including ridership, revenue, costs, long term economic benefits, fleet, train crewing, and other staffing. A key component of the integrate model is an operating and maintenance cost estimating module. This report covers the development and validation of the module and the O&M cost estimates produced for each of the growth scenarios, as well as the approach to calculating potential track access charges that Caltrain and tenant railroads would assess each other for use of shared assets.

1.2 OVERVIEW OF REPORT CONTENTS AND APPROACH

Cost estimates were generated using a Caltrain-specific operating and maintenance cost module within the IBM developed for the Business Plan that estimates changes to the administrative, operations, and maintenance costs as service increases over time. The modeling process included the following key steps:

1. Operating and Maintenance Cost Model Development
    a. Development of a detailed set of O&M costs from Caltrain's base year (existing) financials
    b. Attribution of the detailed costs to a set of cost categories covering all aspects of operations, maintenance and administration
    c. Development of unit costs based on operating statistics for base year service levels and the detailed O&M costs. Then, mapping the unit costs to the cost categories.
2. Calculation of Cost Estimates
    a. Calibration and validation of the model to base year costs
    b. Calculation of operating and maintenance statistics for the proposed Service Vision based on the levels of train service, maintenance needs and administrative considerations; and

c. Applying the unit costs to the operating and maintenance statistics to generate annual operations and maintenance cost estimates for the Service Vision from 2018-2070.

These steps are summarized briefly in the following sections and in more detail in the body of this report.

1.2.1 OPERATING AND MAINTENANCE COST MODEL DEVELOPMENT

The first step in the model development process included translating Caltrain's current financial data into a detailed set of operating and maintenance costs and attributing those costs to a set of cost categories that would be used as the basic model structure. Detailed costs were developed based on the latest available set of full annual financials and then attributed to a set of cost categories that covered all aspects of Caltrain O&M activities. This included determining whether the costs within each category would be fixed costs that would not vary with changes in service, or variable costs that would be expected to grow along with service increases. Some cost categories have both a fixed and variable component. The following cost categories were included in the model:

- **Crew** – the personnel onboard a train including drivers and conductors
- **Dispatch** – the personnel controlling the movement of trains through the network and at terminals
- **Maintenance of Equipment** – upkeep of equipment including daily service and routine maintenance
- **Maintenance of Way** – upkeep of the track and right-of-way
- **Station Maintenance** – upkeep of the stations including cleaning and repairs to items like shelters and benches
- **Contractor Administration** – the costs to oversee the contractors that provide the crew and personnel to operate and maintain train service
- **Diesel Fuel** – the cost of diesel fuel to power trains
- **Administration** – Caltrain staff across all departments
- **Shuttle Buses** – service connecting Caltrain stations to surrounding businesses
- **Clipper Card fare payment system** – costs paid to regional agencies and the vendor for use of the Clipper Card technology
- **Track Access Costs** – costs paid between Union Pacific, Caltrain and (in the future) CA HSR to use each other's track infrastructure
- **Other Operating Costs** – a catchall for other operating costs not captured in the above categories that are incurred by Caltrain direction
- **Contractor Other Operations** – a catchall for other operating costs not captured in the above categories that are incurred by the operations and maintenance contractor

The next step in developing the cost estimates was to generate unit costs for each of the cost categories based on Caltrain's current operations and maintenance costs and operating statistics, supplemented by national and international research for new activities like the maintenance of EMU cars. Operating statistics include the following:

- Train miles
- Train hours
- Coach miles
- Cab car miles
- Diesel locomotive miles
- EMU car miles by number of cars in the set
- Gross ton miles
- Paid crew hours

- Number of stations by size
- Dispatching

These statistics were analyzed and manipulated to develop the unit costs. These unit costs were then mapped or associated to the cost categories, so that the total cost within a particular category could be estimated based on one or more of the operating statistics. To determine the variable portion of the costs, the model multiplies the operating statistics by the associated unit costs. For example, the cost of Diesel Fuel is $6.19 per diesel locomotive mile. Under base year operations, there are about 1.4 million miles traveled by trains annually. By multiplying these two numbers together (the unit cost by the operating statistic) the total annual base year fuel cost is $8.6 million.

In addition to the variable costs, the model also applied fixed costs to certain categories including the following:

- Dispatching
- Contractor other costs
- Station maintenance
- Shuttle services
- Administration

These costs are assumed to remain constant over time, no matter the service levels. For example, the cost of providing connecting shuttle services to Caltrain stations is a fixed cost estimated at $4.6 million a year regardless of train service. Administration costs are the one exception, as they grow significantly to support both increased levels of train service and the evolution the organization is expected to undergo in several areas to support implementation of the Service Vision.

1.2.2 CALCULATION OF COST ESTIMATES

The final steps in the process were to calibrate and validate the O&M Model and apply it to the growth scenarios to generate a set of detailed cost estimates. Calibration and validation were completed by applying the O&M Model to the base year operating statistics and adjusting it to make sure it matched the base year detailed costs. The last step in the process was to generate a set of operating statistics based on the proposed service plans associated with the growth scenarios, and apply the model to generate a set of cost estimates.

1.3 RELATIONSHIP TO OTHER WORK STREAMS

Within the context of the Caltrain Business Planning process, the cost estimates from the O&M Model are key inputs to the calculation of the benefit cost ratio for each growth scenario, the 2040 funding strategy, and 10-year financial plans. They also provided Caltrain with a detailed understanding of the components of its O&M costs and the drivers of these costs, as well as enabling the calculation of key business metrics such as projected operating surplus/deficit, and farebox recovery ratios.

1.4 DEFINED TERMS AND KEY CONCEPTS

The O&M Model is underpinned by some fundamental concepts which are considered as defined terms used throughout this document and the model structure:

- **Cost Categorization** – a process of attributing each O&M cost item to a cost category
- **Variability** – the degree to which any particular O&M Cost item is variable with the level of operations
    - Some costs will be 100 percent variable (e.g., the cost of diesel fuel)
    - Some will be 100 percent fixed (i.e., they do not vary at all with the level of operations, such as executive salaries and certain other administrative overheads)

  - Some costs will be subject to an assumed percentage split between Fixed and Variable (e.g., Track maintenance which involves 'fixed' elements such as daily inspections of the track, plus variable elements such as the cost of grinding which is determined by the amount of wear caused by the running of trains)

- **Unit Cost** – a cost per unit of measurement in a cost category, such as the cost per liter of diesel fuel
- **Unit of Measurement** – a measure of the level of activity in that cost category, such as the number of liters of diesel fuel

In order to help demonstrate the flow of information throughout both the IBM in general, and the O&M Model in particular, the set of defined terms listed in Table 1 is utilized consistently throughout this report.

TABLE 1: DEFINED TERMS

Defined Term	Description	Related Terms
Base Year	FY17 - the year for which the initial financial and operational data was provided, to which the IBM is calibrated	
Capital Maintenance	The component of the maintenance of the Railroad that is funded by the Capital budget	Operating Maintenance, State of Good Repair
Capital Maintenance (SOGR) Costs	Caltrain's expenditure under the Capital budget to maintain the system in a State of Good Repair	
Control Total	Control Totals are published totals or sub-totals of O&M costs, Revenue, Opstats that dictate the totals that the Business Model must produce in order to be validated as properly modeling the O&M costs, Revenues and/or Opstats.	
General Ledger (GL)	A download of Caltrain's O&M costs for the Base Year (FY17)	
Growth Scenarios	The three profiles over time defined for the Caltrain Business Plan – Baseline Growth (BG), Moderate Growth (MG), High Growth (HG)	
Operating Maintenance	that component of the maintenance of the Railroad that is funded by the Operating budget	Capital Maintenance
Operating Statistics	Units of measurement used to describe the level of train operations e.g., train miles, train hours etc.	
Operations	Refers to the analysis of Caltrain's train services, frequencies, consists, stopping patterns, etc.	
Planning Period	Projections are developed for each of the three Growth Scenarios over the Planning Period 2018 to 2070.	
Track Access	Represents the fee charged by one Railroad for having its Infrastructure used by another Railroad	Track Usage fee

Table 2 provides a list of the key abbreviations used throughout this report.

TABLE 2: ABBREVIATIONS

Abbreviation	Description
BG	Baseline Growth
CA HSR	California High-Speed Rail Authority
FFGA	Full Funding Grant Agreement - a document produced by Caltrain in support of its application for Federal Funding for PCEP

TABLE 2: ABBREVIATIONS

Abbreviation	Description
GL	General Ledger
HG	High Growth
HSR	High Speed Rail
IBM	Integrated Business Model
MG	Moderate Growth
O&M	Operating and Maintenance
OCS	Overhead Catenary System
PCEP	Peninsula Corridor Electrification Project
PTC	Positive Train Control
SOGR	State of Good Repair
STC	Salesforce Transit Center station
TA	Track Access
TAM Plan	Transit Asset Management Plan - a federally mandated plan produced by Caltrain to plan for its projected SOGR expenditure on maintaining the infrastructure and fleet
TASI	Transit America Services Incorporated - the company that, under contract, operates Caltrain's train services and maintains Caltrain's infrastructure and Fleet
TASI BSP	TASI's Basic Service Plan - details of the O&M costs associated with the services provided by TASI
TPS	Traction Power System
UP	Union Pacific - owner of the track from CP Lick (a defined point between approximately 1 mile south of Tamien) to Gilroy
UP	Union Pacific - owner of the track from CP Lick (a defined point between approximately 1 mile south of Tamien) to Gilroy
VtoV	Valley to Valley - a term used by CA HSR to define one of the stages of its introduction of HSR trains onto the Caltrain corridor

1.5 WHAT'S IN THIS REPORT

This report includes the following sections which present the development of the cost model, the results, and track access charges:

Section 2 –Model Structure

Section 3 – Cost Attribution

Section 4 – Unit Cost Calculation

Section 5 – Detailed O&M Cost Estimates

Section 6 – Track Access Charges

2 MODEL STRUCTURE

The operating and maintenance cost model uses inputs from Caltrain's financial reports and the operations (train service) module of the IBM to produce a set of detailed cost estimates. The structure of the model, including the key stages in the modeling process, is summarized in Figure 1. Overall, financial data are processed through a number of stages, including application of assumptions around cost variability and cost drivers to produce detailed estimates of Caltrain's O&M costs.

The first stage involves reconciling Caltrain's published cost data into a set of detailed O&M costs. There are generally some differences between the data from the audited accounts, general ledger and TASI (the contract operator), because of the inclusion of certain costs in some of these reports and not others, late changes to the final numbers, and differences between the data sources with respect to the purposes of the reports. The first stage is not addressed again in this report.

The second stage is cost attribution, in which the specific costs identified in the detailed base year O&M costs are organized into cost categories. These categories are used to organize the presentation of the estimates into approachable and readily understandable groupings. At this point, the model also determines whether each category is composed of variable components, fixed cost components, or both.

Next, unit costs are developed and mapped to the cost categories in the third stage. Unit costs are derived from the relationship between the detailed O&M costs and operational statistics, such as train miles, based on Caltrain's base year service levels. Then, the set of unit costs to be used in each cost category is defined such that, when each unit cost is multiplied by the appropriate number of units and added to the fixed part of the cost, it produces the total cost within that category and a representation of how that total cost was built up.

After this stage, the model is validated by producing a base year cost estimate from the model and comparing it to the base year detailed O&M costs, making adjustments in the unit costs and iterating until the estimates and the actuals match.

In the last stage, detailed O&M cost estimates for the growth scenarios are produced by multiplying the projected operating statistics by the appropriate unit cost(s).

The remainder of this report addresses these stages in more detail, including how unit costs were calculated, and presents the resulting cost estimates. In addition, it covers the analysis and calculations used to develop potential track access charges that could be charged to future tenants such as California High-Speed Rail (CA HSR).

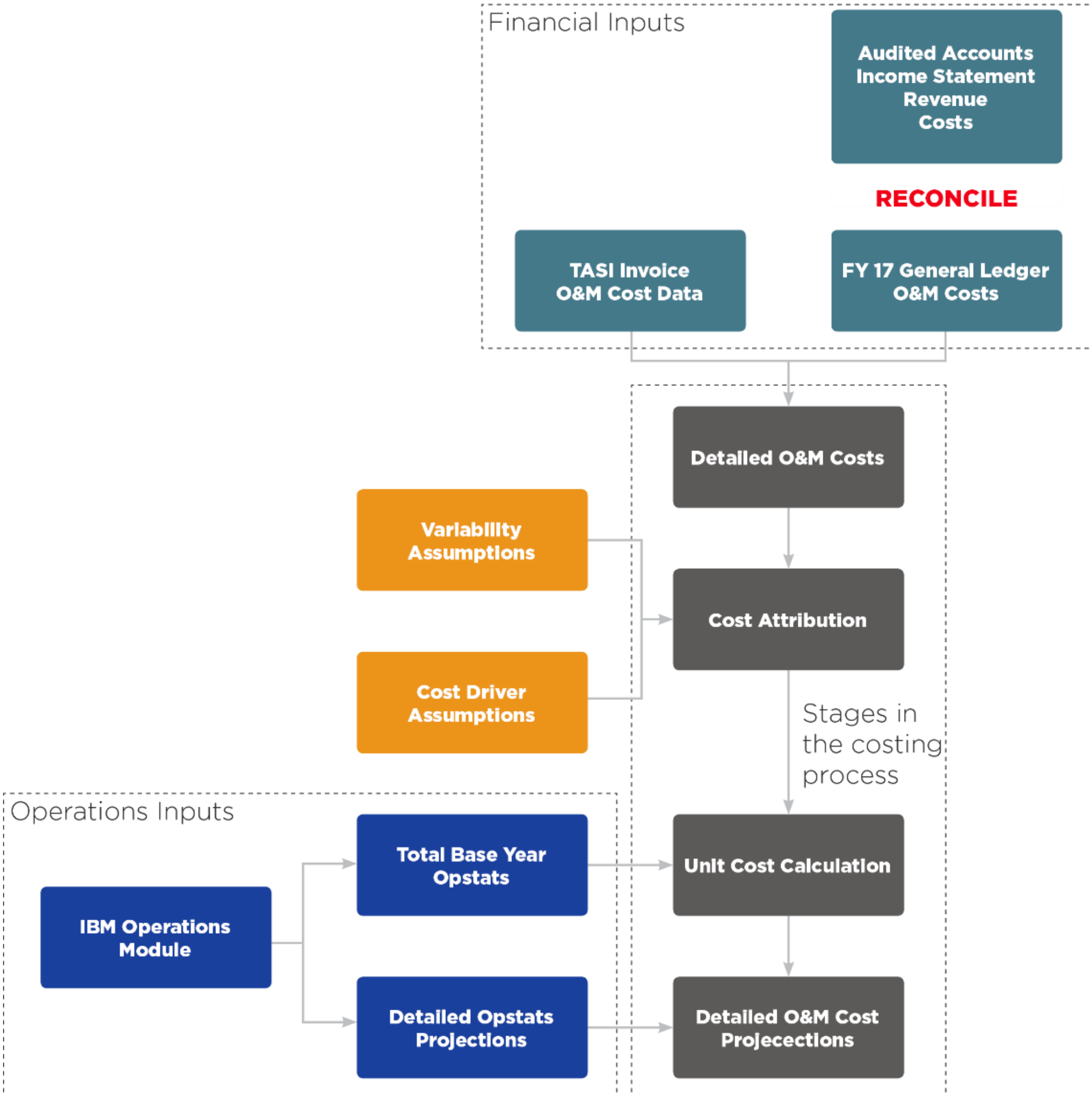

FIGURE 1: OPERATING COST MODEL STRUCTURE

3 COST ATTRIBUTION

This stage of the modeling process maps the detailed base year O&M costs to a set of cost categories to organize the cost estimates into an approachable but comprehensive set of costs covering all of Caltrain's operational, maintenance, and administrative functions. It also determines how much of a cost within each cost category is variable in that it tracks the level of train service and how much is fixed, in that it stays relatively constant no matter the amount of train service.

3.1 INPUTS

The inputs to cost attribution are the total detailed O&M expenses from the base year Caltrain financials and an assumed set of cost categories covering O&M activities. Caltrain Finance provided the FY17 audited accounts from which the following control total was established for the FY17 Operating costs:

- GRAND TOTAL EXPENSE 133,935,488

This total O&M cost is key to the whole model and forms the control total for the calibration of operating costs throughout the model. Caltrain Finance also provided an extract from the FY17 General Ledger (GL) with a more detailed breakdown of the Operating costs (again totaling to $133,935,488).

Caltrain Contract Management provided an extract from the TASI Basic Service Plan (record of actual invoiced amounts) for FY17 which provided a much more detailed breakdown of the costs reported in the General Ledger as having been paid to TASI (Accounts 525131 and 540000) reconciled to a total of $80,378,951.

The set of cost categories to be used for analysis of Caltrain's O&M costs was determined by examining in detail each of the cost items in the GL and TASI invoices, discussing the contents of each item with Caltrain's technical experts, breaking the item down into more detailed components where necessary, and establishing that variabilities and cost drivers could be determined for each item or sub-item.

The resulting Cost Categories are shown in Table 3.

TABLE 3: COST CATEGORIES

Cost	Category	Contents
1	***Crew***	
1.1	Supervisors	TASI Operations Train Services - Management
1.2	Regular crew	TASI Operations Train Services - Non-Management
1.3	Other	TASI Operations Crew Transportation, Uniforms, vehicles, etc.
2	Dispatch	TASI Operations Dispatch Management & Non-management
3	Contractor Other Ops	TASI Operations Special Services crew
4	MoE	TASI SOGR maintenance of equipment (train fleet)
5	MoW	TASI SOGR maintenance of permanent way
6	Station maintenance	TASI SOGR maintenance of stations
7	Contractor Admin	TASI Gen Admin, Safety, Finance
8	Diesel Fuel	Fuel and fuel taxes
9	Other operating	Security, timetables, tickets, insurance
10	***Admin***	
10.1	staff	Caltrain wages, benefits and inter-Agency overheads
10.2	overheads	Admin overheads – buildings, utilities, vehicles, etc.

Cost	Category	Contents
1	***Crew***	
11	***Shuttle***	
11.1	Muni Shuttles	Caltrain costs toward Muni Shuttles
11.2	Caltrain Shuttles	Caltrain Shuttle costs
12	Clipper	Clipper Operator Charges and Ambassador Cards
13	Track Access costs	Charge for running on track owned by other parties

3.2 ASSUMED VARIABILITIES AND COST DRIVERS

Based on international experience, and identification and analysis of any Caltrain-specific costs, assumptions were made as to the variability of the costs in each cost category, what portions of cost were fixed and the drivers of these costs:

- Crew costs – assumed 100 percent variable with level of operation (represented by annual train miles)
- Dispatch – largely fixed relative to small changes in level of operations, but allow 10 percent variable to cater for potential increase in staff numbers due to the large changes in train miles involved here
- Contractor other ops – Special services considered to be fixed – although additional sports stadiums/games will need to be served, the increased regular train frequency will partially cover this need
- Maintenance of Equipment – 100 percent variable with a modeled combination of fleet size (for time-based maintenance) and vehicle miles (for usage-based maintenance).
- Maintenance of Way – sent into the model as 100 percent variable with train miles but later modeling will identify a fixed component and differential by vehicle type.
- Station maintenance – assumed 100 percent fixed relative to level of train operations, but variable with station size
- Contractor Admin – assumed to be Executive/admin staff and building overheads that can be assumed to be fixed relative to the level of operations.
- Diesel fuel – assumed 100 percent variable with annual diesel locomotive miles
- Other operating – the many cost items in this Cost Category were each individually examined and assigned levels of full or partial Variability with train miles. In particular, some insurance policies were identified as partially variable with level of operations.
- Caltrain Admin staff costs are assumed to be 80 percent driven by staffing policies and 20% variable with train miles
- Caltrain Admin overhead costs are assumed to be fixed relative to train miles but have some degree of variability with admin staff levels
- Shuttle costs – known to not have a direct relationship to Caltrain's level of service – hence assumed fixed
- Clipper costs – assumed 100 percent variable with farebox revenue in line with card operator charges
- Track access charges – assumed fixed at this stage, but later modeling supersedes this

3.3 RESULTS

Table 4 shows the results of attributing the total FY17 O&M cost of $133,935,468 to the appropriate cost categories with the assumed levels of variability or fixed for the costs.

These are considered interim outputs in that, while they provide a useful picture of where Caltrain incurs its costs and how they might be expected to vary with changes in service level, they are primarily designed as inputs to the unit cost calculations described in the next section.

TABLE 4: RESULTS OF COST ATTRIBUTION

Cost	Category	Fixed	Variable	Total
Contractor costs				
1	Crew			
1.1	Supervisors	-	1,823,491	
1.2	Regular crew	-	30,315,676	
1.3	Other	-	648,564	
2	Dispatch	3,228,263	358,696	
3	Contractor Other Ops	523,431	-	
4	MoE	-	24,353,804	
5	MoW	-	7,829,759	
6	Station maintenance	1,204,639	5,169,010	
7	Contractor Admin	6,262,107	-	
Caltrain costs				
8	Diesel Fuel	-	8,600,952	
9	Other operating	12,148,838	793,883	
10	Admin	22,212,957	2,711,975	
11	Shuttle			
11.1	Muni Shuttles	256,222	-	
11.2	Caltrain Shuttles	4,328,663	-	
12	Clipper	-	1,134,131	
13	Existing Track Access costs	30,408	-	
	Total	**50,195,527**	**83,739,941**	**133,935,468**

4 UNIT COST CALCULATION

This section describes how unit costs were developed for Caltrain's base year and future operations and maintenance activities and mapped to cost categories. Unit costs covering base year operations and maintenance activities were based on the base year detailed O&M costs and operating statistics covering Caltrain's operation and maintenance of base year train service. To capture the future condition of running an electrified railroad a number of additional unit costs were derived based on national and international experience with similar operations. All the unit costs were then mapped to cost categories such that they can be used to generate a complete set of cost estimates for future growth scenarios. The section concludes with a description of the development of the unit costs of administrative and other staff needed by Caltrain to support growth.

4.1 UNIT COSTS FOR EXISTING OPERATIONS AND MAINTENANCE ACTIVITIES

Unit costs were calculated by cost category for existing activities and included in the model. For several of the cost categories, cost estimates are calculated using relatively simple analysis of a single unit cost such as train miles. The calculations cost estimates for the remaining cost categories were more complex, involving analysis of multiple unit costs to estimate a single cost category.

The inputs to the calculation of existing unit costs include the attributed costs discussed in the previous chapter and the base (existing) year operating statistics from the operations module of the IBM. Table 5 presents an extract from the IBM Operations module of the base year operating statistics used in the calculation of unit costs.

TABLE 5: BASE YEAR OPERATING STATISTICS

Base Year Operating Statistics	Value	Unit
Train miles	1.39	(m)
Train hours	42.66	(000)
Diesel locomotive miles	1.391	(m)
Trailer coach miles	4.300	(m)
Bike coach miles	1.178	(m)
Cab car miles	1.859	(m)
Paid hour	146.05	(000)
Train miles by Caltrain on UP track	0.04	(m)
Gross ton miles by Caltrain on UP track	11.32	(m)
Caltrain train miles	1.39	(m)
Caltrain train hours	42.66	(000)
Caltrain crew paid hours	146.05	(000)
D1BL5 set miles	1.01	(m)
D1BL6 set miles	0.38	(m)
D1BL5 crew paid hours	112.70	(000)
D1BL6 crew paid hours	33.35	(000)
Caltrain-owned route miles	52.29	#
Revenue	92.43	($m)
Large station	4	#
Medium station	24	#
Small station	32	#

4.1.1 SIMPLE COST CATEGORIES

For straightforward cost categories, calculation of the unit costs included identifying the fixed amount, then dividing the remaining variable amount by the appropriate operating statistics value as shown in Table 6.

TABLE 6: SIMPLE COST CATEGORIES

Cost category	Fixed Cost	Variable					
		Variable Cost	Resources		Unit cost		
Dispatching costs	$3,228,263	$358,696	1,390,674	train miles [1]	$0.258	per	train mile
Contractor other Ops	$523,431	$0					
Contractor Admin	$6,262,107	$0					
Diesel Fuel	$0	$8,600,952	1,390,674	diesel locomotive miles [1]	$6.185	per	diesel locomotive mile
Other Operational	$12,148,838	$793,883	1,390,674	train miles [1]	$0.571	per	train mile
Shuttle	$4,584,884	$0					
Clipper	$0	$1,134,131	92.429	Revenue ($m)	$12,270	per	$m of Revenue
Existing Track Access	$30,408	$0					

Note: (1) From Service level calcs

4.1.2 COMPLEX COST CATEGORIES

The calculation of the unit costs for the following categories was more complicated due to the need to consider different rolling stock types and/or train consists:

- Crew costs
- Rolling stock maintenance
- Infrastructure maintenance

Additionally, Station Maintenance required a more complex unit cost calculation. The approach for each of these categories is discussed in the following subsections.

4.1.2.1 CREW COSTS

Crew costs were based on the costs from the TASI operating and maintenance contract. Reconciling the detailed operations costs provided by the TASI Basic Service Plan (summary of actual invoices for FY17) to the cost of rail operations reported in the General Ledger involved marking up the detailed TASI data by 6.9 percent. As shown in Table 7, applying the 6.9 percent markup to TASI's Train Service - Non-management Cost of $28,364,363 established a basic annual total crew cost of $30,315,676. For modeling purposes, TASI's Train Service– Management, Crew Transport and Uniforms costs were treated as overheads that would vary in proportion to the Crew costs, leading to an additional markup of 8.15 percent, such that the attributed crew cost equals the $32,787,732 for items 1.1 – 1.3 shown in Table 4.

TABLE 7: MODELED COST OF TRAIN CREW	
Crew cost from TASI BSP FY17	
Train svc - non-management	$28,364,363
Markup to reconcile to GL FY17 Rail Operations	6.90%
Reconciled Crew cost	$30,315,676
Markup to include Train svc - Management + Crew transport + Uniforms	8.15%
Total of costs related to Crew paid hours	$32,787,732

Analysis of the costs and hours reported in the FY19 Crew Book produced the weighted average costs per hour allowing for Regular hours, Overtime hours, and excess hours shown in Table 8. When the 8.15 percent markup from Table 7 is applied, the average cost per crew paid hour for a three-person crew becomes $224.49 and the cost per hour of an additional Assistant Conductor becomes $67.34.

TABLE 8: CREW COST PER PAID HOUR

Crew member	Crew member Cost per paid hour	
	From FY19 Crew book	With 8.15% crew-related overheads
Engineer	$75.71	$81.88
Conductor	$69.59	$75.27
Assistant Conductor	$62.26	$67.34
Total for three-person crew	$207.57	$224.49

4.1.2.2 ROLLING STOCK MAINTENANCE

The calculation of maintenance unit costs for the existing rolling stock considered the following factors:

- Separation into usage-related costs (per vehicle mile) and time-based costs (per vehicle per year) – Caltrain assumed a 70/30 split based on analysis of data provided by SEPTA (South East Pennsylvania Transit Authority)
- Relative level of effort weighting for different vehicle type – Caltrain analysis undertaken for the Full Funding Grant Agreement (FFGA) for the corridor electrification project indicates that a cab car costs 1.25 more per mile than a trailer car, and a diesel locomotive costs 2.3 times more per mile than a trailer car

Table 9 shows how these factors were applied to the FY17 rolling stock maintenance costs to derive unit costs for maintenance of the existing rolling stock.

TABLE 9: ROLLING STOCK MAINTENANCE UNIT COSTS							
	Usage/ time split [1]	FY17 cost	Weight factor [2]	Operating statistics [3]		Weighted average unit costs	
Rolling stock maintenance cost		24,353,804					
Vehicle mile-related	70%	17,047,662					
Diesel locomotive			2.3	1,390,674	diesel locomotive miles	3.564	per diesel locomotive mile
Cab car			1.25	1,859,189	Cab car miles	1.937	per Cab car mile
Trailer Coach			1	4,299,799	Trailer coach miles	1.550	per Trailer coach mile
Bike Coach			1	1,177,713	Bike coach miles	1.550	per Bike coach mile
Vehicle-related	30%	7,306,141					
Diesel locomotive			2.3	29	Diesel locomotives	80,134	per diesel locomotive per year
Cab car			1.25	36	Cab cars	43,551	per Cab car per year
Coach			1	98	Coaches	34,841	per coach per year

Notes: (1) Caltrain 6/28 interpretation of SEPTA data
(2) Caltrain analysis as reported in FFGA section 6.4.1
(3) From Service level calcs

4.1.2.3 INFRASTRUCTURE MAINTENANCE

The calculation of unit costs for infrastructure maintenance is based on the fixed and variable components of the current costs as follows:

- The fixed component cost is independent of traffic levels and relates only to the length of the network (e.g., daily track inspections)
- The variable component is related to the level of wear and tear caused by the rolling stock passing over the infrastructure, recognizing that the unit cost will be different for each type and class of vehicle

Based on the detailed analysis of infrastructure wear and tear costs caused by different vehicle types undertaken over many years by the Office of Rail Regulation in the United Kingdom (UK), the following estimates were used in the unit costs for this category:

- Diesel locomotives create costs of approximately $0.89 per locomotive mile (based on comparator of UK Class 67 locomotives); and
- Coaches cost $0.10 per coach mile (based on comparator of UK Class MKIII coaches).

Table 10 shows that, by applying these unit costs to the modeled miles values, the variable component of Caltrain's infrastructure maintenance cost is identified as $1,971,370. This means the remainder is the fixed component at $5,858,389, which equates to $112,000 per route mile.

TABLE 10: INFRASTRUCTURE MAINTENANCE UNIT COSTS

	FY17 cost	Operating statistics [1]		Weighted average unit costs	
Infrastructure maintenance cost	$7,829,759				
Fixed	$5,858,389	52	Route miles	$112,037	per route mile
Diesel locomotive	$1,237,700	1,390,674	diesel locomotive miles	$0.89	per diesel locomotive mile [2]
Trailer coach	$429,980	4,299,799	coach miles	$0.10	per Trailer coach mile [2]
Bike coach	$117,771	1,177,713	coach miles	$0.10	per Bike coach mile [2]
Cab car	$185,919	1,859,189	coach miles	$0.10	per Cab car mile [2]

Notes: (1) From Service level calcs
(2) From international research

4.1.2.4 STATIONS MAINTENANCE

The calculation of unit costs for station maintenance takes into account the number of stations and their size. For modeling purposes, a relatively simple assumption was made that the stations could be classified as small, medium or large and, with the help of Caltrain Engineering, the 32 stations were classified into four large, four medium, and 24 small. In order to distribute the cost between the stations on an equal basis, weighting factors of six, two, and one respectively were applied to the numbers of stations. As shown in Table 11, this produced a total of 56 equivalent weighted stations. Dividing this number into the total station maintenance cost of $5.169m produced a Unit Cost of $92,304 per weighted station. By applying the weighting factors, it can be deduced that large stations cost $553,823 per year, Medium stations cost $184,608 per year, and Small stations cost $92,304 per year.

TABLE 11: STATION MAINTENANCE UNIT COSTS

	FY17 cost	Number of stations [1]	Weight factor [2]	Weighted stations	Weighted average unit costs	
Stations maintenance cost	$5,169,010					
Large		4	6	24	$553,823	per Large station
Medium		4	2	8	$184,608	per Medium station
Small		24	1	24	$92,304	per Small station
Total		32		56	$92,304	per weighted station

Notes:

1) Stations categorized as Large, Medium, or Small by Caltrain Engineering
2) Modeling assumption that Large stations cost six times Small stations and Medium stations cost two times Small stations

4.2 UNIT COSTS FOR NEW ASSETS AND OPERATIONS

Since Caltrain is in the process of electrifying the railroad and fleet, a set of unit costs to reflect this future operation were developed within the cost model. For the most part, these unit costs were developed based on the experience of other electrified railroads using similar types of equipment. The unit costs for the relevant cost categories that would be different under an electrified operation are presented in the subsections below.

4.2.1 TRAIN CREW

This section describes the derivation of unit costs for train crew operating the new EMU sets. Assumptions based on direction from Caltrain operations staff are as follows:

- The cost per paid hour for each of Engineer, Conductor, and Assistant Conductor will remain the same as the unit costs calculated for the current operation, hence the cost for a three-person crew will remain at $239.94 per crew hour;
- 7 and 8 car EMUS will require one additional Assistant Conductor; and
- 9 and 10 car EMUS will require a second additional Assistant Conductor.

Table 12 shows the derivation of the train crew cost per crew paid hour for EMU trainsets of varying length.

TABLE 12: EMU TRAIN CREW COSTS PER CREW PAID HOUR

New rolling stock	Code	Base crew Number	Cost per paid hour	Additional Asst Cond.	Cost per paid hour	Total crew cost per paid hour
6 car EMU set	EMUBL6	3	$224.49	0	$0.00	$224.49
7 car EMU set	EMUBL7	4	$224.49	1	$67.34	$291.83
8 car EMU set	EMUBL8	4	$224.49	1	$67.34	$291.83
10 car EMU set	EMUBL10	5	$224.49	2	$134.68	$359.17

4.2.2 ROLLING STOCK MAINTENANCE

Inputs for the calculation of unit costs for the maintenance of the new EMU fleet were taken from the Full Funding Grant Agreement (FFGA) for the corridor electrification project as follows:

- Powered EMU car – $167,000 per year based on recent National Transit Database data for northeastern US-type EMUs
- Unpowered EMU car – $84,000 per year escalated from Caltrain's FY14 maintenance cost for a diesel coach

The following assumptions were utilized in developing the unit costs:

- Adjust to 2018 dollars using the Implicit Price Deflators for Gross Domestic Product – multiply by 1.052 to inflate from 2015 prices to 2018 prices
- 30 percent time-based, 70 percent usage-based (consistent with assumption for current rolling stock)
- From Caltrain calculations supporting the FFGA:
  - 1,481,480 six-car EMU set miles per year in revenue service
  - Fleet of 16 six-car EMU sets
- 7th car is powered, 8th car is unpowered, 9th car is powered, 10th car is unpowered

Using the data from the FFGA, a series of calculations were employed to derive the unit costs as noted below.

- Step 1 – Calculate costs assuming 100 percent time based
  - 1,481,480 six-car EMU set miles per year in revenue service plus 12 percent deadheading = 1,660,000 six-car EMU set miles per year in total = 9,960,000 EMU car miles per year

- For a fleet of 96 EMU cars, that produces an average of 103,750 EMU car miles per year for each EMU car
- Based on an assumption of the costs being 100 percent time-based, the FFGA data presented costs per EMU car per year (in 2015 prices) of:
  - Powered EMU car – $167,000
  - Unpowered EMU car – $84,000

- Step 2 – Calculate the costs assuming 100 percent time-based allocation of costs results in these costs (in 2015 prices):
  - Powered EMU car – $167,000 / 103,750 = $1.61 per car mile
  - Unpowered EMU car – $84,000 / 103,750 = $0.81 per car mile

- Step 3 – Apply the current assumption that Caltrain's fleet maintenance costs are 30 percent time-based (cost per vehicle) and 70 percent usage-based (cost per vehicle mile). Applying these assumptions to the unit costs above produces the following unit costs (in 2015 prices):
  - Powered EMU car:
    - $167,000 per year by 30% = $50,100 per year plus
    - $1.61 per car mile by 70% = $1.13 per car mile
  - Unpowered EMU car: $25,200 per year plus $0.57 per car mile
    - $84,000 per year by 30% = $25,200 per year plus
    - $0.81 per car mile by 70% = $0.57 per car mile

- Step 4 – Escalating these numbers to 2018 prices produces unit costs of
  - Powered EMU car: $52,705 per year plus $1.19 per car mile
  - Unpowered EMU car: $26,510 per year plus $0.60 per car mile

Table 13 shows the resulting EMU rolling stock maintenance costs.

TABLE 13: EMU ROLLING STOCK MAINTENANCE COSTS

New rolling stock	Unit cost	Per Unit
Vehicle mile-related		
6-car EMU set	$5.37	per 6-car EMU set mile
7-car EMU set	$6.56	per 7-car EMU set mile
8-car EMU set	$7.16	per 8-car EMU set mile
10-car EMU set	$8.95	per 10-car EMU set mile
Vehicle-related		
Powered EMU car	$52,705	per Powered EMU car per year
Unpowered EMU car	$26,510	per Unpowered EMU car per year

4.2.3 INFRASTRUCTURE MAINTENANCE

The derivation of a unit cost for the infrastructure wear and tear for the new EMU cars assumed that the Stadler cars being purchased for electrification are similar to the UK's class 350 that has a unit cost of £0.11 per car mile. Using an exchange rate of 1.3, this produces a unit cost of $0.15 per car mile or $0.90 per six-car EMU set mile.

Table 14 shows the resulting EMU infrastructure maintenance unit costs for sets of various lengths derived by factoring up from the six-car value.

TABLE 14: EMU INFRASTRUCTURE MAINTENANCE COSTS

New rolling stock infrastructure maintenance unit costs		
6-car EMU set	$0.90	per 6-car EMU set mile
7-car EMU set	$1.05	per 7-car EMU set mile
8-car EMU set	$1.20	per 8-car EMU set mile
10-car EMU set	$1.50	per 10-car EMU set mile

4.2.4 ELECTRICAL EQUIPMENT MAINTENANCE

The electrical equipment needed to run the new EMU fleet is made up of Overhead Catenary System (OCS) and Traction Power Substations (TPS). This analysis assumed that TPS maintenance is time-based only, and that 10 percent of the OCS/TPS maintenance is usage-based, and the remaining 90 percent is independent of usage and can be expressed as cost per electrified route mile.

Table 15 shows how unit costs were derived for the fixed and variable components of Caltrain's forecast annual budget of $12 million for OCS/TPS maintenance by attributing 90 percent of it to fixed and 10 percent of it to variable, then dividing the variable component by the number of EMU set miles in the first year of the electrified railroad.

TABLE 15: ELECTRICAL EQUIPMENT MAINTENANCE UNIT COSTS

		FY17 cost	Operating statistics [1]		Unit costs	
OCS/TPS maintenance cost		$12,000,000				
Fixed	90%	$10,800,000	52.29	Electrified Route miles	206,540	per electrified route mile
Variable per EMU set mile	10%	$1,200,000	2,239,029	EMU set miles	0.536	per EMU set mile

Notes: (1) From Service level calcs

4.2.5 ELECTRICITY FOR TRACTION

Calculation of unit costs for Electricity for Traction for the new EMU fleet were based on the following assumptions from the FFGA and TAM Plan:

- Electricity for propulsion: $0.11 per kWh
- Consumption rate: 8.23 kWh per EMU car mile
- Inflation at three percent per year

A unit cost of $5.88 per six-car EMU set mile was derived from $0.11 per kWh, 8.23 kWh per EMU car mile, escalated from 2015 prices to 2018 prices. Table 16 shows how unit costs for longer EMU sets were factored up from the six-car set unit cost.

TABLE 16: ELECTRICITY FOR TRACTION UNIT COSTS

Electricity for traction cost	Unit costs	
EMU six-car set	$5.88	per EMUBL6 set mile
EMU 7-car set	$6.86	per EMUBL7 set mile
EMU 8-car set	$7.84	per EMUBL8 set mile
EMU 10-car set	$9.80	per EMUBL10 set mile

4.2.6 PTC OPERATION AND MAINTENANCE

Once the installation of the PTC system is complete, some of the capital staff will transition into an ongoing cost of operating and maintaining the PTC system, but the cost model does not explicitly identify this cost – rather it is assumed, for the time being, that these staff will be included in the large increase in Caltrain staff being modeled for the early years of the planning period.

4.3 CALTRAIN'S STAFF AND OTHER ADMIN COSTS

Caltrain's staff and other administration costs include the Full Time Equivalent (FTE) staff cost of Caltrain's technical and administrative departments, and other administration costs mainly relating to building services and staff-related overheads. It is expected that Caltrain's staff costs will increase as the level of operation increases over time, and it may be reasonable to expect some change in other administration costs as the size of Caltrain staff changes.

While recognizing that, in the long term, a detailed staffing model may be appropriate, for Business Planning purposes at this stage, the cost model addresses Caltrain's staff and other administration costs with a simple model based on the following assumptions:

- 20 percent of staff costs to be made variable with the scale of the operation (represented by train miles)
- The remaining 80 percent of staff costs will be subject to policy-driven growth rates reflecting planned ramp-up, committed increases, etc.
- The other administration costs will be subject to growth rates that reflect in part the assumed changes in Staff costs

Table 17 shows how staff and other admin costs are separated into the base component that is then subject to the assumed growth rates per year, and the scale-driven component that is then converted into a unit cost per train mile.

TABLE 17: STAFF AND OTHER ADMIN BASE AND UNIT COSTS

	FY17 cost	Base cost subject to Growth	Variable cost				
			Cost	Operating statistics		Unit costs	
Staff costs	13,559,874						
Scale-related staff costs (to be driven by train miles)	20%		2,711,975	1,390,674	Caltrain train miles [1]	$1.95	per train mile
Policy-driven staff costs	80%	10,847,899					
Other admin overheads	11,365,058						
Policy-driven other admin costs	100%	11,365,058					

Notes: (1) From Service level calcs

Since Caltrain is demonstrably very understaffed right now – somewhat for the steady state operation but more specifically for the near term implementation of electrified service and additional growth assumed in the growth scenarios – the model includes a substantial ramping up for the period through 2033, and then a smaller growth increment beyond that is tied to train miles.

Table 18 shows the assumed growth rates for policy-driven staff and other admin costs and the periods through which they are applied to the Baseline Growth Scenario.

TABLE 18: ASSUMED GROWTH RATES FOR POLICY-DRIVEN STAFF AND OTHER ADMIN COSTS

Growth period				Growth rates per annum	
Scenario		Start	End	Staff cost	Other Admin
1	Base Year service	2018	2021	10%	2%
4	Base PCEP, 6tph, mixed fleet	2022	2028	5%	2%
8	VtoV CA HSR	2029	2032	2%	2%
10	CA HSR Phase 1	2033	2039	0%	2%

5 DETAILED O&M COST ESTIMATES

This section covers the results of the modeling process; the detailed cost estimates for the base (existing) year and for the Service Vision Growth scenarios. To confirm the model was working correctly, it was first calibrated to the base year costs. Then the model was used to estimate future year O&M costs for the growth scenarios.

5.1 BASE YEAR CALIBRATION

The first step of the estimating process was to validate the model by demonstrating that the O&M cost estimates for the base year calibrate to the control total(s) of the input costs. The FY17 operating and maintenance cost control totals from Table 4 are as follows:

- Fixed $50,195,527
- Variable $83,739,941
- **Total $133,935,468**

As shown in Table 19 the cost estimates for the base year (FY17) calibrate to these totals, validating the model for use in estimating O&M costs with the model for future years.

TABLE 19: CALIBRATION TO BASE YEAR OPERATING COSTS

Variable Operating Costs

	Cost Category	Unit cost ($)		Base Year Unit values		Base Year cost ($m)
1	Crew costs - D1BL5	224.49	per D1BL5 crew paid hours	112,699	D1BL5 crew paid hours	25.30
	- D1BL6	224.49	per D1BL6 crew paid hours	33,353	D1BL6 crew paid hours	7.49
	- D1BL7	291.83	per D1BL7 crew paid hours	0	D1BL7 crew paid hours	0.00
	- EMUBL6	224.49	per EMUBL6 crew paid hours	0	EMUBL6 crew paid hours	0.00
	- EMUBL7	291.83	per EMUBL7 crew paid hours	0	EMUBL7 crew paid hours	0.00
	- EMUBL8	291.83	per EMUBL8 crew paid hours	0	EMUBL8 crew paid hours	0.00
	- EMUBL10	359.17	per EMUBL10 crew paid hours	0	EMUBL10 crew paid hours	0.00
	- HSRBL8	291.83	per HSRBL8 crew paid hours	0	HSRBL8 crew paid hours	0.00
	- HSRBL16	426.51	per HSRBL16 crew paid hours	0	HSRBL16 crew paid hours	0.00
2	Dispatching costs	0.258	per train miles	1,390,674	train miles	0.36
3	Contractor other Ops	0.000	per train miles	1,390,674	train miles	0.00
4	Rolling stock mtce- Diesel loco	3.564	per diesel loco miles	1,390,674	diesel loco miles	4.96
	- Trailer Coach	1.550	per Trailer coach miles	4,299,799	Trailer coach miles	6.66
	- Bike Coach	1.550	per Bike coach miles	1,177,713	Bike coach miles	1.83
	- Cab car	1.937	per Cab car miles	1,859,189	Cab car miles	3.60
	- Diesel loco	80,134	per diesel loco per year	29	Diesel locos	2.32
	- Cab car	43,551	per Cab car per year	36	Cab cars	1.57
	- Coach	34,841	per coach per year	98	Coach	3.41
	- EMU 6-car set	5.370	per EMUBL6 set miles	0	EMUBL6 set miles	0.00
	- EMU 7-car set	6.560	per EMUBL7 set miles	0	EMUBL7 set miles	0.00
	- EMU 8-car set	7.160	per EMUBL8 set miles	0	EMUBL8 set miles	0.00
	- EMU 10-car set	8.950	per EMUBL10 set miles	0	EMUBL10 set miles	0.00
	- HSR 8-car set	7.160	per 8 car HSR set miles	0	HSRBL8 set miles	0.00
	- Powered EMU car	52,705	per Powered EMU car per year	0	Powered EMU car	0.00
	- Unpowered EMU car	26,510	per Unpowered EMU car per year	0	Unpowered EMU car	0.00
5	Infrastructure maintenance - Fixed	112,037	per Caltrain-owned Route miles	52	Caltrain-owned Route miles	5.86
	- Diesel loco	0.890	per diesel loco miles	1,390,674	diesel loco miles	1.24
	- Trailer Coach	0.100	per Trailer coach miles	4,299,799	Trailer coach miles	0.43
	- Bike Coach	0.100	per Bike coach miles	1,177,713	Bike coach miles	0.12
	- Cab car	0.100	per Cab car miles	1,859,189	Cab car miles	0.19
	- EMU 6-car set	0.900	per EMUBL6 set miles	0	EMUBL6 set miles	0.00
	- EMU 7-car set	1.050	per EMUBL7 set miles	0	EMUBL7 set miles	0.00
	- EMU 8-car set	1.200	per EMUBL8 set miles	0	EMUBL8 set miles	0.00
	- EMU 10-car set	1.500	per EMUBL10 set miles	0	EMUBL10 set miles	0.00
	- HSR 8-car set	1.200	per 8 car HSR set miles	0	HSRBL8 set miles	0.00
6	OCS/TPS maintenance- Fixed	206,540	per Caltrain electrified Route miles	0	Caltrain electrified Route miles	0.00
	- train mile	0.536	per train miles	0	train miles	0.00
7	Stations mtce - Large	553,823	per Large station	4	Large station	2.22
	- Medium	184,608	per Medium station	4	Medium station	0.74
	- Small	92,304	per Small station	24	Small station	2.22
8	Contractor Admin	0.000	per train miles	1,390,674	train miles	0.00
9	Fuel	6.185	per diesel loco miles	1,390,674	diesel loco miles	8.60
10	Other Operational	0.571	per train miles	1,390,674	train miles	0.79
11	Administration - variable	1.950	per Caltrain train miles	1,390,674	Caltrain train miles	2.71
12	Shuttle operations	0.000	per train miles	1,390,674	train miles	0.00
13	Clipper	12,270	per Revenue ($m)	92	Revenue ($m)	1.13
14	Existing Track Access costs	0.000	per Train miles by Caltrain on UP track	38,205	Train miles by Caltrain on UP track	0.00
15	Electricity for traction - EMU 6-car set	5.880	per EMUBL6 set miles	0	EMUBL6 set miles	0.00
	- EMU 7-car set	6.860	per EMUBL7 set miles	0	EMUBL7 set miles	0.00
	- EMU 8-car set	7.840	per EMUBL8 set miles	0	EMUBL8 set miles	0.00
	- EMU 10-car set	9.800	per EMUBL10 set miles	0	EMUBL10 set miles	0.00
	- HSR 8-car set	7.840	per 8 car HSR set miles	0	HSRBL8 set miles	0.00
	TOTAL VARIABLE OPERATING COST					83.74

Fixed Operating Costs

	Cost Category					Base Year cost ($m)
1	Crew costs					0.00
2	Dispatching costs					3.23
3	Contractor other Ops					0.52
4	Rolling stock maintenance					0.00
5	Track maintenance					0.00
6	OCS/TPS maintenance					0.00
7	Station mtce					1.20
8	Contractor Admin					6.26
9	Diesel Fuel					0.00
10	Other Operational					12.15
11	Administration					22.21
12	Shuttle					4.58
13	Clipper					0.00
14	Existing Track Access costs					0.03
	TOTAL FIXED OPERATING COST					50.20
	TOTAL OPERATING COST					133.94

5.2 ESTIMATING COSTS FOR GROWTH SCENARIOS

Cost estimates were developed for each of the three growth scenarios (Baseline Growth, Moderate Growth, High Growth) over the planning period. These estimates were based on the following key inputs and model components:

- Operating statistics by cost category by year from the operations module of the IBM
- Unit costs by cost category by year from unit cost calculation (described in section 4), and
- Within each cost category, for each year the O&M cost estimate for Caltrain is derived by multiplying each variable unit cost by the appropriate operating statistic and adding the fixed cost. In addition, costs were estimated for CA HSR service.

5.2.1 SUMMARIZATION AND PRESENTATION OF COST ESTIMATES

Each of the Growth Scenarios includes a profile of growth in train service over time with service levels and the associated O&M costs increasing at a series of change points. In between these change points, service and costs are projected to remain constant. These change points are shown in Figure 2 below.

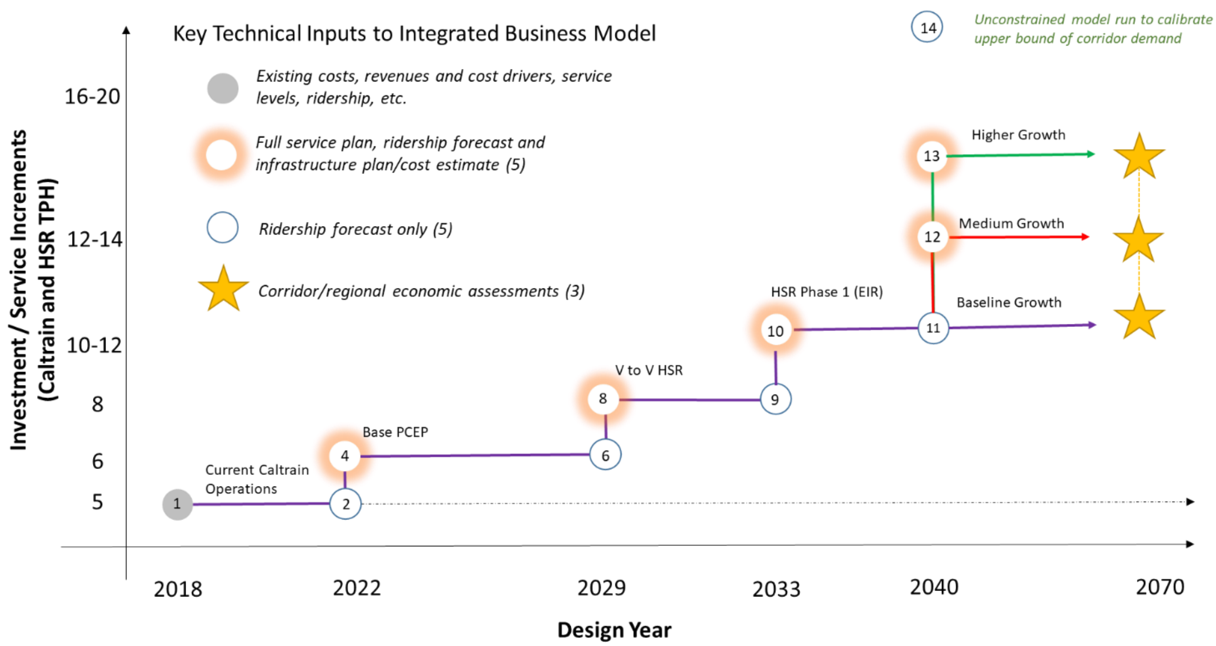

FIGURE 2: GROWTH PROFILES AND CHANGE POINTS

For the purposes of summarization, the following periods of time between change points from Figure 2 are used to present the cost estimates:

- Common to All Growth Scenarios:
  - 2018-22 Current Caltrain Operations
  - 2022-28 Base PCEP
  - 2029-32 Valley to Valley CA HSR
  - 2033-39 CA HSR Phase 1 Complete

- Unique to Each Growth Scenario from 2040-70:
  - Baseline Growth
  - Moderate Growth
  - High Growth

5.2.2 CALIFORNIA HIGH-SPEED RAIL COST ESTIMATES

Due to the complex interaction between Caltrain operations and CA HSR train operations, the IBM models the entirety of the combined operation of the two agencies, but estimates operating and maintenance costs for the HSR trains using token estimated unit costs. The cost estimates presented in this report include CA HSR O&M costs, but separately identifies these costs (generally colored blue) since they are not the focus of the analysis.

5.3 RESULTS

Table 20 presents the detailed annual cost estimates for the growth scenarios during each of the time periods through the Year 2070. As the table shows, the total annual O&M costs during the Year 2040 and 2070 period range from $263m for Baseline to 407m a year for High Growth, compared to $134m today. Figure 3 shows how costs are estimated to grow over time under each of the three growth scenarios. As previously noted, the costs for all three scenarios are common until 2039, growing from $134 million per year in 2018 to $261 million per year in 2039. The scenarios diverge from 2040 where the Moderate Growth shows an increase of $100 million per year above the Baseline Growth and the High Growth shows an increase of $150 million per year above the Baseline Growth.

TABLE 20: DETAILED OPERATING COSTS OVER TIME

				Common to all Growth Scenarios				BG	MG	HG
				2018-21	2022-28	2029-32	2033-39	2040-70	2040-70	2040-70
Variable O&M costs										
1	1	Crew costs - D1BL5	per D1BL5 crew paid hours	24.60	0.00	0.00	0.00	0.00	0.00	0.00
	2	- D1BL6	per D1BL6 crew paid hours	8.18	0.99	0.00	0.00	0.00	0.00	0.00
	3	- D1BL7	per D1BL7 crew paid hours	0.00	1.32	0.00	0.00	0.00	0.00	0.00
	4	- EMUBL6	per EMUBL6 crew paid hours	0.00	0.00	0.00	0.00	0.00	94.08	112.56
	5	- EMUBL7	per EMUBL7 crew paid hours	0.00	56.77	0.00	0.00	0.00	0.00	0.00
	6	- EMUBL8	per EMUBL8 crew paid hours	0.00	0.00	81.85	81.85	81.85	0.00	0.00
	7	- EMUBL10	per EMUBL10 crew paid hours	0.00	0.00	0.00	0.00	0.00	41.85	41.37
	8	- HSRBL8	per HSRBL8 crew paid hours	0.00	0.00	27.90	68.55	68.55	66.44	65.56
	9	- HSRBL16	per HSRBL16 crew paid hours	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	10	Dispatching costs	per train miles	0.36	0.58	1.25	1.92	1.92	2.69	2.98
3	11	Contractor other Ops	per train miles	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	12	Rolling stock mtce- Diesel loco	per diesel loco miles	4.96	0.38	0.00	0.00	0.00	0.00	0.00
	13	- Trailer Coach	per Trailer coach miles	6.66	0.69	0.00	0.00	0.00	0.00	0.00
	14	- Bike Coach	per Bike coach miles	1.83	0.10	0.00	0.00	0.00	0.00	0.00
	15	- Cab car	per Cab car miles	3.60	0.36	0.00	0.00	0.00	0.00	0.00
		- Diesel loco	per diesel loco per year	2.32	0.88	0.00	0.00	0.00	0.00	0.00
		- Cab car	per Cab car per year	1.57	0.57	0.00	0.00	0.00	0.00	0.00
		- Coach	per coach per year	3.41	1.67	0.00	0.00	0.00	0.00	0.00
	16	- EMU 6-car set	per EMUBL6 set miles	0.00	0.00	0.00	0.00	0.00	25.53	31.62
	17	- EMU 7-car set	per EMUBL7 set miles	0.00	13.98	0.00	0.00	0.00	0.00	0.00
	18	- EMU 8-car set	per EMUBL8 set miles	0.00	0.00	22.87	24.05	24.05	0.00	0.00
	19	- EMU 10-car set	per EMUBL10 set miles	0.00	0.00	0.00	0.00	0.00	13.97	13.97
	20	- HSR 8-car set	per 8 car HSR set miles	0.00	0.00	11.81	29.38	29.38	29.38	29.38
		- Powered EMU car	per Powered EMU car per year	0.00	4.01	5.48	5.48	5.48	9.22	12.65
		- Unpowered EMU car	per Unpowered EMU car per year	0.00	1.51	2.76	2.76	2.76	4.64	6.36
5	21	Infrastructure maintenance - Fixed	per Caltrain-owned Route miles	5.86	5.86	5.86	5.86	5.86	5.86	5.86
	22	- Diesel loco	per diesel loco miles	1.24	0.10	0.00	0.00	0.00	0.00	0.00
	23	- Trailer Coach	per Trailer coach miles	0.43	0.04	0.00	0.00	0.00	0.00	0.00
	24	- Bike Coach	per Bike coach miles	0.12	0.01	0.00	0.00	0.00	0.00	0.00
	25	- Cab car	per Cab car miles	0.19	0.02	0.00	0.00	0.00	0.00	0.00
	26	- EMU 6-car set	per EMUBL6 set miles	0.00	0.00	0.00	0.00	0.00	4.28	5.30
	27	- EMU 7-car set	per EMUBL7 set miles	0.00	2.24	0.00	0.00	0.00	0.00	0.00
	28	- EMU 8-car set	per EMUBL8 set miles	0.00	0.00	3.83	4.03	4.03	0.00	0.00
	29	- EMU 10-car set	per EMUBL10 set miles	0.00	0.00	0.00	0.00	0.00	2.34	2.34
	30	- HSR 8-car set	per 8 car HSR set miles	0.00	0.00	1.98	4.92	4.92	4.92	4.92
6	31	OCS/TPS maintenance- Fixed	per Caltrain electrified Route miles	0.00	10.80	10.80	10.80	10.80	10.80	10.80
	32	- train mile	per train miles	0.00	1.20	2.60	4.00	4.00	4.00	4.00
7	33	Stations mtce - Large	per Large station	2.22	2.22	2.22	2.22	2.22	2.22	2.22
	34	- Medium	per Medium station	0.74	0.74	0.74	0.74	0.74	0.74	0.74
	35	- Small	per Small station	2.22	2.22	2.22	2.22	2.22	2.22	2.22
8	36	Contractor Admin	per train miles	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	37	Fuel	per diesel loco miles	8.60	0.66	0.00	0.00	0.00	0.00	0.00
10	38	Other Operational	per train miles	0.79	1.28	2.76	4.26	4.26	5.95	6.60
11	39	Administration - variable	per Caltrain train miles	2.71	4.37	6.23	6.55	6.55	12.32	14.53
12	40	Shuttle operations	per train miles	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	41	Clipper	per Revenue	1.13	1.57	2.39	2.55	2.84	3.28	3.78
14	42	Existing Track Access costs	per Train miles by Caltrain on UP track	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	43	Electricity for traction - EMU 6-car set	per EMUBL6 set miles	0.00	0.00	0.00	0.00	0.00	27.96	34.62
	44	- EMU 7-car set	per EMUBL7 set miles	0.00	14.62	0.00	0.00	0.00	0.00	0.00
	45	- EMU 8-car set	per EMUBL8 set miles	0.00	0.00	25.04	26.33	26.33	0.00	0.00
	46	- EMU 10-car set	per EMUBL10 set miles	0.00	0.00	0.00	0.00	0.00	15.30	15.30
	47	- HSR 8-car set	per 8 car HSR set miles	0.00	0.00	12.93	32.17	32.17	32.17	32.17
		TOTAL VARIABLE OPERATING COST	this total includes HSR op costs	83.74	131.74	233.49	320.64	320.93	422.16	461.84
				For calibration to input variable costs in Unit Cost Calculation						
Fixed O&M costs										
	1	Crew costs		0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	Dispatching costs		3.23	3.23	3.23	3.23	3.23	3.23	3.23
	3	Contractor other Ops		0.52	0.52	0.52	0.52	0.52	0.52	0.52
	4	Rolling stock maintenance		0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	Track maintenance		0.00	0.00	0.00	0.00	0.00	0.00	0.00
	6	OCS/TPS maintenance		0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	Station mtce		1.20	1.20	1.20	1.20	1.20	1.20	1.20
	8	Contractor Admin		6.26	6.26	6.26	6.26	6.26	6.26	6.26
	9	Diesel Fuel		0.00	0.00	0.00	0.00	0.00	0.00	0.00
	10	Other Operational		12.15	12.15	12.15	12.15	12.15	12.15	12.15
	11	Administration		22.21	31.14	39.78	42.52	44.53	44.53	44.53
	12	Shuttle		4.58	4.58	4.58	4.58	4.58	4.58	4.58
	13	Clipper		0.00	0.00	0.00	0.00	0.00	0.00	0.00
	14	Existing Track Access costs		0.03	0.03	0.03	0.03	0.03	0.03	0.03
		TOTAL FIXED OPERATING COST		50.20	59.13	67.76	70.51	72.51	72.51	72.51
Total Caltrain Operating Costs										
	1	Crew		32.79	59.07	81.85	81.85	81.85	135.94	153.93
	2	Dispatching		3.59	3.81	4.48	5.15	5.15	5.92	6.21
	3	Contractor other Ops		0.52	0.52	0.52	0.52	0.52	0.52	0.52
	4	Rolling stock maintenance		24.35	24.16	31.10	32.28	32.28	53.37	64.60
	5	Infrastructure maintenance		7.83	8.26	11.67	14.81	14.81	17.40	18.42
	6	OCS/TPS maintenance		0.00	12.00	13.40	14.80	14.80	14.80	14.80
	7	Station mtce		6.37	6.37	6.37	6.37	6.37	6.37	6.37
	8	Contractor Admin		6.26	6.26	6.26	6.26	6.26	6.26	6.26
	9	Fuel		8.60	0.66	0.00	0.00	0.00	0.00	0.00
	10	Other Operational		12.94	13.43	14.91	16.41	16.41	18.10	18.74
	11	Administration		24.92	35.51	46.00	49.07	51.08	56.85	59.06
	12	Shuttle		4.58	4.58	4.58	4.58	4.58	4.58	4.58
	13	Clipper		1.13	1.57	2.39	2.55	2.84	3.28	3.78
	14	Existing Track Access costs		0.03	0.03	0.03	0.03	0.03	0.03	0.03
	15	Electricity for Traction		0.00	14.62	25.04	26.33	26.33	43.26	49.92
		Total Caltrain		133.94	190.87	248.61	261.03	263.33	366.68	407.24
Direct HS1 Operating Costs										
		HSR Crew		0.00	0.00	27.90	68.55	68.55	66.44	65.56
		HSR Rolling stock maintenance		0.00	0.00	11.81	29.38	29.38	29.38	29.38
		HSR Electricity		0.00	0.00	12.93	32.17	32.17	32.17	32.17
		Check: Caltrain + HSR = Variable + Fixed		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

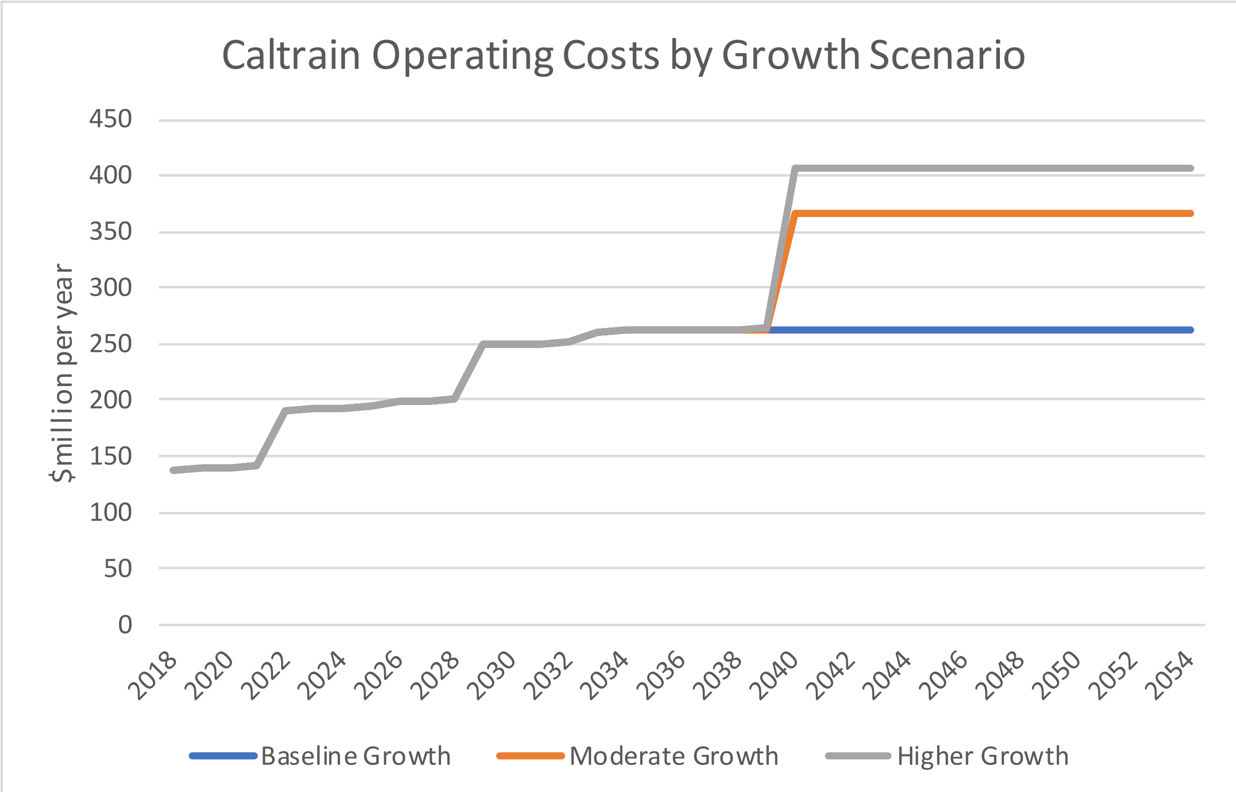

FIGURE 3: CALTRAIN OPERATING COSTS BY GROWTH SCENARIO

Using the Moderate Growth Scenario as an example, Figure 4 shows the breakdown by cost category of estimated O&M costs. The largest costs are train crews, followed by administration and rolling stock maintenance.

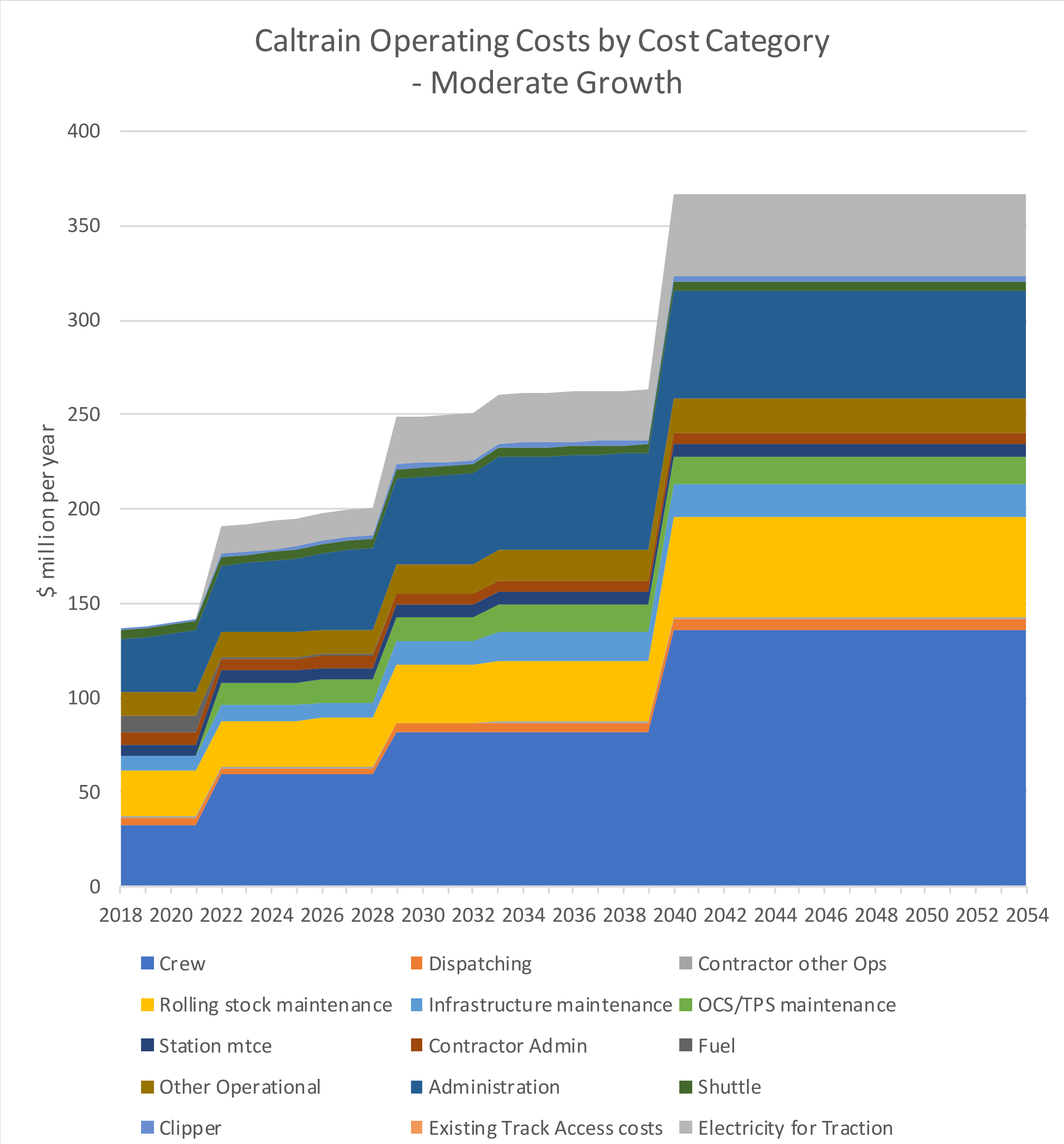

FIGURE 4: CALTRAIN OPERATING COSTS BY COST CATEGORY – MODERATE GROWTH SCENARIO

The main drivers of the cost increases over time are as follows:

- Crew costs rise both because the number of trains being operated increases and because the number of train crew per train increases as the trains become longer.
- Rolling stock maintenance costs increase as the level of service and fleet size both grow.
- As the service becomes electrified, diesel fuel costs are replaced by the cost of electricity for traction which increases as the number and length of trains being operated increases.
- The costs of administration staff and overheads increase in line with the need to manage a growing railroad.

The main increases in operating costs associated with each change point, and the drivers of these costs, are as follows:

- Change Point 4: in 2022 when corridor electrification is complete and the mixed fleet service begins:
    - Increased service levels require additional crew costs ($27m) and traction energy costs ($7m)
    - A ramp up in administrative staff is required to manage the expanded operation ($11m)
    - New OCS/TPS equipment requires maintenance cost ($12m)
- Change Point 8: in 2029 when the service is fully electrified and extended to run from Tamien to San Francisco, Salesforce Transbay Center and the AM and PM peak hours are increased from three to five hours each:
    - Increased service levels and the addition of an 8th car to each EMU set generate additional crew costs ($22m) and traction energy costs ($11m)
    - A further ramp up in admin staff is required to manage the expanded operation ($12m)
    - Increase in service levels, fleet size and train lengths causes increase in fleet maintenance costs ($6m) and infrastructure and OCS/TPS maintenance costs ($5m)
- Change Point 10: in 2033 when CA HSR substantially increases its service levels
    - Increased CA HSR service levels generate increased costs of Infrastructure and OCS/TPS maintenance costs ($4m)
    - The costs of administration staff and overheads continue to be increased ($3m)

6 TRACK ACCESS CHARGES

Caltrain has a number of existing agreements with UP, ACE, Capitol Corridor and other parties which involve Caltrain both paying for use of other railroad's assets and receiving payment from other railroads for the use of JPB-owned assets. These types of payments are known as Track Access (TA) charges. As a modeling convenience, the IBM assumes the small amounts of TA revenue and cost associated with these existing agreements is fixed.

Of greater significance is the estimation of TA payments between Caltrain and the CA HSR for use of each other's infrastructure – particularly when the costs start rising steeply as a result of HSR's proposed rapid increase in level of operation in the late 2020s.

This section covers the approach to estimating track access charges and the results used in the Business Planning process. All calculations shown are conceptual and would ultimately be determined through and subject to future agreements between Caltrain and CA HSR.

6.1 INPUTS AND CALCULATIONS

The estimating process for track access charges identifies the share of each other's maintenance costs that Caltrain and CA HSR should be paying for use of the other's infrastructure. From Caltrain's point of view, the following relationships need to be captured in the estimates:

- Revenue from CA HSR paying for its share of Caltrain's maintenance of the infrastructure between CP Lick (a defined point approximately one mile south of Tamien) and San Francisco
- An operating cost to be paid to CA HSR for Caltrain's share of CA HSR's maintenance of the HSR-proposed infrastructure between CP Lick and Gilroy

To develop the estimates of the access charges three inputs are needed. The first is the number of train miles to be operated by Caltrain and CA HSR on their own and each other's tracks as taken from the operations module of the IBM. These inputs are shown in Table 21.

TABLE 21: TRAIN MILES BY OPERATOR AND TRACK OWNER

	Annual train miles (millions)	Common to all Growth Scenarios				BG	MG	HG
		2018-21	2022-28	2029-32	2033-39	2040-70	2040-70	2040-70
1	**Total train miles**	**1.39**	**2.24**	**5.03**	**7.46**	**7.46**	**10.42**	**11.55**
	Caltrain train miles	1.39	2.24	3.36	3.36	3.36	6.32	7.45
	Train miles by Caltrain on JPB track	1.35	2.21	3.23	3.23	3.23	5.53	6.67
	Train miles by Caltrain on UP track	0.04	0.03	0.13	0.13	0.13	0.78	0.78
	CA HSR train miles	0.00	0.00	1.67	4.10	4.10	4.10	4.10
	Train miles by CA HSR on JPB track	0.00	0.00	0.96	2.37	2.37	2.37	2.37
	Train miles by CA HSR on UP track	0.00	0.00	0.71	1.74	1.74	1.74	1.74

The second input is the portion of Caltrain's O&M costs that are eligible to be shared. As the track access charges are based on the degree of wear and tear caused by train traffic, the cost basis for these charges is only those cost categories that have been determined as being variable with train miles. The eligible costs in both the operating maintenance and the capital maintenance are shown in Table 22.

TABLE 22: CALTRAIN MAINTENANCE COSTS TO BE SHARED BY CA HSR

		Common to all Growth Scenarios				BG	MG	HG
		2018-21	2022-28	2029-32	2033-39	2040-70	2040-70	2040-70
O&M costs for sharing ($m)								
2	Dispatching	3.59	3.81	4.53	5.15	5.15	5.92	6.21
5	Infrastructure maintenance	7.83	8.26	11.89	14.81	14.81	17.40	18.42
6	OCS/TPS maintenance	0.00	12.00	13.50	14.80	14.80	14.80	14.80
	Total O&M cost to be shared	11.42	24.07	29.91	34.77	34.77	38.12	39.43
Capital maintenance (SOGR) costs for sharing ($m)								
1	Track & Structures	5.80	5.43	10.96	11.43	11.43	12.65	21.74
2	Grade crossings	0.00	0.38	0.45	0.45	0.57	0.99	1.16
4	Signaling/PTC	0.00	0.94	0.94	0.94	0.94	0.94	0.94
5	OCS/TPS	0.00	1.44	1.44	1.44	1.44	1.44	1.44
	Total SOGR cost to be shared	5.80	8.20	13.80	14.26	14.38	16.03	25.28
Total O&M + Capital maintenance cost ($m)		**17.22**	**32.26**	**43.71**	**49.03**	**49.14**	**54.15**	**64.71**

The last input is the track access rate per train mile. This is calculated by dividing Caltrain's total eligible maintenance cost by the total number of train miles operated on the JPB track as shown in Table 23.

TABLE 23: CALCULATION OF TRACK ACCESS CHARGE RATE PER TRAIN MILE

	Common to all Growth Scenarios				BG	MG	HG
	2018-21	2022-28	2029-32	2033-39	2040-70	2040-70	2040-70
Total O&M + Capital maintenance cost ($m)	17.22	32.26	43.71	49.03	49.14	54.15	64.71
Total Train miles on JPB track (m)	1.35	2.21	4.19	5.60	5.60	7.90	9.03
Track Access charge rate ($ per train mile)	12.73	14.61	10.42	8.76	8.78	6.86	7.17

Note: The fact that the average cost per train mile varies slightly with the level of service suggests that further, more detailed cost analysis is advisable when it comes to actually implementing the TA charges to improve upon the current modeling assumptions.

6.2 RESULTS

The final outputs of the track access charging sub-module are the amount to be paid to Caltrain by CA HSR for use of the JPB track, and the amount to be paid by Caltrain to CA HSR for use of the CA HSR track. The amount to be paid to Caltrain by CA HSR is calculated by applying the Track Access rate from Table 23 to the train miles operated by CA HSR on JPB track from Table 21 as shown in Table 24.

TABLE 24: TRACK ACCESS INCOME FROM CA HSR

	Common to all Growth Scenarios				BG	MG	HG
	2018-21	2022-28	2029-32	2033-39	2040-70	2040-70	2040-70
Amount to be paid to Caltrain by CA HSR ($m)							
Train miles by CA HSR on JPB track	0.00	0.00	0.96	2.37	2.37	2.37	2.37
Track Access charge rate ($ per train mile)	0.00	0.00	10.42	8.76	8.78	6.86	7.17
Total TA charged to CA HSR by Caltrain ($m)	0.00	0.00	10.03	20.72	20.77	16.21	16.95

As the Track Access rate that CA HSR will charge Caltrain is yet to be negotiated, for Business Planning purposes it is assumed that CA HSR will charge Caltrain the same rate per train mile as Caltrain charges CA HSR. Hence the amount to be paid to CA HSR by Caltrain is calculated by applying the Track Access rate from Table 23 to the train miles operated by Caltrain on CA HSR track from Table 21 as shown in Table 25.

TABLE 25: AMOUNT TO BE PAID TO CA HSR FOR TRACK ACCESS

	Common to all Growth Scenarios				BG	MG	HG
	2018-21	2022-28	2029-32	2033-39	2040-70	2040-70	2040-70
Assume same rates for Caltrain payments to CA HSR							
Train miles by Caltrain on UP track (m)	0.04	0.03	0.13	0.13	0.13	0.78	0.78
Total Track Access rate ($ per train mile)	0.00	0.00	10.42	8.76	8.78	6.86	7.17
Total annual TA payment to CA HSR ($m)	0.00	0.00	1.33	1.12	1.12	5.37	5.61

Capital Cost Memo

Prepared for:

Caltrain

October 2019

Prepared by:

ARUP

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1. INTRODUCTION

1.1 PURPOSE

This memo provides the methodology for the development of the capital cost estimates used in the Caltrain Business Plan (Plan). It refers to the Capital Cost Model (Cost Model) developed for purposes of the Business Plan effort and includes detailed descriptions of various Cost Elements, sources of information, costing assumptions, and model outputs.

The key outputs from the Cost Model are the capital cost estimates for each of the three 2040 Growth Scenarios studied as part of the Business Plan: Baseline Growth, Moderate Growth, and High Growth. These are summarized in Section 3.5. There is a single cost associated with each Growth Scenario and that cost is the best estimate of all the Infrastructure and Fleet investment needed in the corridor to support the respective Growth Scenarios. These estimates include infrastructure under development by cities and by Caltrain partners along the corridor- including transportation projects that have multiple purposes and serve a range of economic development, transportation, and community objectives beyond the core mission of Caltrain. The cost estimates included in the Cost Model therefore go beyond what Caltrain as an agency is directly responsible for funding and delivering or the minimum investments that might strictly be required to deliver a specific level of train service. Instead, these costs provide a more holistic picture of the level of infrastructure improvement needed to deliver an expanded Caltrain service and improved corridor from a broader stakeholder perspective.

Planning level cost estimates for individual infrastructure elements were developed to add robustness to the three 2040 cost estimates, and to provide transparency around the variety of investments that need to be made. These planning level cost estimates are based on the best assumptions available at this time. They are reflective of the indicative nature of the Plan and are not based on any design work. They will therefore change as information becomes available through more detailed planning and design efforts by Caltrain and partners in future efforts.

Finally, the sub-allocation of capital costs to different beneficiaries and stakeholders for the purposes of economic is briefly described at the end of this memo as an appendix. This process of allocation was undertaken solely for the purposes of economic modeling to align project costs with beneficiaries (an inherently challenging undertaking when infrastructure may benefit multiple rail operators or can have transportation benefits that extend beyond rail). It is critical to note that these allocations are intended to reflect a reasonable approach for the purposes of economic analysis and are no way intended to reflect a policy determination on the part of Caltrain or to imply the funding responsibilities of individual stakeholders or project participants. The modeling work associated with allocation was performed by First Class Partnerships in conjunction with Caltrain staff and was not part of the Arup work scope.

1.2 WHAT'S COVERED IN THIS MEMO

The memo is structured as follows:

Section 1: Introduction

Section 2: Cost Model Methodology and Parameters (includes the methodology overview, assumptions, external model data, and description of the estimates for each capital Cost Element)

Section 3: Capital Cost Estimates Summary

Section 4: Capital Cost Estimates Build Up Over Time

Section 5: Capital Replacement Costs

Appendix: Capital Cost Allocation for Modeling Purposes

1.3 DESCRIPTION OF ALTERNATIVES

The Baseline Growth Scenario includes Caltrain projects already underway (positive train control, electrification, and others) and additional Caltrain-identified investments needed to support Baseline levels of service (full electrification, platform lengthening, level boarding and others). The Baseline Growth Scenario also includes investments planned and proposed by Caltrain Partners, including:

- Downtown Extension (DTX) to Salesforce Transit Center
- Diridon Station and surrounding rail infrastructure
- California High Speed Rail Authority (CAHSR)-enabling investments between San Francisco and Gilroy
- Grade separation projects currently planned by local jurisdictions

The Moderate and High Growth Scenarios have additional Caltrain-identified investments to support higher levels of service.

The estimates were profiled over time by the assumed dates key service changes and events are planned for the corridor:

- 2022 – Start of (partially) electrified service
- 2029 – Opening of DTX and initial CAHSR service
- 2033 – Full Phase 1 CAHSR service
- 2040 – Growth Scenario build out

1.4 RELATIONSHIP TO OTHER WORK STREAMS

This Capital Cost Memo is one of a series of memos that describe the technical work associated with the development of the Caltrain Business Plan. It is based primarily on estimated capital costs for projects defined in conjunction with Caltrain but also includes inputs documented in the Market Analysis and Ridership Memo (ridership forecasts) and the Service Planning Memo (assumptions for new infrastructure needed along the corridor. The outputs from the Capital Cost Memo were inputs to the Integrated Business Model which was used to comprehensively analyze the long-term financial impacts of the growth scenarios.

1.5 DEFINED TERMS

The set of Defined Terms listed in Table 1 is utilized consistently throughout this report.

Table 1: Defined Terms

Defined Term	Description
Change Points	Series of steps between 2022 and 2040
Cost Categories	The categories used to identify investment types
Cost Elements	Major cost elements that make up the total cost estimate
Cost Model	The framework tool used to develop the cost estimate
Fleet	Cost category includes new fleet
Grade Crossings	Cost category includes improvements at grade crossings
Growth Scenario	The three profiles over time defined for the Caltrain Business Plan: Baseline Growth, Moderate Growth, High Growth
Stations	Cost category includes new investments, improvements, and enhancements at the stations
Systems	Cost category includes train control, electrification, traction power, communication and signal system improvements and enhancements

Table 1: Defined Terms

Defined Term	Description
Terminal and Yards	Cost category includes improvements, expansion, and new investments in terminals and yards
Track and Rail	Cost category includes rail track improvements and new investments
Unit Costs	The amount of cost generated by one unit of measurement

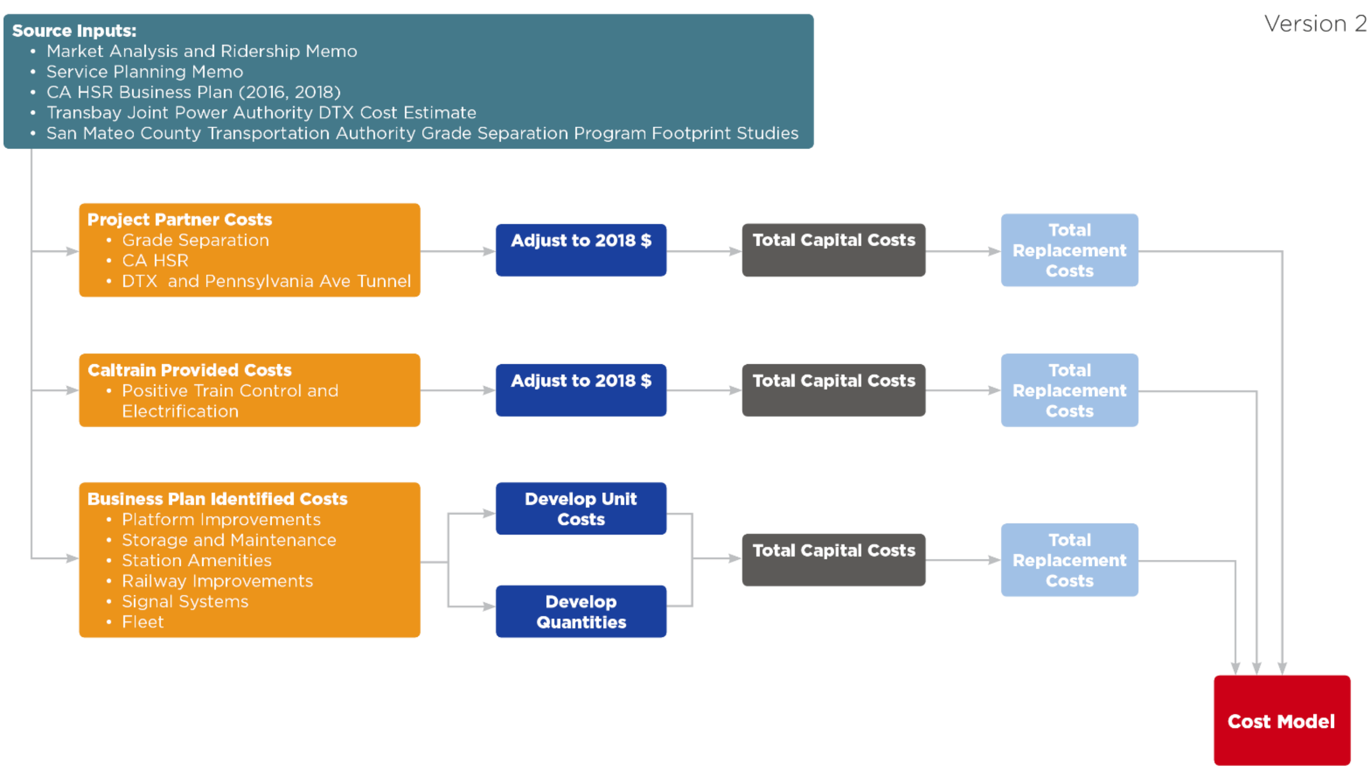
2. COST MODEL METHODOLOGY AND PARAMETERS

This section describes the general assumptions, data sources, and overall Cost Model methodology for the major capital Cost Elements.

2.1 COST MODEL STRUCTURE

The Cost Model structure is shown in Figure 1. The Cost Model relies on three types of cost inputs (described in Section 2.2), that combine to become the total cost estimate.

FIGURE 1: COST MODEL STRUCTURE



2.2 COST INPUTS

The cost estimates are sourced from three main inputs:

1. Project partner costs
2. Caltrain-provided costs
3. Business Plan-identified costs

2.2.1 PROJECT PARTNER COSTS

Project partner costs are defined as project cost estimates provided by partner transportation agencies or local jurisdictions. The Cost Model incorporated costs from the following partners:

- The California High Speed Rail Authority
- City of San Francisco (for costs associated with DTX and the Pennsylvania Avenue Tunnel)
- Cities along the Caltrain corridor that are leading efforts to plan or design grade separations and grade crossing treatments

Costs provided by Caltrain and by Caltrain partners already incorporate all the necessary project costs and contingencies and all the necessary professional services costs required to deliver the infrastructure assets. The total contingency and escalation costs were distributed within each cost category.

2.2.2 CALTRAIN-PROVIDED COSTS

Costs for several investments were developed or provided directly by Caltrain to the project team. Examples of Caltrain-provided costs include the costs for the Peninsula Corridor Electrification Project (PCEP), Communications Based Overlay Signal System Positive Train Control (CBOSS PTC), and previous grade crossing data from the San Mateo County Transportation Authority.

2.2.3 BUSINESS PLAN-IDENTIFIED COSTS

Business Plan-identified costs were developed by the project team using industry and consultant team databases. Estimated project costs were developed on a conceptual, “pre-design” basis, which relied on developing “average” or “typical” cost elements to derive a cost estimate. A key input for the estimates was the service planning work which identified infrastructure and systems requirements. For other elements, the project team modeled a range of costs to allow a determination to be made of the most appropriate estimate. The best example of this is in the grade separation cost estimates. In other cases, the project team referenced case studies of similar projects.

The source inputs are shown in Table 2. Due to the conceptual nature of the estimated project costs, they are high level and will be subject to change and refinement over time as more detailed work is completed. These projects include:

- At-grade crossing improvements
- Rail infrastructure improvements
- Maintenance and storage yards
- Station platform and level boarding
- Station improvements (parking and access)

2.2.4 LEVEL OF ACCURACY

The estimated project costs were developed in accordance with the Association of the Advancement for Cost Engineering International (AACE) methodology using a Level 5 (Rough Order of Magnitude). The methodology takes account of all appropriate contingencies to reflect the level of accuracy. For estimated project costs, the team applied a standard estimating contingency of 30 percent, reflecting the low level of detail and design available and a standard estimating owner’s soft cost (professional services) of 15 percent.

For the purposes of presentation (in this report and for public materials), the following rounding was applied to the values:

- Round to the nearest $10,000,000 if estimated cost is below $100,000,000
- Round to the nearest $100,000,000 if estimated cost is above $100,000,000

All cost estimates are presented in billions of dollars and to a precision on the nearest hundred million (i.e., one decimal point), where appropriate.

2.2.5 RIGHT-OF-WAY (ROW) COSTS

The project team developed right-of-way cost estimates for a select number of project elements using unit rates provided by Caltrain. Right-of-way cost estimates provided by project partners were incorporated without review or refinement as inputs into the Cost Model.

2.2.6 SOURCE DOCUMENTS

Table 2 summarizes the source documents for the inputs to the cost model.

Table 2: Input Sources of Information

	Source Document	Source
1	Arup Unit Cost Database	Arup
2	California High Speed Rail Business Plan (2016, 2018)	California High Speed Rail
3	Transbay Joint Powers Authority DTX Cost Estimate (June 2016)	Transbay Joint Powers Authority
4	City of San Jose City Generated Options (CGO) Estimates	City of San Jose
5	San Mateo County Transportation Authority Grade Separation Program Footprint Studies (2009)	San Mateo County
6	Caltrain - Proposed and Planned Grade Separation Projects 03.28.19	Caltrain
7	Draft Caltrain Fleet Maintenance and Storage Requirements Document	Caltrain
8	2017 Caltrain Parking Survey	Caltrain
9	Caltrain Ridership Forecasts for Growth Scenarios	Fehr and Peers
10	Caltrain Bicycle Parking Management Plan (BPMP)	Caltrain
11	SPUR Caltrain Vision Plan	SPUR
12	PTC / PCEP Capex FY18 to FY22	Caltrain

The Arup Unit Cost Database is provided in Appendix I.

2.3 ESTIMATING CAPITAL COST ELEMENTS

There are ten (10) major capital Cost Elements that make up the cost estimate. This section describes the methodology for each of the ten Cost Elements. These are generally reported in two geographic segments: San Francisco to San Jose (Tamien Station) and San Jose to Gilroy. This distinction was adopted to assist with the cost allocation effort that is described in section 1.6 of this memo.

The Cost Elements are:

1. Grade separations
2. CAHSR
3. Downtown Extension and Pennsylvania Avenue Tunnel
4. Platform Improvements
5. Storage and Maintenance Facility
6. Station Amenities and Access Improvements
7. Railway Improvements
8. Positive Train Control & Electrification
9. Signal Systems
10. Fleet

2.3.1 GRADE SEPARATIONS

2.3.1.1 Purpose

The grade separation cost estimate was developed to generate an estimate of the overall investment in grade separations and grade crossing treatments (improvements) for the three Growth Scenarios.

2.3.1.2 Background

There are 42 at-grade crossings on the corridor Caltrain owns between San Francisco and San Jose and an additional 28 at-grade crossings on the Union Pacific-owned corridor south of Tamien. Currently, roughly half of the at-grade crossings between San Francisco and San Jose are undergoing grade separation studies by the representative local jurisdictions. The Business Plan assumes that those grade crossing improvement projects will continue to be led by the individual city jurisdictions, and if cost estimates had been approved by the jurisdictions at the time of this effort they were captured as fixed costs within the Cost Model. For the remaining grade crossings, a determination was made of the extent and nature of improvements required along the corridor under the Baseline, Moderate and High Growth Scenarios.

This was a multi-step process that included an initial assignment of improvements for all at-grade crossings (San Francisco to Gilroy) and their indicative costs. However, this assignment does not imply that decisions have been made about any improvement or treatment. The improvements assigned were only used to support the corridor-wide cost estimate.

2.3.1.3 Methodology

The overall methodology can be described in three steps:

Step 1: Development of generic investment types and costs for crossings where no plans are currently contemplated.

Step 2: Documentation of current City-led plans for grade separations.

Step 3: Development of ranges of potential investment costs that vary by Growth Scenario and intensity of investment (low, medium, high).

Development of Generic Investment Types and Cost Estimates

For the existing automobile grade crossings, three types of investment were considered to represent typical improvements: full grade separation, a mitigated closure, and quad gate and safety improvements. The mitigated closure was assumed to include closure of the street and the provision of a bicycle/pedestrian overcrossing. For the existing bicycle and pedestrian crossings, it was assumed that they would either be closed or be fully grade separated. The cost estimates for these generic improvement types are shown in Table 3.

Table 3: Generic Grade Crossing Cost Estimates

Existing	Type of Investment	Description	Cost Estimate
Auto Grade Crossing	Grade Separation	Full grade separation (2-track)	$254M
		Full grade separation (4-track)	$353M
	Mitigated Closure	Grade crossing closure with new bicycle/pedestrian crossing	$35.6M
	Crossing Improvement	Quad safety gates	$1M
Bicycle or pedestrian crossing	Closure	Safety gates	$0.1M
	Grade separation	Full grade separation	$35M

Documentation of City-Led Plans for Grade Separation

Many cities along the corridor are actively planning or considering grade separations. Each grade separation represents a major community effort associated with planning and implementing a significant and impactful project. These projects, including their estimated and potential costs (as available), were included in the Cost Model. Table 4 shows each grade crossing and their cost estimate.

Table 4: City-Led Grade Separation and Closure Plans

City	Crossings Under Study	Status of Plan or Study	City Generated Cost Estimate or Range	Used in Business Plan?
San Francisco	Pennsylvania Ave. Tunnel	Feasibility	$1.4B	√
San Francisco	Mission Bay Dr.	Feasibility	$516M	Covered by Penn Ave. Tunnel
San Francisco	16th St.	Feasibility	$240M	Covered by Penn Ave. Tunnel
South San Francisco	Linden Ave.	PSR	To Be Determined (TBD)	√
San Bruno	Scott St.	PSR	TBD	√
Burlingame	Broadway	EIR	$274M	√
San Mateo	25th Ave.	Construction	$180M	√
Redwood City	Whipple Ave., Brewster Ave., Broadway (possibly Maple St.)	PSR	$350 - 500M	√
Menlo Park	Glenwood Ave. Oak Grove Ave. Ravenswood Ave.	PSR	$310M – 380M	√
Menlo Park	Middle Ave. (Ped. xing only)	Feasibility	TBD	√
Palo Alto	Churchill Ave.	PSR	$20 - 25M	√
Palo Alto	East Meadow Dr. Charleston Rd.	PSR	$200 - 950M	√
Mountain View	Rengstorff Ave.	PE/EIR	$150M	√
Mountain View	Castro St.	PE/EIR	$44 - 64M	√
Sunnyvale	Mary Ave.	PSR	$100 - 200M	√
Sunnyvale	Sunnyvale Ave.	PSR	$40 - 250M	√

(Source: Caltrain)

Developing Ranges of Potential Investment Costs That Vary by Growth Scenario and Intensity of Investment (Low, Medium, High)

A range of low, medium, and high intensity investments was established by considering different applications of three metrics: a) whether an at-grade crossing has the potential to be widened to four-tracks due to service needs, b) the future predicted gate downtimes, and c) the existing average daily traffic (ADT) for each at-grade crossing.

Four Track Grade Separations

In the Baseline Growth Scenario, there are no new assumed 4-track sections. In the Moderate Growth Scenario, six at-grade crossings will be expanded to accommodate four tracks. These at-grade crossings are assumed to be grade separations. In the High Growth Scenario, 13 at-grade crossings will be expanded to accommodate four tracks, an increase of thirteen grade separations above the Baseline Growth Scenario.

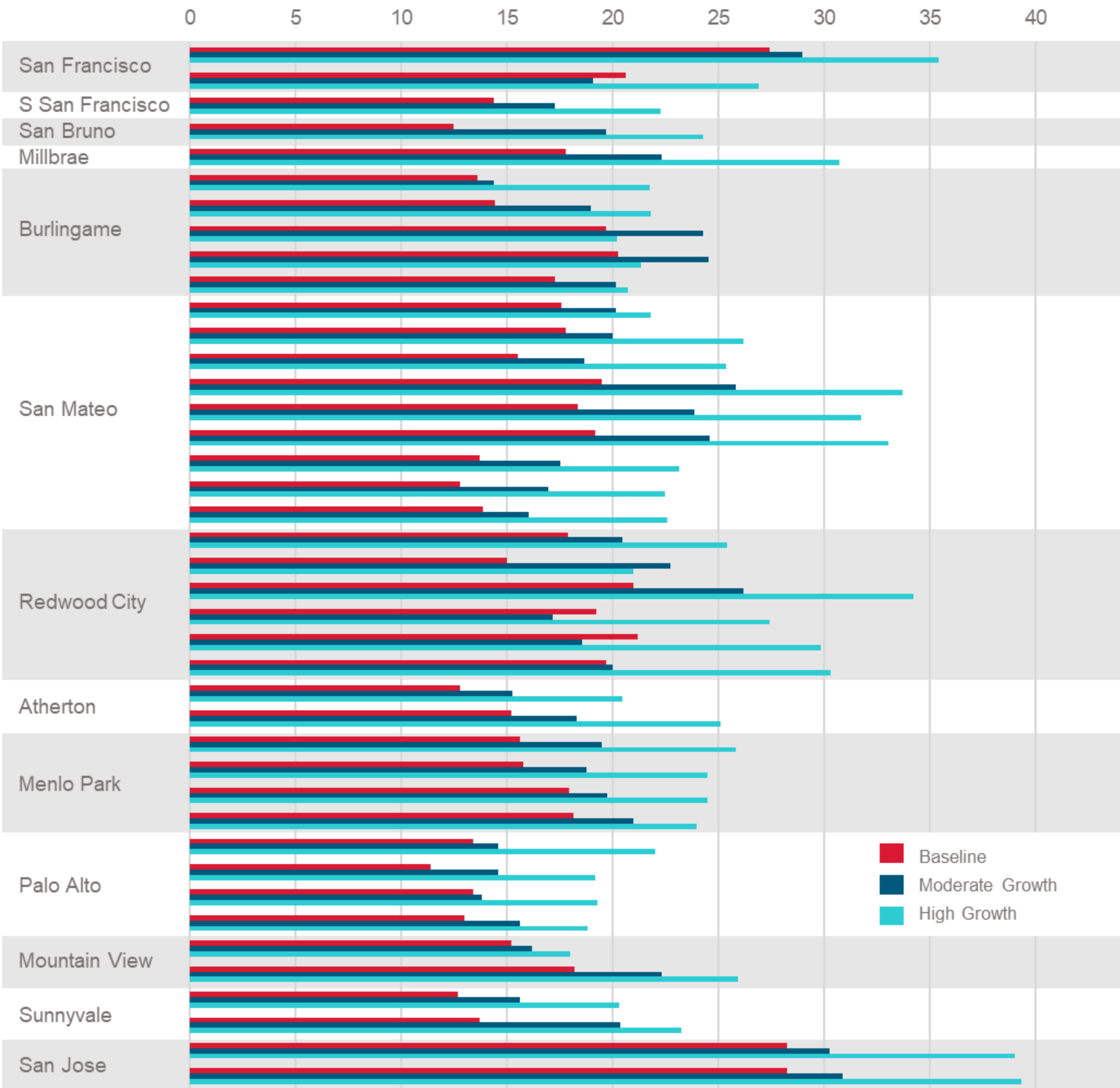
Gate Downtimes

Today, Caltrain's crossing gates are down for an average of 11 minutes during the peak weekday commute hour. Gate downtimes range from 6 minutes up to nearly 17 minutes. An estimate was made of gate downtimes in 2040 using prototypical schedule inputs. The range for results across Growth Scenarios are shown in Table 5. Figure 2 shows the predictions at each grade crossing. The projected gate downtimes vary by Growth Scenario as shown but it should also be noted that changes to schedule and crossing gate technology would likely yield different downtimes.

Table 5: Projected 2040 Gate Downtime Ranges at Grade Crossings

	Gate Downtime by Scenario (Minutes in 1 hour)		
	Shortest	**Average**	**Maximum**
Baseline	11	17	27
Moderate	14	20	29
High	18	25	35

FIGURE 2: PROJECTED GATE DOWNTIME: 2040 (MINUTES PER PEAK HOUR)

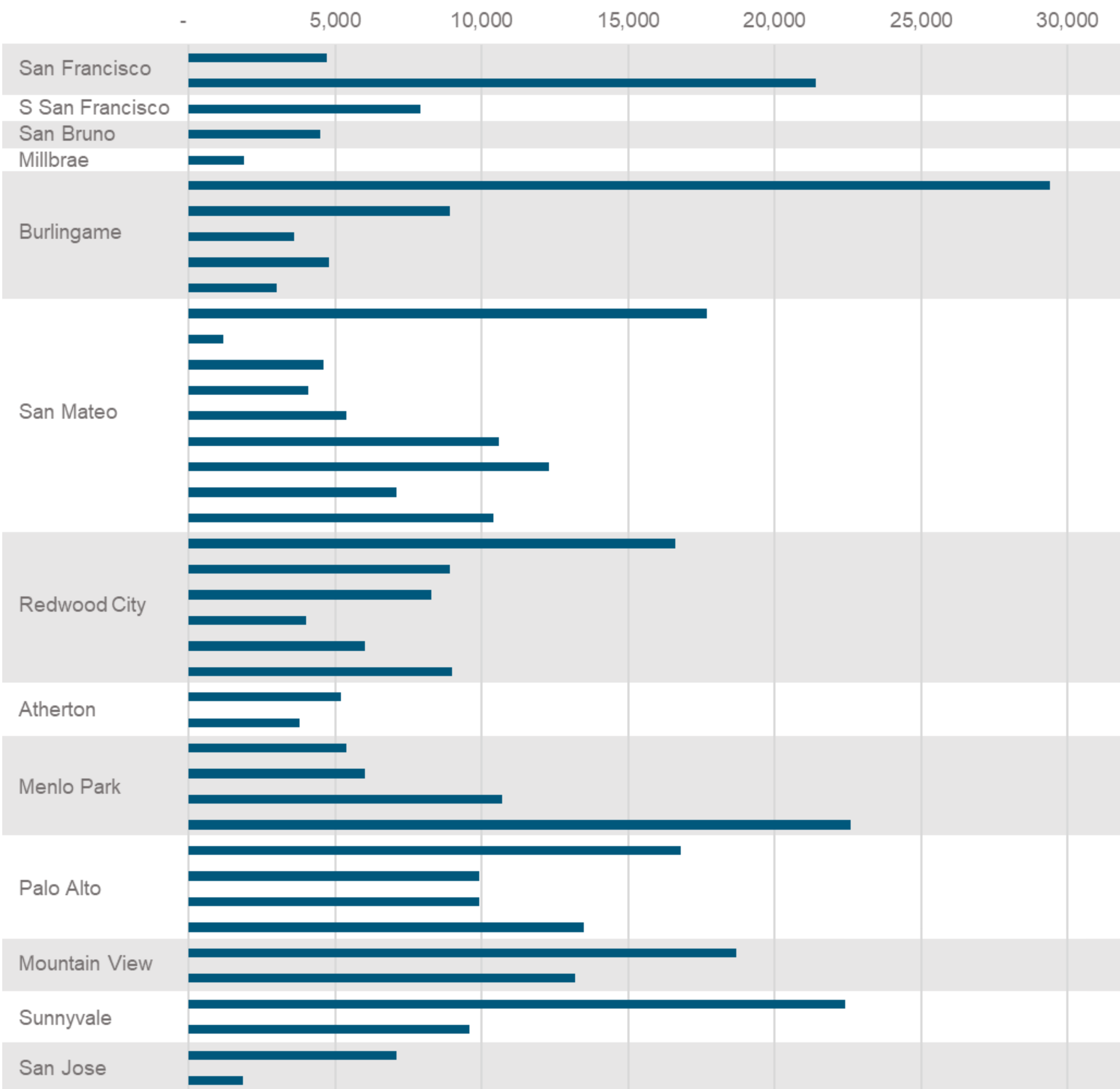


(Source: Fehr and Peers)

Average Daily Traffic

During a typical weekday, Caltrain's at-grade crossings are traversed by approximately 400,000 cars. This is equivalent to the combined traffic volumes on the Bay Bridge and San Mateo Bridge. The 10 busiest at-grade crossings account for half of all traffic volumes.

FIGURE 3: EXISTING DAILY TRAFFIC CROSSING CALTRAIN GRADE CROSSINGS



(Source: Fehr and Peers)

Assignment of Grade Crossing Treatments

Minimum thresholds were established to determine what investment type an at-grade crossing qualified for. Using the minimum thresholds, the project team established a decision tree calculation to generate the different potential investment ranges:

1. Lower Level Potential Investment Range
    - Assumes all at-grade crossings requiring 4-tracking are grade separated
    - Assumes all remaining at-grade crossings that will experience future gate downtimes exceeding 18 minutes and have more than 6,000 ADT will be a grade separation or mitigated closure
    - Assumes the split between mitigated closures and grade separations is 50/50
2. Medium Level Potential Investment Range
    - Assumes all at-grade crossings requiring 4-tracking are grade separated
    - Assumes all remaining at-grade crossings that have future gate downtimes exceeding 18 minutes and also have more than 4,000 ADT will be treated as a grade separation or mitigated closure
    - Assumes the split between mitigated closures and grade separations is 50/50
3. Higher Level Potential Investment Range
    - Assumes all at-grade crossings requiring 4-tracking are grade separated
    - Assumes all remaining at-grade crossings that have future gate downtimes exceeding 18 minutes and also have more than 500 ADT will be treated as a grade separation or mitigated closure
    - Assumes the split between mitigated closures and grade separations is 50/50

Union Pacific Corridor

Plans for expanded service on this corridor are relatively new and the details of potential future train volumes are highly dependent on CAHSR's future plans and service levels. For Business Planning purposes, a single general allocation cost was used to capture the need for grade crossing improvements on this corridor. This allocation assumes estimated costs for City planned separations in San Jose as well as potential additional investments throughout the UP corridor as follows:

- City planned separations at Skyway Drive, Branham Lane, and Chynoweth Ave
- Two additional separations
- 3 mitigated closures
- Quad gates at remaining crossings

By using the decision tree calculation, the project team developed different investment types for each intensity range. Table 6 shows the investment type breakdown.

Table 6: Number of Grade Crossings Under Each Investment Range

	Investment Type	Baseline Growth	Moderate Growth	High Growth
	Lower Intensity Potential Investment Range			
Investments in JPB-owned corridor	Crossing Improvement	14	14	10
	Mitigated Closure	3	3	6
	Grade Separation	24	24	25
Investments in UP-owned corridor	Crossing Improvement	20	20	20
	Mitigated Closure	3	3	3
	Grade Separation	5	5	5
	Medium Intensity Potential Investment Range			
Investments in JPB-owned corridor	Crossing Improvement	12	11	6
	Mitigated Closure	4	5	8
	Grade Separation	25	25	27
Investments in UP-owned corridor	Crossing Improvement	20	20	20
	Mitigated Closure	3	3	3
	Grade Separation	5	5	5
	High Intensity Potential Investment Range			
Investments in JPB-owned corridor	Crossing Improvement	10	5	0
	Mitigated Closure	5	8	11
	Grade Separation	26	28	30
Investments in UP-owned corridor	Crossing Improvement	20	20	20
	Mitigated Closure	3	3	3
	Grade Separation	5	5	5

The project team used the city generated cost estimates where available and generic investment type Unit Costs (from Table 3) to calculate the total cost for each investment range. The medium level potential investment range was used as the representative input for grade crossing improvements into the Cost Model.

2.3.1.4 Cost Summary

The medium intensity potential investment range was used as the input for grade crossing improvements costs into the Cost Model. Table 7 shows the summary of the medium intensity costs.

Table 7: Summary of Grade Crossing Cost Estimates (Medium Intensity Potential Investment Range)

Type	Baseline Growth	Moderate Growth	High Growth
Auto (JPB-Owned Corridor)	$6.8B	$7B	$8.3B
Auto (UP-owned Corridor)	$1.9B	$1.9B	$1.9B
Bike/Ped	$0.14B	$0.14B	$0.14B
Total	**$8.8B**	**$9B**	**$10.3B**

2.3.2 HIGH SPEED RAIL

2.3.2.1 Background

High-speed rail service between San Jose and San Francisco is assumed to begin in 2033. Up to four CAHSR trains will be sharing the corridor with six or more Caltrain trains, for a total of 10 or more trains per hour per direction in all Growth Scenarios. Between Gilroy and San Jose there will be two Caltrain trains and eight CAHSR trains per hour per direction.

The corridor improvements CAHSR requires for service are outlined in the 2018 California High Speed Rail Business Plan, which includes track improvements, elevated structures, signaling, electrification, grade crossings, communication systems, and station improvements.

The CAHSR costs were identified for the two geographic segments: San Francisco to San Jose (south of 4th & King to Control Point (CP) Coast) and San Jose to Gilroy (south of CP Lick through Gilroy Station).

San Francisco to San Jose - South of 4th & King to CP Coast

CAHSR improvements in this segment are shown in Table 8 and include the cost for curve straightening and track updates, a rebuilt Millbrae station (including the cost of right-of-way) and signal or system costs.

Table 8: San Francisco to San Jose - South of 4th & King to CP Coast Cost Estimate

South of 4th & King to CP Coast	Total Cost (2018$)
Curve straightening and track updates	$99M
Rebuilt Millbrae station (including ROW)	$288M
Signal or Systems enhancements[1]	$65M
Total	**$452M**

San Jose to Gilroy – south of CP Lick through Gilroy Station

CAHSR improvements for this segment are shown in Table 9 and include track upgrades for rebuilding the corridor to three tracks, traction power supply (TPS), and signaling enhancements. Additionally, all the Caltrain stations between Tamien and Gilroy are assumed to be rebuilt, including a new rebuilt CAHSR/Caltrain station at Gilroy. Any costs associated to initial corridor acquisition from UP are not included in this estimate.

[1] The signal or system enhancements are exclusively for improvements related to CAHSR service. Additional signal costs (shown in Section 2.4.10) support improvements related to the Moderate and High Growth Scenarios.

Table 9: San Jose to Gilroy – South of CP Lick Through Gilroy Station Cost Input

South of CP Lick through Gilroy Station	Total Cost (2018$)
Rebuilding corridor to three tracks	$986M
TPS Systems	$255M
Signal enhancements	$129M
Caltrain stations rebuilding allowance	$120M
Rebuilt CAHSR/Caltrain Gilroy station allowance	$74M
ROW allowance (not including costs of corridor acquisition from UP)	$126M
Total	**$1.7B**

2.3.2.2 Cost Summary

The costs from CAHSR were escalated to 2018 USD using a 3.5% annual rate. The total costs are shown in Table 10.

Table 10: Summary of High-Speed Rail Cost Estimates

	South of 4th & King to CP Coast	South of CP Lick through Gilroy Station	Total Cost (2018$)
Segment Subtotal	$ 452M	$ 1.7B	$2.1B

2.3.3 DOWNTOWN EXTENSION AND PENNSYLVANIA AVENUE TUNNEL

2.3.3.1 Background

The Downtown Extension (DTX) and Pennsylvania Avenue Tunnel projects are assumed to be complete by 2029. The two projects are integral for delivering service along an exclusive right-of-way into Salesforce Transit Center. The DTX project is Phase 2 of the Transbay Transit Center program, and includes construction of the Downtown Rail Extension, a new Fourth and Townsend Street Caltrain station, completion of the Transit Center's train station, a pedestrian connection to BART and Muni, and a new intercity bus facility. The Pennsylvania Avenue Tunnel project is an extended tunnel from the DTX project that would eliminate the surface rail portion of DTX.

2.3.3.2 Sources

All source information was taken from the Transbay Joint Powers Authority (TJPA) DTX cost estimate, dated June 2016, the TJPA Staff Report Calendar Item 15, dated, July 12, 2018, and the San Francisco Planning Rail Alignment and Benefits (RAB) Study (2018).

2.3.3.3 Methodology

Table 11 shows the cost estimate from the Transbay Joint Powers Authority DTX cost estimate and Table 12 the cost estimate from the San Francisco Planning Rail Alignment and Benefits (RAB) Study (2018).

Table 11: DTX Cost Estimate Detail

2016 Phase 2 Cost Estimate (in year of expenditure dollars)

		Direct Costs	Design Contingency	Total Cost
Phase 2 Construction				
DTX				**$1,467,777,900**
	Segment 10 Fourth and King Surface Station and Yard Upgrade	$0		$0
	Segment 9 At Grade Trackway	$707,000		$707,000
	Segment 8 U-Wall Segment	$57,906,000		$57,906,000
	Segment 7 Cut and Cover West of Fifth St	$92,220,000		$92,220,000
	Segment 6 Cut and Cover Fourth & Townsend Underground Station	$123,721,000		$123,721,000
	Segment 5 Cut and Cover East of Fourth St	$82,069,000		$82,069,000
	Segment 4 NATM Mined Tunnel	$387,981,000		$387,981,000
	Segment 3 Cut and Cover Throat Structure	$151,037,000		$151,037,000
	Segment 2 Transit Center	$889,000		$889,000
	Trackworks	$82,775,000		$82,775,000
	Systems	$92,662,000		$92,662,000
	Allowances	$90,162,000		$90,162,000
	Design Contingency		$199,551,900	$199,551,900
Allowance for Properties Demolition		$3,000,000		$3,000,000
Tunnel Stub Box		$99,876,000	included	$99,876,000
DTX Vent Structures (heighting of structures)		$3,222,000	included	$3,222,000
Transit Center Building (TCB)				**$247,203,907**
	Transit Center Fit Out	$150,255,780	$7,512,576	$157,768,356
	Allowance for RVA for above at 5%	$7,512,789		$7,512,789
	Train Box Extension	$55,631,840	$2,782,176	$58,414,016
	Allowance for RVA for above at 5%	$2,781,592	$514,738	$3,296,330
IBF - PCPA 95% CD Estimate item 2.3 plus 16.8% for escalation to 2016		$12,582,864	$629,552	$13,212,416
Allowance for IBF Escalator and Elevator from Beale street to Below Grade Train Box		$5,000,000		$5,000,000
Allowance for Main Street Utility Relocation		$2,000,000		$2,000,000
	Subtotal DTX and TCB Construction excluding escalation	**$1,503,991,865**	**$210,990,942**	**$1,714,981,807**
DTX and TCB Construction Escalation at 5% to mid construction (2023)				$583,257,836
	Subtotal DTX and TCB Construction including escalation			**$2,298,239,643**
ROW**				$266,200,000
Programwide @ 22.5% of above excluding ROW				$517,103,920
	Subtotal Program Costs			**$3,081,543,562**
Construction Contingency @ 10%				$229,823,964
Program Reserve @ 15% of Subtotal Program Costs				**$462,231,534**
	Total Program Cost excluding BART/Muni Pedestrian Connector			**$3,773,599,061**
BART/Muni Pedestrian Connector - Direct Construction Cost		$109,525,767	included	$109,525,767
BART/Muni Pedestrian Connector - Escalation				$37,249,236
BART/Muni Pedestrian Connector - Construction Contingency				$14,677,500
	BART/Muni Pedestrian Connector Total Cost			$161,452,503
	Total Program Cost including BART/Muni Pedestrian Connector	**$1,613,517,632**	**$210,990,942**	**$3,935,051,564**

* *Total Contingency/Reserves is $903 million or 29.3% of Total Program Costs excluding BART/Muni Pedestrian Connector*

** *ROW number was last updated with the 2013 Phase 2 cost estimate*

Table 12: Pennsylvania Avenue Tunnel Cost Estimate Detail

RAB Cost Estimates

Baseline (DTX) Alignment	Unit	Quantity	Unit Cost	Cost
Cut and Cover Transbay Throat Structure	CY	140,400	$670	$94,068,000
SEM Tunnel (DTX box to Townsend Street)	CY	318,963	$760	$242,412,096
Cut and Cover Tunnel (Townsend Street to Station)	CY	142,100	$670	$95,207,000
4th/Townsend Station (2 platform)	CY	115,267	$1,200	$138,320,000
Retained Cut (Station to at-grade)	CY	127,102	$562	$71,468,421
Ventilation / Escape Structures	CY	14,467	$670	$9,692,667
Systems	LS		25%	$162,792,046
4th/King Railyard Upgrade	LS	DTX		$34,159,483
Utility Relocation and Protection	LS	DTX		$75,293,195
Mobilization		10%		$92,341,291
Design/Construction Contingency		15%		$152,363,130
		Total Construction		$1,168,117,329
ROW Acquisition	DTX			$200,000,000
Project Development / Management				
PE/Environmental			4%	$46,724,693
Final Design			8%	$93,449,386
Construction Management			10%	$116,811,733
Project Management/Owner Costs			10%	$116,811,733
Program Contingency			20%	$348,382,975
		Total Probable Cost		**$2,090,000,000**

Pennsylvania Ave Alignment	Unit	Quantity	Unit Cost	Cost
Cut and Cover Transbay Throat Structure	CY	140,400	$670	$94,068,000
SEM Tunnel (DTX box to Townsend Street)	CY	318,963	$760	$242,412,096
Cut and Cover Tunnel (Townsend Street to Station)	CY	142,100	$670	$95,207,000
4th/Townsend Station (4 platform)	CY	155,193	$1,200	$186,231,111
Cut and Cover Tunnel (South of Station)	CY	103,756	$670	$69,516,222
Twin Bore TBM Tunnels (To 22nd Sta)	CY	168,948	$800	$135,158,297
22nd Street Station (Cut and Cover)	CY	155,193	$1,200	$186,231,111
Twin Bore TBM Tunnels (south of 22nd Sta)	CY	39,421	$800	$31,536,936
Cross Passages	CY	1,681	$12,094	$20,333,977
Ventilation / Escape Structures	CY	14,467	$670	$9,692,667
Systems		25%		$264,972,802
Railyard (Relocate to Site 1 or Site 2)	LS			$153,000,000
Utility relocation and protection	DTX		150.0%	$112,939,792
Mobilization		10%		$160,130,001
Design/Construction Contingency		25%		$440,357,503
		Total Construction		$2,201,787,517
ROW Acquisition	DTX		140.0%	$280,000,000
Project Development / Management				
PE/Environmental			4%	$88,071,501
Final Design			8%	$176,143,001
Construction Management			10%	$220,178,752
Project Management/Owner Costs			10%	$220,178,752
Program Contingency			20%	$637,271,904
		Total Probable Cost		**$3,824,000,000**

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The DTX costs were estimated in 2016 USD, escalated to midpoint of construction in 2023 by the project sponsor. The Business Plan project team removed the escalation from total cost and then re-applied the escalation to increase the 2016 estimated cost to 2018 USD. The Pennsylvania Avenue Tunnel costs were estimated in 2016 USD and were escalated to 2018 USD.

The cost estimates in the Cost Model are shown in Tables 13 and 14.

Table 13: DTX Cost Estimates

Description	Total Cost (2018$)
Guideway - underground tunnel	$ 1.8B
Trackwork	$ 0.4B
Stations	$ 0.2B
DTX Transit Center Building	$ 0.4B
BART/MUNI pedestrian corridors	$ 0.1B
Total Project Costs DTX	$ 3B
Total ROW Costs DTX	$ 0.2B
Total	**$ 3.3B**

Table 14: Pennsylvania Avenue Tunnel Cost Estimates

Description	Total Cost (2018$)
22nd Street Station construction	$ 0.4B
Pennsylvania Avenue ROW Costs	$ 0.1B
Pennsylvania Avenue Tunnel	$ 1.3B
Total	**$ 1.8B**

2.3.3.4 Cost Summary

The costs as input to the Cost Model are shown in Table 15.

Table 15: DTX and Pennsylvania Cost Estimates

	DTX	Pennsylvania Avenue Tunnel
Total Cost (2018$)	$ 3.3B	$ 1.8B

2.3.4 PLATFORM IMPROVEMENTS

2.3.4.1 Purpose

The purpose of the platform improvements cost estimate was to reflect the changes needed to modify existing platforms to accommodate longer Caltrain trainsets and to achieve level boarding at a height associated with Caltrain's Stadler EMUs. Background

Today, Caltrain platforms lengths vary, but all can accommodate the six-car trainsets currently in operation. In the Baseline Growth Scenario, platform lengths will be extended to accommodate eight-car trainsets. In the Moderate and High Growth Scenarios, platform lengths will be extended to accommodate ten-car trainsets.

All stations will need to have their platforms extended to accommodate ten-car trainsets while only some stations will need to extend platforms to accommodate eight-car trainsets as their platform lengths currently meet the minimum lengths. The stations that do not need to be extended to accommodate eight-car trainsets are 4th & King, 22nd Street, Millbrae, Broadway, Burlingame, San Mateo, Hayward Park, Belmont, San Carlos, Redwood City, Atherton, Menlo Park, California Avenue, San Antonio, Mountain View, Sunnyvale, and College Park. Diridon and Tamien Station platform extension costs are included within the CAHSR costs detailed in Section 2.3.2.

As service levels increase in the corridor, achieving level boarding will become an essential investment to support system performance and station platforms between Gilroy and San Francisco will need to be raised to 25" from the current 8". Costs associated with raising platforms for stations south of Tamien to Gilroy are included in the CAHSR cost estimates and would be associated with the overall improvement of that segment of the corridor.

Cost estimates for platform improvements were developed for the Baseline Growth Scenario. The cost estimates for the Moderate and High Growth Scenarios were developed as incremental costs above the Baseline Growth Scenario.

2.3.4.2 Source

The Platform-Train Interface Study: Caltrain and CAHSR (2012) was the source used to develop the cost estimates. The study provided the length (in feet) required for accommodating eight and ten-car trainsets, the height requirement for the level boarding current width and thickness of existing platforms, the height requirement for the platform heightening, and a list of standard items that would need modification to extend each platform.

2.3.4.3 Methodology

The methodology is described below for platform lengthening and separately for platform heightening:

Platform Lengthening

The project team developed the platform lengthening cost estimate in the following five steps:

Step 1: Confirmed and documented the length of all existing station platforms.

Step 2: Measured, using aerial photos, the additional length required to extend the platforms to accommodate either 8 or 10-car Caltrain trainsets for each platform.

Step 3: Calculated the cost of the additional platform length and other platform items.

Step 4: Added additional cost allowances based on each specific platform constraint (tack realignment, special trackwork impact, building impact, impact to other civil structures, and impacts to future platform heightening).

Step 5: Summed the additional platform length cost with the additional allowance for the total platform lengthening cost for each platform.

Platform Heightening

The project team developed the cost of raising platforms in the following four steps:

Step 1: Confirmed and documented the height of all existing station platforms.

Step 2: Calculated the additional volume of material required to raise the lengthened (8 or 10-car) platforms to the required height.

Step 3: Developed a list of standard items that require modification for each platform.

Step 4: Calculated the cost to raise the platform and other platform item modifications

Establishing Baseline Conditions

The project team established the baseline lengths for each platform between 4th & King in San Francisco to Tamien Station in San Jose. The current platforms' lengths were recorded (for both north and south platforms) and, using aerial photographs, the team measured each platform length to determine if the platform met the minimum required for 8 or 10-car Caltrain trainsets. For the 8-car platforms, it was assumed that all platforms would need to be a minimum of 686 feet, and 875 feet for the 10-car platforms.

The project team reviewed the Platform-Train Interface Study: Caltrain and CAHSR (2012) for existing platform widths and thickness to calculate the additional volume needed to raise each platform to the minimum required height (25").

Calculating Work Needed to Lengthen and Heighten Platforms

The platform costs were combined with additional allowances to account for site specific conditions, such as the need to accommodate specific platform constraints including track realignment, special trackwork, building impact, and potential impacts to other civil structures. No site-specific designs were undertaken. Right-of-way costs were excluded from the total cost, as it was assumed that all platform lengthening would be accommodated within the existing Caltrain ROW. Any overlap with grade crossing costs has not been considered in developing platform costs. The potential for overlap was addressed in a separate exercise as described in section 2.2 of this memo.

The total cost includes additional allowances, such as tactile strips for the entire length of the extended platform, canopies and entrances required for the station modification. Included within the Unit Costs are platform shaving scope of work per cubic yard of concrete and assumptions for direct fixation track for the entire platform length.

2.3.4.4 Cost Summary

The costs used as inputs to the Cost Model are shown in Tables 16, 17, 18, and 19.

Table 16: Summary of 8-Car Platform Extension Cost Estimate

Platform Lengthening to Accommodate 8 Cars - San Francisco to San Jose	
Fourth & King Total	$7.9M
22nd Street	$0.7M
Millbrae	$0.2M
Broadway	$1.1M
Burlingame	$0.4M
San Mateo	$0.3M
Hayward Park	$0.5M
Belmont	$0.8M
San Carlos	$0.8M
Redwood City	$0.4M
Atherton	$0.4M

Table 16: Summary of 8-Car Platform Extension Cost Estimate	
Platform Lengthening to Accommodate 8 Cars - San Francisco to San Jose	
Menlo Park	$0.7M
California Avenue	$0.7M
San Antonio	$0.8M
Mountain View	$1.5M
Sunnyvale	$0.8M
College Park	$2.1M
Total	**$20.1M**

Table 17: Summary of Incremental Cost to Extend from 8 to 10-Car Platforms	
Platform Lengthening to Accommodate all Cars - San Francisco to San Jose Increment from 8-Car to 10-Car	
Fourth & King Total	$3.7M
22nd Street	$0.6M
Bayshore	$0.7M
South San Francisco	$2.2M
San Bruno	$1M
Millbrae	$0.7M
Broadway	$0.7M
Burlingame	$0.6M
San Mateo	$0.6M
Hayward Park	$0.6M
Hillsdale	$1.5M
Belmont	$0.6M
San Carlos	$0.6M
Redwood City	$0.6M
Atherton	$0.6M
Menlo Park	$0.7M
Palo Alto	$0.6M
California Avenue	$0.6M
San Antonio	$0.6M
Mountain View	$0.6M
Sunnyvale	$0.6M
Lawrence	$1.2M
Santa Clara	$2.1M
College Park	$0.6M
San Jose Diridon	$5.3M
Total	**$28.2M**

Table 18: Summary of Level Boarding Cost for 8-Car Platform	
Platform Level Boarding - San Francisco to San Jose	
Fourth & King Total	$42.5M
22nd Street	$6.5M
Bayshore	$6.6M
South San Francisco	$6.6M
San Bruno	$6.9M
Millbrae	$6.5M
Broadway	$6.5M
Burlingame	$6.5M
San Mateo	$6.5M
Hayward Park	$6.5M
Hillsdale	$6.6M
Belmont	$6.5M
San Carlos	$6.5M
Redwood City	$6.5M
Atherton	$6.5M
Menlo Park	$6.5M
Palo Alto	$7M
Stanford Stadium	$8.3M
California Avenue	$6.5M
San Antonio	$6.5M
Mountain View	$6.5M
Sunnyvale	$6.5M
Lawrence	$6.6M
Santa Clara	$6.7M
College Park	$6.5M
San Jose Diridon Total	$48.2M
Tamien	$9M
Total	**$259M**

Table 19: Summary of Incremental Cost to Raise Platform from 8 to 10-Car Platforms	
Platform Level Boarding - San Francisco to San Jose Increment from 8-Car to 10-Car	
Fourth & King Total	$9.5M
22nd Street	$1.6M
Bayshore	$1.5M
South San Francisco	$1.5M
San Bruno	$1.2M
Millbrae	$1.6M
Broadway	$1.6M
Burlingame	$1.6M
San Mateo	$1.6M
Hayward Park	$1.6M
Hillsdale	$1.5M
Belmont	$1.6M
San Carlos	$1.6M
Redwood City	$1.6M
Atherton	$1.6M
Menlo Park	$1.6M
Palo Alto	$1.6M
California Avenue	$1.6M
San Antonio	$1.6M
Mountain View	$1.6M
Sunnyvale	$1.6M
Lawrence	$1.5M
Santa Clara	$1.4M
College Park	$1.6M
San Jose Diridon	$1.2M
Total	**$46M**

2.3.5 STORAGE AND MAINTENANCE YARD

2.3.5.1 Purpose

The purpose of the storage and maintenance yard cost estimate was to generate an estimate of the overall conceptual investment needed for new and expanded storage and maintenance facilities to support the three Growth Scenarios. These estimates are highly preliminary and further analysis of storage and maintenance needs, and phasing will be required as the railroad proceeds with implementation.

2.3.5.2 Background

Caltrain currently has a Fleet of 29 diesel locomotives and 134 cars. This equipment is maintained at the Centralized Equipment Maintenance and Operations Facility (CEMOF), located in San Jose. The Business Plan assumes that there will continue to be a need for a primary maintenance facility in the southern end of the corridor and a secondary storage/light maintenance facility at the northern end of the line. However, given the forecast increase in fleet size, there was an initial determination that the CEMOF facility would not be adequate to meet all the future storage and maintenance needs under any of the Growth Scenarios and that a new facility would be required at a new location.

The northern facility, currently located at the 4th and King Station, is not large enough to provide light repairs and progressive maintenance. A cost estimate was therefore developed for a new facility at a new location, although a specific location was not identified for the new northern facility. The southern facility was assumed to be in the general south San Jose area, adjacent to what is now the UP corridor. This allowed for a more informed assessment to be made of the site requirements in terms of land area required and the infrastructure needed for rail access to the new location. This was described in the Caltrain Fleet Maintenance and Storage report that estimated the size for both facilities to support the assumed fleet size and the transition from diesel trains to electric multiple unit (EMUs).

2.3.5.3 Sizing of Maintenance and Storage Facilities

Sizing the facilities included checking site boundaries, facility areas, covered and un-covered track lengths and equipment installations in existing Caltrain operations asset databases. The sizing of maintenance and storage facilities relied on using satellite data and interviews with staff to validate existing maintenance capability and storage capacity at both existing locations. Available overnight platform storage capacity at San Francisco, San Jose and Gilroy was added to derive a current total storage capacity figure.

Progressive delivery of new EMU train sets and replacement of the existing locomotive fleet was assumed to have reached a point where Caltrain would be operating a homogenous EMU fleet before 2029. This was assumed to be preceded by a transition phase while loco sets were taken out of service in conjunction with the ongoing expansion of the EMU fleet up to, and beyond, 2040 under each of the Baseline, Moderate and High Growth Scenarios.

Maintenance and storage requirements at any point in time were assumed to be primarily a derivative of (1) fleet size, (2) the schedule for EMU delivery and introduction into service, (3) replacement and removal of diesel locomotive sets, and (4) expansion of train consists (from 7 to 10 car sets).

Other influencing variables were taken into consideration to determine the scale, characteristics, location, and timing of any shortfalls in maintenance and storage capacity over the planning horizon, including:

- Peak and midday service extensions
- Increasing service frequencies
- Availability of overhead catenary traction power
- Spare train set requirements

Based on this assessment, statements of requirements were generated. These took account of the capacity and capability gaps at each location under each Growth Scenario and any remedial initiatives to address short term deficiencies (for example, those driven by loco to EMU transition peaks). These were converted into scope of work definitions for the size of the maintenance and storage yards as an input to the cost estimates.

Cost Estimating

The project team conducted a benchmark assessment of other maintenance facilities in North America to compare peer facility costs per square foot to the project team's estimate. The cost per square foot includes site preparation work (utility relocations, earthworks, control systems), buildings (maintenance facility building for both light and heavy maintenance facilities), other project costs (temporary facilities, landscaping, access roads, parking, and pedestrian access), equipment and general requirements, contractors overhead and profit, and soft costs such as design, insurance, and bonds. All the cost data from the benchmarked facilities were normalized using location factors for the San Francisco Bay Area and escalated to 2018 USD.

The project team conducted a similar benchmark assessment for calculating the storage track cost per square foot. The unit cost includes yard trackwork and associated systems and walkways, site preparation including utility relocation, general requirements overhead and profit, and soft costs. The unit cost for linear feet of track is based on Arup's Unit Cost Database. All the costs per square foot from the benchmarked facilities were normalized using location factors for the San Francisco Bay Area and escalated to 2018 USD.

The southern facility requires a (rail) flyover for access to and from the main line and the cost of the flyover was developed using a sketch design to establish quantities (length of flyover and additional structures) and Arup's Unit Cost Database to develop cost estimates.

The ROW costs for both facilities were calculated using cost per square foot data provided by Caltrain and quantities provided by the Caltrain Fleet Maintenance and Storage Yard Requirements report.

The infrastructure elements of the storage and maintenance facilities were organized into three categories: ROW, buildings, and track. For modeling purposes, it was assumed that the same size site needed for the High Growth Scenario would be acquired in all scenarios.

Table 20: Northern and Southern Storage Facility Conceptual Size Requirements

	Baseline Growth	Moderate Growth	High Growth
Southern Facility			
Site/ROW	1,200,000 SF	1,200,000 SF	1,200,000 SF
Building	172,500 SF	262,500 SF	281,500 SF
Track (Storage)	180,000 SF	323,750 SF.	471,750 SF
Track (Switch/Mainline)	23,300 LF	31,350 LF	42,380 LF
Northern Facility			
Site/ROW	600,000 SF	600,000 SF	600,000 SF
Building	3,500 SF	3,500 SF	3,500 SF
Track (Storage)	191,250 SF	323,000 SF	356,250 SF
Track (Switch/Mainline)	15,710 LF	19,400 LF	22,250 LF

The project team calculated the cost for the Moderate and High Growth Scenarios as incremental increases to the Baseline Growth Scenario. Incremental increases for Baseline to Moderate Growth Scenario and Baseline to High Growth Scenario are given separately as each scenario has different requirements.

2.3.5.4 Cost Summary

The costs used as inputs to the Cost Model are shown in Table 21.

Table 21: Summary of Cost Storage and Maintenance Yard

		Baseline	Moderate Incremental Cost from Baseline	High Incremental Cost from Baseline
Southern Facility		***$713M***	***$189M***	***$334M***
Site/ROW Acquisition		$360M	$-	$-
Other Storage area				
Building				
	Maintenance Building	$96M	$77M	$93M
	Administration Building	$51M	$-	$-
Track				
	Storage Track	$90M	$72M	$146M
	Track from switches	$91M	$41M	$95M
	Track to mainline	$26M	$-	$-
Flyover			***$66M***	***$66M***
Retaining Wall			$42M	$42M
Flyover			$24M	$24M
Northern Facility		***$357M***	***84M***	***115M***
ROW Acquisition		$180M	$-	$-
Other Storage area				
Building		$3M	-	-
Track				
	Storage Track	$96M	$66M	$83M
	Track from switches	$52M	$18M	$33M
	Track to mainline	$26M		

2.3.6 STATION AMENITIES AND ACCESS IMPROVEMENTS

2.3.6.1 Background

The increasing ridership levels for the different Growth Scenarios will result in the need for additional station access improvements as well as more general improvements to station facilities to serve larger passenger flows. The 2040 ridership forecasts show significant increases in the demand for access at stations, necessitating a significant investment in new facilities and services. Caltrain has not yet developed a policy for addressing future station access and parking demand, but for the purposes of modeling, the cost of building new car and bicycle parking was used a proxy to size the investment in overall station access improvements including transit service. To use parking as the proxy, a working assumption was needed as to the amount of new parking that would be used for the estimates. It was assumed that parking would be built to accommodate 50% of parking demand in parking decks as discussed more in the following sections. It is important to note that this approach does not reflect a Caltrain policy, plan, or intention to invest in additional parking- rather it was used as a high level proxy measure to establish a reasonable system wide basis of cost for a significant overall investment in access facility expansion.

2.3.6.2 Data Sources

- 2017 Caltrain Parking Survey
- Ridership Forecasts (Fehr & Peers)
- Caltrain Bicycle Parking Management Plan (BPMP)
- SPUR Caltrain Vision Plan
- Arup's Unit Cost Database
- Unit cost inputs from Fehr & Peers

Calculation of Car Parking for Estimates

The 2017 Caltrain Parking Survey was used as the source for understanding Caltrain's current number of occupied car parking spaces. The survey was used to calculate the ratio between the number of existing parking spaces currently in use and the current ridership (the parking ratio). The 2040 demand for parking was estimated by applying the parking ratio to 50% of the 2040 forecast ridership. The number of additional parking spaces needed in 2040 was calculated as the difference between the 2040 parking demand and the current parking supply. It was assumed that all additional new parking spaces in 2040 will be provided as structured parking, at the cost of $50,000 per space.

Calculation of Bicycle Parking for Estimates

A bicycle parking ratio was calculated using the same methodology as described for auto parking. The bicycle parking ratio was applied to the 2040 forecast ridership to calculate future bicycle demand. The additional number of bicycle spaces was calculated as the difference between the future demand and current supply. It was assumed that 100% of future bicycle demand would be provided for, with the provision broken into three types: e-lockers, bicycle racks, and a consolidated parking facility. The cost estimate assumed that the additional new bicycle parking would be 20% in e-lockers, 40% in racks and 40% in a consolidated parking facility. The cost estimates assumed for each was $255 per e-lockers space, $4,500 per racks space, and $3,100 per space for the consolidated facility.

Requirements for Other Station Improvements

Other station improvements include new wayfinding, wi-fi, surveillance measures, and ticket vending machines. Wayfinding, wi-fi and surveillance measure cost estimates were calculated based on the station area requirements. These costs were based on a representative station sample which was multiplied by the number of stations in the Caltrain-owned corridor to generate the total corridor cost. San Mateo Station was selected to be the representative station sample.

2.3.6.3 Cost Summary

The costs used as inputs to the Cost Model are shown in Tables 22, 23, and 24.

Table 22: Summary of Station Improvements Costs for Baseline Growth per Segment

Baseline Growth	SF-Tamien	Capitol-Gilroy
Car, Transit and Other Access Improvements	$201M	$40M
Bicycle Parking	$8M	$5M
Amenities	$25M	$6M
Cost per Segment	**$234M**	**$51M**

Table 23: Summary of Station Improvement Costs for Incremental Increase from Baseline to Moderate Growth per Segment

Moderate Growth (incremental)	SF-Tamien	Capitol-Gilroy
Car, Transit and Other Access Improvements	$39M	$0
Bicycle Parking	$2M	$866,000
Amenities	$5M	$1M
Cost per Segment	**$46M0**	**$2M**

Table 24: Summary of Station Improvement Costs for Incremental Increase from Baseline to High Growth per Segment

High Growth (incremental)	SF-Tamien	Capitol-Gilroy
Car, Transit and Other Access Improvements	$100M	$75M
Bicycle Parking	$6M	$2M
Amenities	$10M	$2M
Cost per Segment	**$116M**	**$79M**

2.3.7 RAILWAY IMPROVEMENTS

2.3.7.1 Purpose

The purpose of the railway improvements cost estimate was to generate an estimate of the investment needed in new railway infrastructure to support the Moderate and High Growth Scenarios. The Baseline Growth Scenario does not require additional rail infrastructure to support the proposed level of service beyond the overall platform, systems and other improvements that are captured in the High Speed Rail Cost Category and would be needed to support the baseline level of service as well as the expansion needed at the Millbrae station to accommodate High Speed Rail's use of that station. The general requirements for additional rail infrastructure were identified in the Service Planning Report.

2.3.7.2 Background

For the Moderate and High Growth Scenarios additional rail infrastructure is required to provide running overtakes with much of this investment focused at and on the approach to stations. In the Moderate Growth Scenario, a total of four miles of new overtake segments are required in the corridor, including accommodating additional tracks at four stations. In the High Growth Scenario, 14 miles of overtake are required, including additional tracks at seven stations. The types of railway improvements generally include new platforms, new track, widening of grade crossings, elevating stations, retaining walls, fill, and ROW acquisition.

2.3.7.3 Source

The length of running overtakes, and their general location was identified in the Service Planning Report, but these locations are highly conceptual and have not been translated into any site-specific design work. To develop cost estimates, assumptions were made about possible locations but only as a means to develop placeholder cost estimates. Estimates did not take account of site-specific constraints associated with ground conditions, utilities etc., although allowances for typical site-specific conditions were included in the cost estimate. All costs were developed using the Arup Unit Cost Database. Further policy work, planning and design will ultimately need to be undertaken by Caltrain to select locations of potential overtakes and to develop more precise estimates of likely cost.

2.3.7.4 Methodology

The Moderate and High Growth Scenarios assume new investment is required:

1. Moderate Growth Scenario
   - A new 4-track segment generally from Hayward Park to Hillsdale Station (includes demolition of three existing platforms and five new at-grade platforms)
   - The widening of two grade separations to accommodate four tracks at 25th Avenue in San Mateo and East Hillsdale Boulevard between 28th and 31st avenues.
   - A new 4-track at Redwood City Station. This includes demolition of existing platforms, two new elevated platforms, right-of-way, and a new grade separation at Jefferson Avenue. The Jefferson Avenue grade separation is not included in the grade crossing category to avoid double counting.
   - A new 4-track at California Avenue Station (one of multiple potential stations – selected for costing purposes only). This includes demolition and reconstruction of two platforms and widening of the grade separation at Page Mill Road.
   - New tail tracks past Blossom Hill Road Station to enable train turnaround.
2. High Growth Scenario
   - A new 4-track segment generally from South San Francisco to Millbrae. Specific improvements in this segment are:
     - Construction of two new platforms at the South San Francisco station and elevated platforms at the San Bruno station.
     - Realignment of freight track
     - Widening of eight grade separations from 2-track to 4-track at Airport Boulevard, Colma, Linden Street, Scott Street, San Bruno Avenue, Angus Avenue, Center Street and Hillcrest Boulevard[2].
   - A new 4-track segment from Hayward Park to Redwood City Station. Specific improvements in this segment are:
     - Demolition of eight platforms, reconstruction of nine platforms and two new elevated platforms at the Redwood City Station
     - Eleven new grade separations at East Hillsdale Boulevard, 42nd Avenue, Ralston Avenue, Harbor Boulevard, Holly Street, Arroyo Avenue, Brittan Avenue, Howard, Whipple, Jefferson and 25th Avenue, 28th Avenue, and 31st Avenue[3].
   - A new 4-track at California Avenue Station. This includes demolition of four station platforms and reconstruction of six platforms and grade separation over two creeks. All other 4-track separation costs (Rengstorff, Charleston, E. Meadow Drive) are included as part of the Grade Crossing category.
   - New tail tracks past Blossom Hill Road Station to enable train turnaround.

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[2] The cost to grade separate at Linden Street, Center Street and Scott Street are included within the grade crossing costs. The cost included within the Track and Rail category include widening from 2-track to 4-track only to avoid double counting.

[3] The costs included within the Track and Rail category include widening from 2-track to 4-track only to avoid double counting.

Calculating the Infrastructure Quantities

Using aerial photographs, the project team estimated the quantities of the required infrastructure elements. Key quantities were determined for each category: new platforms, relocation of existing platforms, track relocation, new track, any retaining structures, and ROW areas.

The project team calculated the total infrastructure costs by applying composite unit rates to all quantities, using Arup's Unit Cost Database. For the additional right-of-way estimates, the project team used square foot costs provided by Caltrain. The costs do not include severance damages or the acquisitions or improvements of real property. Appraisers were not commissioned to support the report, nor were any appraiser's opinions relied upon.

Addressing Potential for Overlap Between Railway and Grade Separation Improvements

The cost estimates for railway improvements were developed using the methods noted above; however, an additional step was undertaken to mitigate the potential for double counting with the grade crossing projects that have a potential physical overlap. An example of the potential for overlapping costs is at Redwood City. Redwood City Station is included in one of the lengths of track that would need to be increased from two to four tracks. The increase to four tracks means that the nearby at-grade crossings would all need to be grade separated. In developing the cost estimate, the costs were built up using a cost to elevate Redwood City Station and expand to four tracks (with associated works) plus the individual costs of each of the nearby grade separations. In practice however, this would be designed and constructed as a single project in which a long section of elevated railway would be constructed which would provide for an elevated station and the grade separation of all the nearby crossings. This would result in a cost savings. Adjustments were therefore made to reduce the cost estimates for the railway improvements, while the grade separation portion of the costs continued to be reflected in the grade crossing estimates. Similar adjustments were made at several other segments to address the potential for overlapping costs.

2.3.7.5 Cost Summary

The Moderate and High Growth Scenario rail improvement costs used as inputs to the Cost Model are shown in Table 25 and 26. The costs represent a total for each Growth Scenario and are not incremental above the Baseline Growth Scenario.

Table 25: Summary of Cost for Moderate Growth Scenario Railway Improvements by Segment

	Stations	Passing loops	Land (ROW)
Hayward Park Station to Hillsdale Station	$22M	$455M	$11M
Redwood City Station	$92M	$123M	$14M
California Station	$9M	$119M	$6M
Blossom Hill Station	$-	$9M	$-
Total Moderate Growth Scenario Cost	**$123M**	**$706M**	**$31M**

Table 26: Summary of Cost for High Growth Scenario Railway Improvements by Segment

	Stations	Passing loops	Land (ROW)
Blossom Hill Station	$-	$9M	$-
South SF St to Millbrae Station	$95M	$958M	$145M
Hayward Park St to Redwood City Station	$133M	$1.4B	$93M
California Station to Mountain View Station	$27M	$307M	$20M
Total High Growth Scenario Cost	**$255M**	**$2.7B**	**$258M**

2.3.8 DIRIDON STATION

Diridon Station is currently undergoing a multi-agency, multi-stakeholder planning effort and no partner cost is available for the Diridon Station improvements at time of writing. With the agreement of the partner agencies, a $3 billion placeholder cost was assumed. This cost is assumed to be inclusive of all rail infrastructure modifications between Control Point Coast and Control Point Lick, except for grade separations at Virginia and Auzerais. The Diridon Station improvement costs do not include the cost of relocating / expanding the Caltrain heavy maintenance facility (CEMOF) which has been estimated separately as noted in section 2.3.5.

2.3.9 CALTRAIN MODERNIZATION PROGRAM (CALMOD)

2.3.9.1 Background

The Caltrain Modernization (CalMod) Program will electrify and upgrade the performance, operating efficiency, capacity, safety, and reliability of Caltrain's commuter rail service. The components of the CalMod program includes the installation of the advanced signal system project (Communications Based Overlay Signal System Positive Train Control or CBOSS PTC) and the Peninsula Corridor Electrification Project (PCEP).

CBOSS PTC project is fully funded and is virtually complete. The Caltrain-provided project costs were included in the Cost model.

PCEP is electrifying the corridor from San Francisco's 4th and King Caltrain Station to the Tamien Caltrain Station, upgrading the performance, efficiency, capacity, safety, and reliability of Caltrain's service. The project is scheduled to be completed in 2022 and is fully funded. The project team reviewed project costs sourced from Caltrain and input any related CalMod costs occurring in 2022 into the Cost Model. These included costs associated with a new traction power substation, electrification, real estate, utilities, and tunnel modifications.

2.3.9.2 Cost Summary

The costs used as inputs to the Cost Model are shown in Table 27.

Table 27: CalMod Cost Estimates

	Total cost (2018-2022)
PTC capex	$89M
Total PTC	**$89M**
PCEP Electrification + Add-ons	$223M
Traction Power Substation	$708M
PCEP Real Estate + Add-ons	$28M
PCEP Utilities + Add-ons	$123M
PCEP Tunnel Modifications + Add-ons	$15M
Total PCEP	**$1.1B**

2.3.10 NEW SIGNAL SYSTEMS

Supporting the improvements in all Growth Scenarios, the Business Plan assumes the corridor will require a new signal system for the Caltrain-owned portion of the corridor (44 route miles). Using the Arup Unit Cost Database, the project team calculated the cost of a new signal system. The total cost is shown in Table 28.

Table 28: New Signal System Cost Estimate	
New Signal System Cost	$440M

2.3.11 FLEET

Increasing service, lengthening trainsets, and transitioning to an all-electric fleet requires Caltrain to increase its fleet. Between 2022 and 2033, the fleet is expected to grow from 133 EMU cars to 192 EMU cars to support the Baseline Growth Scenario. Under the Moderate and High Growth Scenarios, the fleet will add additional cars, growing the total fleet size to 350 and 480 EMU cars, respectively.

Unit prices (average prices per EMU car) were derived from the prices in the original Stadler contract executed in June 2016 and the Option exercised in December 2018. The estimated fleet costs for the Baseline, Moderate and High Growth Scenarios shown in Table 29 were derived from these unit prices and the projected fleet sizes for the three scenarios.

Table 29: Fleet Cost Estimates

	Total Baseline Growth	Total Moderate Growth	Total High Growth
PCEP Fleet Cost (Already funded/committed)	$853M	$853M	$853M
2040 Baseline Growth Scenario	$371M	$371M	$371M
2040 Moderate Growth Scenario – increment to baseline	$-	$703M	$-
2040 High Growth Scenario – increment to Baseline	$-	$-	$1.3B
Total	**$1.2B**	**$1.9B**	**$2.6B**

3. CAPITAL COST ESTIMATES SUMMARY

3.1 COST CATEGORIES

Section 2 describes how the cost estimates were organized by ten Cost Elements. Separately, the cost estimates were also organized by Cost Categories for the purpose of summarization and sharing costs with the public and stakeholders. The six Cost Categories are consistent with a cost structure that is used by the Federal Transit Administration for rail infrastructure projects. The Cost Categories are:

- Track and Rail
- Systems
- Stations and Platforms
- Grade Crossings and Separations
- Terminals and Yards
- Fleet

Each of the ten Cost Elements identified in Section 2 can either be summarized into a single Cost Category or can be broken into component Cost Categories. An example of a Cost Element that is summarized in a single category is Station Access and Amenities which is included in Stations and Platforms. An example of a Cost Element that is split between multiple categories is the Downtown Extension and Pennsylvania Avenue Tunnel. When this cost is broken down by Cost Category, the Pennsylvania Avenue Tunnel falls into the Grade Crossing and Separations Cost Category while the Downtown Extension is included in the Track and Rail Cost Category and the 22nd Street Station is included in the Stations and Platforms Cost Category. The cost summaries below are all provided by Cost Category.

3.2 BASELINE GROWTH SCENARIO 2040 RESULTS

The Baseline Growth Scenario includes electrifying Caltrain's Fleet and expanding to six trains per hour per direction during peak periods, including blended service operations with CAHSR on a mostly two-track corridor (as described in the CAHSR Business Plan); and extending operations to the Salesforce Transit Center via DTX.

The Baseline Growth Scenario cost estimate is the sum of the costs (within each Cost Category) across all Change Points from 2022 to 2040 Baseline. This is shown in Table 30 below.

Table 30: Baseline Growth Scenario Total Cost Estimate

Cost Category	Baseline Growth Scenario
Track and Rail	$1.4B
Systems	$2.1B
Stations	$1.3B
Grade Crossings	$8.5B
Terminals and Yards	$7.5B
Fleet	$1.3B
Total	**$22.1B**

3.3 MODERATE SCENARIO 2040 RESULTS

The 2040 Moderate Growth Scenario expands on the Baseline Growth Scenario by increasing Caltrain service to eight trains per hour per direction during peak periods. The Moderate Growth plan includes several locations in which faster trains overtake slower trains along the corridor. To facilitate these overtakes, approximately three miles of new four track segments and stations are needed. These infrastructure investments include a short four track main line section between Hayward Park and Hillsdale (inclusive of stations), a 4-track station at Redwood City, and a 4-track station somewhere in northern Santa Clara County (Palo Alto, California Avenue, San Antonio, or Mountain View). Tail tracks are also required just beyond the Blossom Hill station to facilitate turning two Regional Express trains at this location.

The Moderate Growth Scenario cost estimate is the sum of the costs (within each Cost Category) across all Change Points from 2022 to 2040 Moderate. This is shown in Table 31 below.

Table 31: Moderate Growth Scenario Total Cost Estimate

Cost Category	Moderate Growth Scenario
Track and Rail	$2.3B
Systems	$2.2B
Stations	$1.4B
Grade Crossings	$7.9B
Terminals and Yards	$7.7B
Fleet	$2B
Total	**$25.3B**

3.4 HIGH GROWTH SCENARIO 2040 RESULTS

The High Growth Scenario expands on the Baseline Growth Scenario by increasing Caltrain service to twelve trains per hour per direction during peak periods. The High Growth service plan needs approximately 14 miles of new four track segments spanning South San Francisco to Millbrae, Hayward Park to Redwood City, and California Avenue to Mountain View (or elsewhere in northern Santa Clara County between Palo Alto and Mountain View).

The High Growth Scenario cost estimate is the sum of the costs (within each Cost Category) across all Change Points from 2022 to 2040 High. This is shown in Table 32 below.

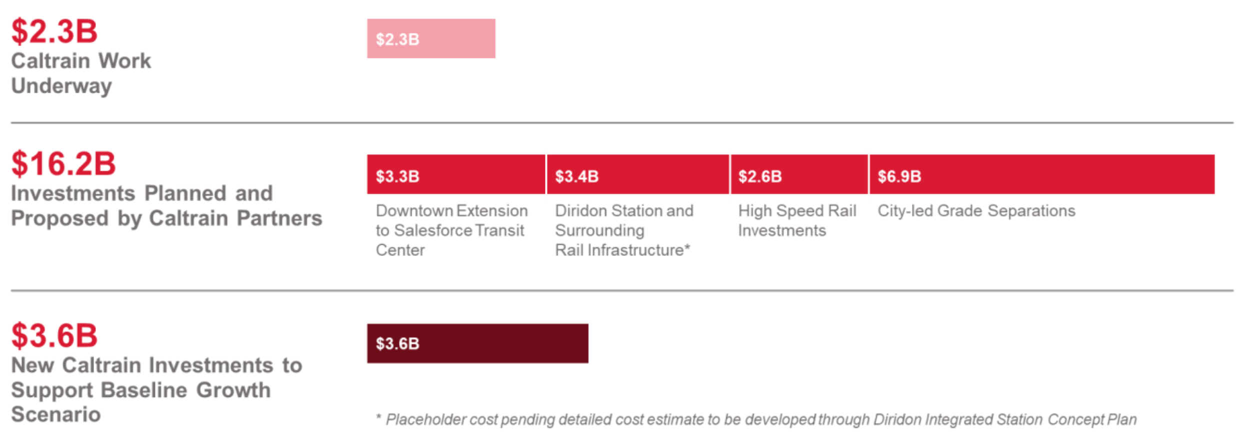
Table 32: High Growth Scenario Total Cost Estimate

Cost Category	High Growth Scenario
Track and Rail	$4.6B
Systems	$2.2B
Stations	$1.6B
Grade Crossings	$11B
Terminals and Yards	$7.9B
Fleet	$2.6B
Total	**$29.9B**

3.5 COSTS BY INPUT SOURCE

The total costs for the Baseline Growth Scenario are shown in Figure 4, broken out by the source of the costs. This indicates that Partner Projects make up the majority of the total costs for the Baseline Growth Scenario. This is also true for the Moderate and High Growth Scenarios, since they are incremental costs on top of the Baseline Growth Scenario.

FIGURE 4: 2040 BASELINE GROWTH SCENARIO – COSTS BY SOURCE



3.6 GROWTH SCENARIO COMPARISON

The total costs for each Growth Scenario are shown in Table 33. The incremental costs above the Baseline Growth Scenario are the additional projects requirement to support the increased service levels.

Table 33: Growth Scenario Cost Comparison

Cost Category	Baseline Growth Scenario	Moderate Growth Scenario	High Growth Scenario
All	$22.1B	$25.3B	$29.9B
Incremental cost	--	$3.2B	$7.8B

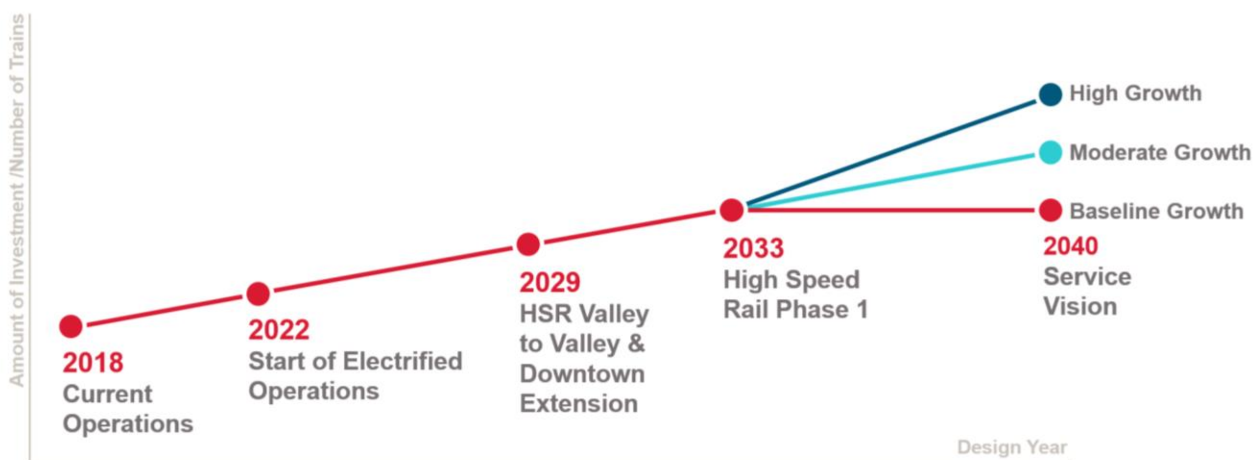
4. CHANGE POINTS AND GROWTH SCENARIOS

4.1 KEY SERVICE DATES

Capital investments are assumed to be made in a series of steps (Change Points) between 2022 and 2040. Organizing the cost estimates by Change Point was needed to support the development of the Business Case since the time value of money was key to developing performance measures like Benefit-Cost Ratio and Net Present Value. Please see the Business Case Memo for more detail. The cost estimates are structured to reflect the Change Points with the infrastructure investment requirement identified and recorded for each Change Point. The primary definers of required infrastructure for each Change Point were the service plans and partner project schedules. The Change Points and corresponding investment level against time are listed below and shown in Figure 5.

- 2022 - Start of electrified service
- 2029 - Opening of DTX and initial CAHSR service
- 2033 - Full Phase 1 CAHSR service
- 2040 - Growth Scenario Build out

FIGURE 5: CORRIDOR CHANGE POINTS



As shown in the figure, all Growth Scenarios share the same investments between the years 2018 – 2033.

A summary of the cost estimates by cost and temporal categories is shown in Table 34.

Table 34: Incremental Cost Estimates by Category and Corridor Change Point

Cost Category	2022	2029	2033	2040 (Baseline)	2040 (Moderate)	2040 (High)
Track and Rail	-	$1.4B	-	-	$0.9B	$3.2B
Systems	$1.2B	$0.9B	-	-	$0.1B	$0.1B
Stations	$70M	$0.1B	$0.2B	-	$0.1B	$0.3B
Grade Crossings	$0.2B	$1.4B	$0.1B	$6.8B	$1.1B	$2.5B
Terminals and Yards	-	$7.5B	-	-	$0.3B	$0.4B
Fleet	$0.9B	$0.4B	-	-	$0.7B	$1.3B
Total	**$2.3B**	**$12.6B**	**$0.35B**	**$6.8B**	**$3.2B**	**$7.8B**

The following sections provide a narrative description of the investments by Cost Category at each Change Point, noting if the costs are incremental over the previous Change Point.

4.2 BASELINE, MODERATE, HIGH GROWTH SCENARIO – YEAR 2022

In 2022, the Peninsula Corridor Electrification Project (PCEP) from Tamien to San Francisco is assumed to be complete, with 19 7-car EMU sets and 11 diesel locomotives and 61 coaches providing six trains per hour during the peak period in a mixed fleet operation.

4.2.1 TRACK AND RAIL

There are no assumed Track and Rail investments in the period up to 2022.

4.2.2 SYSTEMS

In 2022, PCEP is in its planned final year of construction. The remaining project elements are to support the completion of electrification and a new traction power substation. In addition, broadband communication improvements across the corridor are being completed.

The installation of PTC will have been completed.

4.2.3 STATIONS

Caltrain, in coordination with the City of South San Francisco, is preparing to replace the existing South San Francisco Station (South San Francisco Caltrain Station Improvement Project) with a new center boarding platform connecting to a pedestrian underpass. The project consists of track work, signal work, a new 700-foot center board platform with amenities and connectivity to a new pedestrian underpass from the platform to Grand Avenue/Industrial Way. The project improves safety by eliminating the hold out rule and will provide increased connectivity along Grand Avenue for the City of South San Francisco. The improvements will also make the station fully compliant with the Americans with Disabilities Act (ADA).

4.2.4 GRADE CROSSINGS

Caltrain completes several improvements at grade crossings along the corridor, including the 25th Avenue Grade Separation Project, hazard mitigation at select at-grade crossings, and improvements to the Guadalupe Bridge and the Marin/Napoleon Bridge.

4.2.5 TERMINALS AND YARDS

There are no assumed terminal and yard improvements in 2022.

4.2.6 FLEET

It is assumed that the 19 7-car EMU sets that are already funded and committed as part of PCEP will have been delivered and placed into service by 2022.

4.2.7 COST ESTIMATE

The total cost estimate for 2022 is shown in Table 35.

Table 35: 2022 Cost Estimate

Cost Category	2022
Track and Rail	-
Systems	$1.2B
Stations	$70M
Grade Crossings	$200M
Terminals and Yards	-
Fleet	$900M
Total	**$2.3B**

4.3 BASELINE, MODERATE, HIGH GROWTH SCENARIO – YEAR 2029

It is assumed that in 2029, CAHSR Valley to Valley service will begin. On the Caltrain corridor, full electrification will be complete, with eight trains per hour operating during peak periods (six Caltrain, two CAHSR). Platforms will have been extended to accommodate eight-car consists and raised for level boarding for seamless transitions between Caltrain and CAHSR trains.

Between San Jose and Gilroy, CAHSR will have completed several improvements to support service to San Jose, including improvements at Diridon and within the station area, track upgrades, new aerial structures, rebuilt Stations and Systems works such as electrification, communication systems and train control.

Between San Francisco and San Jose, the Downtown Extension project (and the ROW acquisition for the Pennsylvania Avenue Tunnel) in San Francisco will have been implemented, new northern and southern maintenance and storage facilities will be operational, and a new signal system will be in place to support additional service.

4.3.1 TRACK AND RAIL

The Track and Rail investments occurring by 2029 focus mostly on improving the corridor to support CAHSR service. These projects include:

- Curve straightening and track upgrades in order to achieve 110 mile per hour (mph) trains speeds between San Francisco and San Jose
- Expand Millbrae Station to accommodate four tracks
- Rebuild the corridor between CP Lick and Gilroy with three tracks

4.3.2 SYSTEMS

Like the Track and Rail investments for 2029, the Systems investments support delivering CAHSR service to the corridor. These projects include:

- New signal and Systems south of 4th & King to Gilroy for CAHSR
- New overhead contact system/traction power supply for CAHSR
- New train signal system between Tamien and San Francisco

4.3.3 STATIONS

It is assumed that by 2029, work to improve and expand stations to support CAHSR and 8-car Caltrain trains for the Baseline Growth Scenario will have been completed. It is further assumed that extending platforms to accommodate 10-car Caltrain train lengths for the Moderate and High Growth Scenarios will have been completed by 2040.

Station projects include:

- Extend Caltrain station platforms to accommodate 8-car Caltrain trains (only for stations currently not meeting minimum length)
- Raise all Caltrain station platforms to 25" to provide level boarding with CAHSR trains
- Total rebuilding of all Caltrain Stations from Capitol to Gilroy (includes platform extensions and level boarding for 8-car Caltrain trains)
- Build a CAHSR station at Gilroy
- Build new 22nd Street Station in San Francisco (in advance of the Pennsylvania Avenue Tunnel project)

4.3.4 GRADE CROSSINGS

The grade crossing improvements completed by 2029 are limited to the UP corridor. These support CAHSR service to San Jose. Improvements have not been identified at specific locations, only the amount of the proposed investment:

- Twenty (20) quad safety gates
- Three (3) mitigated closures
- Five (5) grade separations.

4.3.5 TERMINALS AND YARDS

It is assumed that the terminals at each end of the Caltrain-owned portion of the corridor (Downtown Extension and Diridon) will have been completed by 2029. In addition, the new north light maintenance facility will have been completed and the Central Equipment & Maintenance Facility (CEMOF) will have been relocated to the new heavy maintenance facility near Capitol Expressway in San Jose. The north light maintenance facility size supports the Baseline Growth Scenario.

Terminal & Yard projects are:

- Completion of the Downtown Extension (excluding Pennsylvania Avenue project)
- Completion of the Diridon Station Project (includes all improvements between CP Coast and CP Lick)
- Completion of the north light maintenance facility
- Completion of CEMOF relocation to newly constructed high maintenance facility near Capitol Expressway

4.3.6 FLEET

For 2029, it is assumed that the Baseline Growth Scenario fleet of 24 8-car EMU sets will have been delivered and readied for service implementation.

4.3.7 COST ESTIMATE

The total cost estimate for 2029 is shown in Table 36.

Table 36: 2029 Cost Estimate

Cost Category	2029
Track and Rail	$1.4B
Systems	$900M
Stations	$1B
Grade Crossings	$1.4B
Terminals and Yards	$7.5B
Fleet	$400M
Total	**$12.6B**

4.4 BASELINE, MODERATE, HIGH GROWTH SCENARIO – YEAR 2033

It is assumed that by 2033, CAHSR Phase I will have been completed. On the Caltrain corridor ten trains per hour will be operating during peak periods (six Caltrain, four CAHSR).

Between San Francisco and San Jose, all of the grade crossings improvements under the Baseline Growth vision will have been completed. As ridership continues to grow, station improvements including new bicycle and car parking and additional station amenities will be provided. It is assumed that by 2033 the Pennsylvania Avenue Tunnel will have been completed, thus completing the DTX project.

4.4.1 TRACK AND RAIL

There are no assumed Track and Rail investments for 2033.

4.4.2 SYSTEMS

There are no assumed Systems investments for 2033.

4.4.3 STATIONS

Station investments assumed to be completed by 2033 revolve around expanding station access services and facilities and improving station amenities, such as enhanced wayfinding, safety and security, and additional fare vending machines.

4.4.4 GRADE CROSSINGS

There are no further grade crossing investments assumed for 2033.

4.4.5 TERMINALS AND YARDS

There are no terminals and yards investments assumed for 2033.

4.4.6 FLEET

There are no fleet investments assumed for the 2033 service.

4.4.7 COST ESTIMATE

The total cost estimate for 2033 is shown in Table 37.

Table 37: 2033 Cost Estimate

Cost Category	2033
Track and Rail	-
Systems	-
Stations	$200M
Grade Crossings	$100M
Terminals and Yards	-
Fleet	-
Total	**$350M**

4.5 BASELINE GROWTH SCENARIO – YEAR 2040

In the 2040 Baseline Growth Scenario, it is assumed that CAHSR Phase I and other major regional projects will have been completed. Service along the corridor will be at ten trains per hour (six Caltrain and four CAHSR) during the peak period. The grade crossing investments specifically required for the Baseline Growth Scenario will have been completed (12 quad gates, four mitigated closures, and 25 grade separations).

4.5.1 TRACK AND RAIL

There are no assumed Track and Rail investments for Baseline 2040.

4.5.2 SYSTEMS

There are no assumed systems investments for Baseline 2040.

4.5.3 STATIONS

There are no assumed station improvements for Baseline 2040.

4.5.4 GRADE CROSSINGS

To support the Baseline Growth Scenario, the medium level of grade separation investments (including 25th Avenue grade separation project and the Pennsylvania Avenue Tunnel) will have been completed. The mix of investments is not location-specific and includes:

- Twelve (12) quad gates & safety improvements
- Four (4) mitigated closures
- Twenty-five (25) grade separations

The grade crossing investments are for grade crossings on the Caltrain-owned corridor only.

4.5.5 TERMINALS AND YARDS

There are no assumed terminals and yards improvements for Baseline 2040.

4.5.6 FLEET

There are no assumed Fleet improvements for Baseline 2040.

4.5.7 COST ESTIMATES

The total cost estimate for Baseline Growth Scenario - 2040 is shown in Table 38.

Table 38: Baseline Growth Scenario 2040 Cost Estimate

Cost Category	Baseline Growth Scenario 2040
Track and Rail	-
Systems	-
Stations	-
Grade Crossings	$6.8B
Terminals and Yards	-
Fleet	-
Total	**$6.8B**

4.6 MODERATE GROWTH SCENARIO – YEAR 2040

In the 2040 Moderate Growth Scenario, it is assumed that the service level during the peak period will increase to 12 trains per hour (eight Caltrain and four high speed trains). All discussion in this section is for incremental investments above the 2040 Baseline Growth Scenario.

Increasing service to 12 trains per hour requires additional infrastructure, including new passing track between Hayward Park and Hillsdale Stations, Redwood City Station, California Avenue Station, and Blossom Hill Station. The number of station improvements is greater than for the Baseline Growth Scenario, as is the required size of the storage yard and maintenance facility. The locations for the new storage and maintenance facility (one in the northern portion of the corridor and one in the south), have not been identified, but are assumed to be the same for all growth visions, with differing sizes based on need. It is assumed that platforms will have been lengthened to accommodate 10-car consists, an increase from 8-car consists in 2029, and the grade crossing investments developed for the Moderate Growth Scenario will have been implemented.

The higher service levels are accompanied by increase ridership demand, which will be supported by additional station access improvements and other passenger-related investments.

4.6.1 TRACK AND RAIL

The Moderate Growth Scenario requires additional Track and Rail investments to support the increase from six to eight Caltrain trains per hour per direction above the Baseline Growth Scenario. The investment cost estimates shown here are indicative of the improvements needed to support the service levels for the Moderate Growth Scenario and are not a set of decisions or assumptions of location specific Track and Rail improvements. The indicative improvements needed include new passing track between Hayward Park and Hillsdale, at Redwood City Station and at California Avenue Station, new tail tracks at Blossom Hill Road Station, and the widening of two grade separations in San Mateo.

4.6.2 SYSTEMS

It is assumed that additional traction power supply will be needed to support the additional service operating along the corridor in Moderate Growth 2040.

4.6.3 STATIONS

Stations in the Moderate Growth Scenario are expanded to accommodate the increased train service through further platform lengthening and additional station parking and amenities. The costs are captured as incremental improvements above the Baseline Growth Scenario. The projects include:

- Extending all Caltrain station platforms to accommodate 10-car Caltrain trains
- Raising all new Caltrain station platform extensions to 25” to provide level boarding
  Increasing statin access and amenities based on ridership increase assumptions.

4.6.4 GRADE CROSSINGS

The Moderate Growth Scenario requires a different, more costly mix of investment in grade crossing improvements. The mix of improvements with the incremental change over the 2040 Baseline Growth Scenario in parenthesis are summarized as follows:

- Eleven (11) quad gates & safety improvements (One less than Baseline Growth Scenario)
- Five (5) mitigated closures (One more than Baseline Growth Scenario)
- Twenty-five (25) grade separations (Same as Baseline Growth Scenario)

The assumed grade crossing investments are for Grade Crossings on the Caltrain-owned corridor only.

4.6.5 TERMINALS AND YARDS

It is assumed that both the light maintenance facility and the high maintenance facility will have been increased in size in terms of terminal and yard space for maintenance and storage and right-of-way to accommodate the increased Fleet size required for the Moderate Growth Scenario.

4.6.6 FLEET

It is assumed that the additional 158 EMU cars to support the Moderate Growth Scenario will have been delivered and readied for service implementation by 2040.

4.6.7 COST ESTIMATES

The total incremental cost estimate for Moderate Growth Scenario - 2040 is shown in Table 39.

Table 39: Moderate Growth Scenario 2040 Incremental Cost Estimate

Cost Category	Incremental Cost
Track and Rail	$0.9M
Systems	$0.1M
Stations	$0.1M
Grade Crossings	$1.1B
Terminals and Yards	$0.3M
Fleet	$0.7M
Total	**$3.2B**

4.7 HIGH GROWTH SCENARIO – YEAR 2040

In the 2040 High Growth Scenario it is assumed that service will increase to 16 trains per hour (12 Caltrain and four high speed trains) during the peak period in 2040. All discussion in this section is for incremental investments above the 2040 Baseline Growth Scenario.

Increasing service to 12 trains per hour requires additional infrastructure, including new passing track (South San Francisco to Millbrae Stations, Hayward Park to Redwood City Stations, California Avenue to Mountain View Stations, and Blossom Hill Station). The number of station improvements is greater than the Baseline Growth Scenario improvements, as is the required size of the storage yard and maintenance facility. It is assumed that platforms will have been lengthened to accommodate 10-car consists, an increase from 8-car consists in 2029, and that the grade crossing investments developed for the High Growth Scenario will have been implemented.

The higher service levels are accompanied by increase ridership demand, which will be supported by additional station access and other passenger-related investments.

4.7.1 TRACK AND RAIL

The High Growth Scenario requires additional Track and Rail investments to support the increase from six to twelve Caltrain trains per hour per direction above the Baseline Growth Scenario. The cost estimates for these are indicative only, based on the amount of improvement needed to support the service levels for the High Growth Scenario, and not a set of decisions or assumptions of where the Track and Rail improvements will be required. The exact improvement locations will be defined in a future conceptual design. The indicative improvements include new passing track between South San Francisco and Millbrae, Hayward park to Redwood City Station, at California Avenue Station, and new tail tracks at Blossom Hill Road Station. There will also be grade crossing improvements, ranging from widening existing grade separations to new grade separations.

4.7.2 SYSTEMS

It is assumed that additional traction power supply will be needed to support the increased service operating along the corridor.

4.7.3 STATIONS

Stations in the High Growth Scenario will be expanded to accommodate the increased train service through further platform lengthening and additional station parking and amenities. The costs are captured as incremental improvements above the Baseline Growth Scenario. The projects include:

- Extending all Caltrain station platforms to accommodate 10-car Caltrain trains
- Raising all new Caltrain station platform extensions to 25" to provide level boarding with CAHSR trains
- Increasing station access and amenities based on ridership increase assumptions.

4.7.4 GRADE CROSSINGS

The High Growth Scenario requires a different, more costly mix of investment in grade crossing improvements. The mix of improvements with the incremental change over the 2040 Baseline Growth Scenario in parenthesis are summarized as follows:

- Six (6) quad safety gates (Six less than Baseline Growth Scenario)
- Eight (8) mitigated closures (Four more than Baseline Growth Scenario)
- Twenty-seven (27) grade separations (Two more than Baseline Growth Scenario)

The grade crossing investments are for grade crossings on the Caltrain-owned corridor only.

4.7.5 TERMINALS AND YARDS

It is assumed that both the light maintenance facility and the high maintenance facility will have been increased in size in terms of terminal and yard space for maintenance and storage and right-of-way to accommodate the increased fleet size required for the High Growth Scenario.

4.7.6 FLEET

It is assumed that the additional 288 EMU cars required to support the High Growth Scenario will have been delivered and readied for service implementation by 2040.

4.7.7 COST ESTIMATES

The total incremental cost estimate for the High Growth Scenario - 2040 is shown in Table 40.

Table 40: High Growth Scenario 2040 Incremental Cost Estimate

Cost Category	Incremental Cost
Track and Rail	$3.2B
Systems	$0.1M
Stations	$0.3M
Grade Crossings	$2.5B
Terminals and Yards	$0.4M
Fleet	$1.3B
Total	**$7.8B**

5. CAPITAL REPLACEMENT COSTS

5.1 PURPOSE

The purpose of the capital replacement cost estimate is to generate an estimate for the overall financial investment in the corridor over 53 years, from 2018 through 2070. It was an essential part of developing the business case for increased Caltrain service to appropriately align the potential cost of new service with the long-term cost and benefits.

5.1.1 BACKGROUND

Capital replacement costs are used as an input to the IBM developed as part of the Caltrain Business Plan, so that the total financial impact of infrastructure investment over the long term could be captured in the analysis.

5.1.2 SOURCE

Capital replacement costs were developed by the project team based on recommended industry practices for life cycle cost for infrastructure projects and FTA recommended projected useful life for each separate asset.

5.1.3 METHODOLOGY

The Cost Model provides replacement cost estimates for each project based on having the infrastructure replaced by the end of the "projected useful life" after the assumed end of construction, with the replacement cost being spread over the number of years needed to implement the replacement. Not all projects will require the full one hundred percent replacement at the end of the projected useful life, and assumptions were made as to the percentage of each project that would have to be replaced each cycle. The Cost Model utilizes the capital costs as a baseline, applying percentages of required replacement for each line item, to generate the replacement cost at each life cycle of each entry.

5.1.4 OUTPUT

Based on the replacement model, the tables below show the total replacement cost for each Growth scenario in 2018 USD.

Table 41: Baseline Growth Scenario Replacement Cost Summary

Cost Category	Projected useful life (years)	Allowance spread (years)	Required replacement (% of initial capex)	Total Repex Cost (2018 $)
Track and Rail	15 – 35	2 – 4	15 – 100%	$2.2B
Systems	15 - 35	1 – 4	15 – 100%	$1.8B
Stations	5 – 35	1 – 4	15 – 20%	$1.1B
Grade Crossings	15	3	15%	$2.5B
Terminals and Yards	20 – 35	2	10% - 100%	$0.5B
Fleet				$1.2B
Total				**$9.3B**

Table 42: Moderate Growth Scenario Replacement Cost Summary

Cost Category	Projected useful life (years)	Allowance spread (years)	Required replacement (% of initial capex)	Total Repex Cost (2018 $)
Track and Rail	15 – 35	2 – 4	15 – 100%	$2.3B
Systems	15 - 35	1 – 4	15 – 100%	$1.8B
Stations	5 – 35	1 – 4	15 – 20%	$1.1B
Grade Crossings	15	3	15%	$2.7B
Terminals and Yards	20 – 35	2	10% - 100%	$0.5B
Fleet				$1.9B
Total				**$10.4B**

Table 43: High Growth Scenario Replacement Cost Summary

Cost Category	Projected useful life (years)	Allowance spread (years)	Required replacement (% of initial capex)	Total Repex Cost (2018 $)
Track and Rail	15 – 35	2 – 4	15 – 100%	$2.7B
Systems	15 - 35	1 – 4	15 – 100%	$1.8B
Stations	5 – 35	1 – 4	15 – 20%	$1.2B
Grade Crossings	15	3	15%	$2.3B
Terminals and Yards	20 – 35	2	10% - 100%	$0.5B
Fleet				$2.6B
Total				**$11.1B**

Appendix A: Capital Cost Allocation for Modeling Purposes

As described in the preceding memo, many of the infrastructure investments needed to deliver either the baseline, moderate or high growth scenarios will be shared by or benefit multiple users. While new EMUs will be used exclusively by and to the benefit of Caltrain's service, a new station at Diridon will be shared by multiple rail operators, and a grade separation will have benefits to both rail operations as well as road users. The capital infrastructure costs developed in this memo represent the estimated total costs of these investments, however establishing the "Caltrain" benefit of these improvements for the purposes of cost-benefit analysis requires that some costs be conceptually divided and allocated to different beneficiaries. The allocation methodology used to conduct this analysis is outlined below.

It is critical to note that this process of allocation is inherently abstract and was undertaken solely for the purposes of economic modeling to align project costs with beneficiaries (an inherently challenging undertaking when infrastructure may benefit multiple rail operators or can have transportation benefits that extend beyond rail). These allocations are intended to reflect a reasonable approach for the purposes of economic analysis and are no way intended to reflect a policy determination on the part of Caltrain regarding benefits of individual projects or to imply the funding responsibilities of individual stakeholders or project participants. The modeling work associated with allocation was performed by First Class Partnerships in conjunction with Caltrain staff and was not part of the Arup work scope.

Allocation of Infrastructure Costs for Analysis Purposes

Capital costs were allocated between stakeholders based on Caltrain guidance as to which of the stakeholders is the primary driver of the need for the project.

In order to isolate the costs and benefits accruing to Caltrain alone, assumptions were made about how the capital costs identified by HSR and other corridor partners might be 'allocated' back to those parties for the purpose of aligning costs and benefits. These assumptions do not reflect a policy judgement on which party should bear the costs of funding specific improvements.

The generic assumption is that major projects have been allocated to the party that identified the need, including:

- Track upgrades
- Tunnels
- Buildings
- Storage yards & Maintenance Facilities
- PTC
- Communications systems
- New signaling system - for now treated as an HSR-only investment as it is triggered by the need to go to 110 mph in 2029.

Exceptions to this are:

- **Grade Crossings:** allocations between road and rail for each grade crossing based on analysis of Gate Down Time then allocation between Caltrain and HSR based on share of number of trains passing
- **Overtakes and passing loops:** as per analysis of operations to represent the underpinning purpose of each loop
- **Electrification:** Caltrain north of CP Lick, HSR south of CP Lick

- **Station improvements, lengthening, level boarding:** Caltrain north of CP Lick, HSR south of CP Lick
- **Diridon station:** a major station upgrade project to be shared between Caltrain, HSR and other railroads, currently allocated 4/4/2 per number of platforms
- **HSR annex to Millbrae station:** an HSR project separate from the upgrades needed for the Caltrain station

Economic Evaluation Technical Memo

Prepared for:

Caltrain

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Prepared by:

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1. INTRODUCTION

This technical report describes the methodology used to evaluate the impacts of two potential Caltrain scenarios from an economic perspective. These scenarios – moderate growth and higher growth – are compared to a baseline to understand how the investments change economic outcomes. The comparison relies on two separate types of economic evaluation, benefit-cost analysis and economic impact analysis, to capture benefits to users and changes in the regional economy.

For both types of evaluation, three scenarios are defined. The "Baseline Growth" scenario refers to the existing Caltrain service plus planned investments. The "Moderate Growth" scenario refers to the moderate growth service expansion with the improvements being built upon the baseline investments. The "Higher Growth" scenario refers to the higher growth service expansion with the improvements being built upon the baseline investments.

The first type of economic evaluation, a **benefit-cost analysis (BCA)** of the moderate and high growth passenger rail scenarios, compares estimates of monetized user benefits to incremental agency costs. The results are summarized in measures of economic return, including net present value and benefit-cost ratio. The analysis uses monetized benefits derived from changes in ridership between the moderate and high growth scenarios and the baseline growth. This evaluation is similar to a separate analysis conducted in the Integrated Business Model (IBM), but with some notable differences.

Both the IBM and the BCA analysis described in this methodology report were used to evaluate the benefits anticipated from the Caltrain service planning scenarios in this project. While these models provide combined benefit to Caltrain, they have their own nuances. For example, the BCA outlined in this report includes public health impacts. This benefit is not captured in the IBM model. However, the IBM analysis has the advantage of being integrated into the business model framework, so that it can be updated dynamically as Service Vision scenarios and or incremental investments are further planned and defined. The BCA output is static and cannot be updated without new travel demand and service planning inputs. In addition, the IBM includes financial impacts, which are not typically part of a BCA.

To ensure that Caltrain has the benefits of the detailed analysis described in this report and the responsiveness and flexibility of the IBM, the two tools were used in concert and input values were coordinated. When comparing results, Caltrain should keep in mind the specific focus of each tool. The BCA focused on user benefits. The BCA results will differ from the IBM results that included financial impacts. For example, changes in ridership will affect fare revenues. Additional fare revenues are not included as a benefit in the BCA because they are a transfer payment from a benefit standpoint. However, the IBM includes these revenues in the financial analysis, because they make an important financial contribution to Caltrain revenues.

The second evaluation described in this report is an **economic impact analysis (EIA)**. This evaluation helps Caltrain understand the short-term and long-term impacts on the regional economy of investment in expanded passenger rail service. These impacts are driven primarily by changes in spending associated with construction and the operations and maintenance of the high and moderate growth scenarios. The results are summarized in terms of gross regional product (GRP), jobs, and personal income.

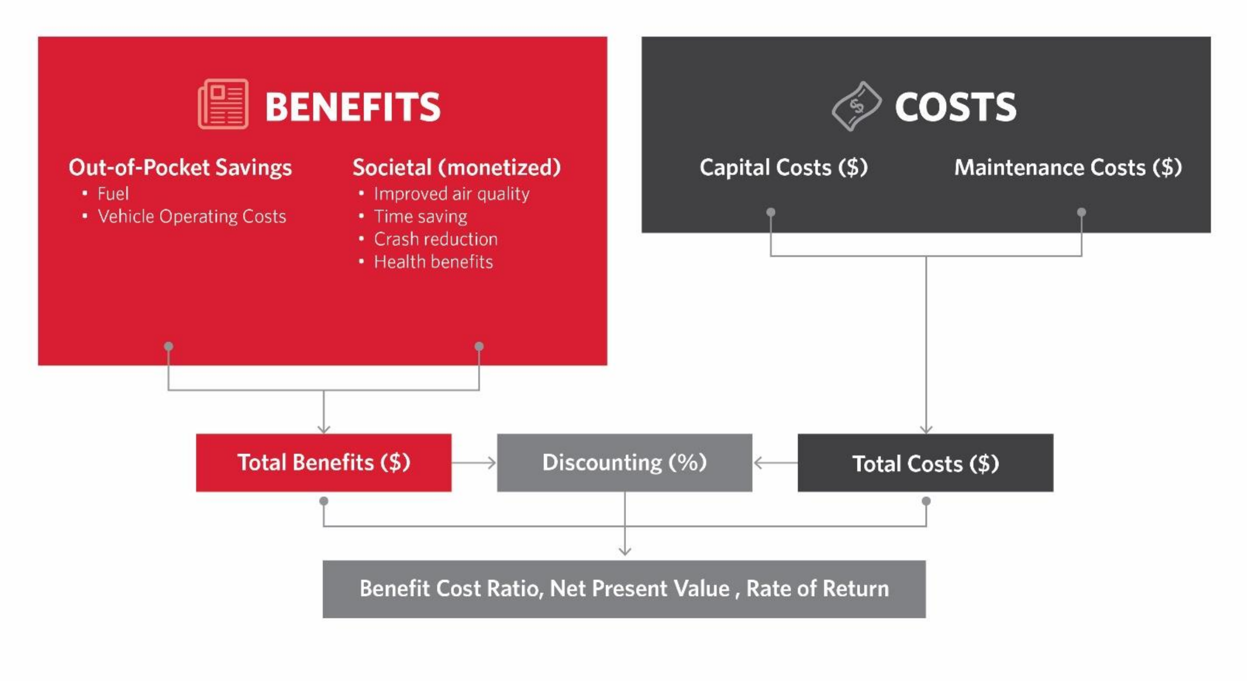
The sections that follow describe the methodology, key assumptions, data requirements and results for both the BCA and EIA evaluations.

2. BCA METHODOLOGY AND PARAMETERS

Benefit-cost analysis (BCA) is a systematic approach to compare the benefits and costs of scenarios, with the goal of determining the soundness of investment decisions. BCA can be used to select preferable options by considering the public benefits generated by investments to the lifecycle costs of those investments. BCA can also be used to articulate the benefits of a potential investment to stakeholders and the public at large.

To conduct this analysis for the Caltrain Business Plan, the Project Team relied on California standard values developed by the California Department of Transportation (Caltrans) on behalf of the California Transportation Commission (CTC), industry-accepted standards and parameters, as well as US Department of Transportation (USDOT) guidance where additional values were needed. Capital (CAPX) and operating (OPX) costs were estimated over time, while benefits included travel time savings, safety benefits, and vehicle operating costs among others. The net present value (NPV) of total costs and benefits was estimated, and discounted to reflect the time value of money. In addition, a benefit-cost ratio was calculated by comparing project benefits to project costs. The BCA process is presented in Figure 1.

FIGURE 1: BENEFIT-COST ANALYSIS PROCESS DIAGRAM



To estimate benefits for the Business Plan, the Project Team looked at benefits generated at the corridor level to monetize the costs and benefits of passenger rail growth scenarios, within the context of the full project life while accounting for the time value of money through the use of discount rates.

Benefits were estimated for both the moderate and higher growth passenger rail service scenarios from 2040 onward. The scenarios consider the impact of their respective growth services expansion investments compared against baseline investments.

2.1 GENERAL ECONOMIC VALUES AND ASSUMPTIONS

YEAR OF CURRENT DOLLARS

The Project Team converted all economic values for monetizing benefits to 2018 dollars using the Implicit Price Deflators for Gross Domestic Product (also called the GDP deflator) from the Bureau of Economic Analysis (BEA). Economic values were adjusted by the factors shown in Table 1.

TABLE 1: GROSS DOMESTIC PRODUCT (GDP) DEFLATOR

Year	GDP	Factor
2007	92.486	1.192
2008	94.285	1.169
2009	95.004	1.160
2010	96.111	1.147
2011	98.118	1.124
2012	100.000	1.102
2013	101.755	1.083
2014	103.680	1.063
2015	104.789	1.052
2016	105.935	1.041
2017	107.948	1.021
2018	110.247	1.000

Source: Bureau of Economic Analysis (BEA)

PERIOD OF ANALYSIS

USDOT recommends that the period of analysis for a BCA covers the full development and construction of the project, plus at least 20 years of operation after construction is complete to account for the benefits and costs of transportation projects.[1] The Project Team used a period of analysis from 2022 to 2070 for the BCA. This period includes project development and construction years (2022 to 2040) and operations (2040 to 2070). This is a longer period than USDOT typically recommends, but consistent with the timeframe for the IBM analysis. It is assumed that there will be no benefits generated during the period between 2033 and 2040. The first full year of benefits will be realized in 2040.

REAL DISCOUNT RATE

California and the Federal Government differ in the discount rate used for benefit-cost analyses. Caltrans uses a real discount rate of 4 percent in its Cal-B/C model.[2] The CTC has adopted the Cal-B/C model and requested that Caltrans and applicants use the same assumptions in analyses for the State Transportation Improvement Program (STIP) and state grant applications.

Federal guidance is driven by Office of Management and Budget (OMB) Circular A-94, which requests that federal agencies use a real discount rate of 7 percent to discount benefits and costs for regulatory analysis.[3] In guidance for recent TIGER, FASTLANE, INFRA, and BUILD discretionary grant applications, USDOT has requested that applicants use a 7 percent real discount rate, consistent with OMB guidance. [4] However, it has also allowed applicants to use a lower real discount rate of 3 percent for sensitivity analysis.

The Project Team used a real discount rate of 4 percent for the Caltrain analysis, which is consistent with other California practices.

[1] Source: USDOT 2018, Benefit-Cost Analysis Guidance for Discretionary Grant Programs.

[2] Source: Cal-B/C Technical Support Vol 4 - Economic & Parameter Updates; Caltrans - Vehicle Operation Cost Parameters: http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_cost/LCBCA-economic_parameters.html

[3] For more information, refer to the following link: https://www.transportation.gov/regulations/omb-circular-94 (Last Accessed: August 9, 2018).

[4] Source: USDOT 2018, Benefit-Cost Analysis Guidance for Discretionary Grant Programs. Accessed via the following link: https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance.

2.2 EXTERNAL MODEL DATA

The BCA required information from external models to capture changes in Caltrain ridership and travel time impacts due to service improvements in the Moderate Growth and High Growth scenarios.

The Project Team obtained estimated Caltrain ridership numbers for the existing operations (2018) and projected ridership in 2022, 2027, 2030, 2040, 2050, 2060 and 2070 for the Baseline Growth, Moderate Growth, and High Growth service planning scenarios. The ridership model forecasts for Baseline Growth, Moderate Growth, and High Growth are assumed to be the same until 2040, at which point the ridership data deviate depending on the level of service being evaluated. This deviation in forecasted ridership is due in part to the number of local and express trains and their respective operating frequency defined in each service planning scenario. While ridership is not necessarily needed for each of these years, it helped with the ridership extrapolation. Ridership figures were needed for different times of day and day of the week (i.e., AM peak, PM peak, off-peak, and weekend).

2.3 ESTIMATING BENEFIT CATEGORIES

In the sections that follow, the processes used to estimate user benefits for each passenger rail service scenario are described, including the key assumptions and quantified outcomes. The Project Team estimated the following primary categories of user benefits:

- Travel time savings
- Out-of-pocket cost savings
- Accident reduction benefits
- Public health benefits

Table 2 summarizes the primary categories of user benefits from the investments and the corresponding population affected by each impact.

TABLE 2: SUMMARY OF IMPACT CATEGORIES AND AFFECTED POPULATIONS

Benefit Category:	Existing Caltrain Riders	Former Automobile Users
Travel Time Savings	x	x
Accident Reduction Benefits		x
Reduced Out-of-Pocket Costs		x
Public Health Benefits*		x

* Public health benefits accrue only to people who use active transportation modes to access Caltrain stations.

TRAVEL TIME SAVINGS

The Project Team calculated travel time savings as the difference in the Moderate Growth or High Growth person hours traveled and the Baseline Growth person hours traveled (PHT) based on estimated Generalized Journey Time (GJT). This was adjusted for the number of trips plus the consumer surplus associated with new Caltrain travelers.

GJT is equal to the trip time plus wait time and transfer penalty between different station pairings. Trip time is defined as the in-vehicle travel time plus the actual time of any required transfer activity to travel between station pairings. Wait time is defined as half the headway, capped at 10 minutes, times a factor of 2.5 to adjust for rider's perception of time spent waiting. The transfer penalty is perceived time added to the trip and wait times to represent the inconvenience of making a transfer. The penalty varies based on how inconvenient the transfer is to make. The following equation shows how Travel Time Savings are calculated for the High Growth (HG) service scenario.

$$Travel\ Time\ Savings = (Adj\ PHT_{BG} - Adj\ PHT_{HG}) + \frac{1}{2}(\Delta\,Trips \times \Delta\,Travel\ Time)$$

Where,

Adj PHT = Person hours traveled, adjusted for the number of trips. *Note: Person hours traveled; PHT is equal to the generalized journey time (GJT)*

GJT = trip time + wait time + transfer penalty

ΔTrips = Change in number of trips; net number of new trips (e.g., $Trips_{HG}$ – $Trips_{BG}$)

ΔTravel Time = Change in travel time; travel time is equal to generalized travel time (e.g., GJT_{HG} – GJT_{BG})

Travel time costs were compared between the Baseline Growth and Moderate Growth or High Growth scenarios. The difference is the travel time savings. An in-vehicle value of time was used to monetize the travel time savings estimated using GJT, which already adjusts for riders' perception of time.

Caltrain passenger rail service is expected to serve both local and intercity travel. In addition, wages in the Caltrain service area differ substantially from the statewide average. Therefore, travel time savings were estimated using an average between two in-vehicle values of time. One reflects the California statewide wage rate, while the other captures local wages and are reflective of the higher values for time typical for intercity travel. Both can be calculated from USDOT guidance, which is consistent with the method used by the CTC and Caltrans. The values are summarized in Table 3. Details are provided below on the calculation of these values.

TABLE 3: ASSUMPTIONS USED IN THE ESTIMATION OF TRAVEL TIME SAVINGS

Variable Name	Unit	Value
Travel Time Cost – California Statewide Average*	Dollars per hour	$14.06
Travel Time Cost – San Francisco, San Mateo, and Santa Clara counties	Dollars per hour	$19.00

Source: Project Team calculation from Occupational Employment Statistics (OES) Survey, State of California Employment Development Department.
* This value is updated, but comparable with the value that Caltrans and the California Transportation Commission use for benefit-cost analysis

In its value of time recommendations, USDOT distinguishes among three types of travel: 1) local personal travel, 2) intercity personal travel, and 3) business local and intercity travel. USDOT recommends using 50 percent of the wage rate for local personal travel, 70 percent for intercity personal travel, and 100 percent for business travel (on both local and intercity trips).[5] The Project Team used 50 percent of the wage rate to derive a value of time for automobile travel. This is also consistent with Caltrans practices. Values of time were estimated using the statewide and local wage rates. Note that the value of time estimated with the higher local wage rate is roughly equal to 70 percent of the statewide wage rate, or the value for intercity travel under USDOT guidance.

The out-of-vehicle value of walk access, waiting, and transfer time was estimated as equal to the value of in-vehicle time for automobile travel. Typically, these activities are valued higher than in-vehicle time, but the analysis used a generalized journey time (GJT) that already incorporates travelers' perceptions of time. This assumption is consistent with both Caltrans and the Victoria Transport Policy Institute (VTPI) practices. VTPI is an independent research organization dedicated to developing innovative and practical solutions to transportation problems. This organization provides free resources to help improve transportation planning and policy analysis, and is funded primarily through consulting and project grants.

The Project Team extracted wage data at the state and county level from the Occupational Employment Statistics (OES) Survey from the State of California Employment Development Department website. Caltrain is located in a high wage area and many users are employed in the region. Therefore, average wage data from San Francisco, San Mateo, and

[5] Source: U.S. Department of Transportation 2016 Revised Value of Travel Time Guidance, Table 1 (Revision 2 – 2016 Update).

Santa Clara County was used to calculate one value of time. California State level wage data was also collected and is presented below for comparison. The OES survey is conducted in conjunction with the Bureau of Labor Statistics (BLS). Using a single source makes the values of time for automobile travel more consistent.

The Project Team used the following information for estimating the values of time to 2018 dollars:

- **Statewide Average Hourly Wage**: According to the OES Survey, the mean hourly wage for all California workers in all occupations was $28.12 in May 2018.[6] [7] **This results in a value of time for all travel of $14.06 (i.e., half the wage rate).**
- **Project Area Specific Average Hourly Wage**: According to OES Survey, the mean hourly wage for San Francisco, San Mateo, and Santa Clara county workers in all occupations for May 2018 was similar across counties ($38.03 in San Francisco/San Mateo and $37.94 in Santa Clara).[8] The average across all three counties is approximately $38.00 in May 2018. **This results in a value of time all travel of $19.00 (i.e., half the wage rate).**

An average value of time of $16.53 was applied to the travel time savings (in hours) to estimate the travel time savings benefit for each growth scenario.

The estimated travel time savings are presented in Table 4. Over the period of analysis, Moderate Growth is expected to save 27.7 million total trip hours for existing Caltrain riders (equal to an average of 1.6 minutes saved per existing Caltrain rider) and 12.9 million total trip hours for new Caltrain riders. Alternately, 40.4 million total trip hours for existing Caltrain riders (equal to an average of 2.4 minutes saved per existing Caltrain rider) and 20.9 million total trip hours for new Caltrain riders in travel time savings are anticipated from High Growth.

TABLE 4: OUTPUT GENERATED FROM TRAVEL TIME SAVINGS

Metric	Moderate	High
Total Travel Time Savings for Existing Caltrain Riders; trip time only (total hours)	27,724,205	40,415,158
Travel Time Savings; trip/transfer time only (minutes per existing Caltrain rider)	1.6	2.4
Total Travel Time Savings for New Caltrain Riders; trip time only (total hours)	12,882,677	20,943,466
Travel Time Savings; trip/transfer time only (minutes per new Caltrain rider)	5.8	4.7

OUT-OF-POCKET COST SAVINGS

Out-of-Pocket Cost Savings account for changes in three types of costs for travelers:

- Parking costs at Caltrain stations for rail users and in public parking garages for automobile users
- Fuel costs associated with automobile use
- Non-fuel vehicle operating costs (e.g., tire wear and tear, cost of maintenance, and depreciation) for automobile users.

The Project Team calculated vehicle operating cost savings based on Caltrain ridership projections for new Caltrain users, of which, 95 percent were assumed to have shifted from automobile use. This demand data was for the years

[6] The Project Team extracted hourly wage data from the following link: https://www.labormarketinfo.edd.ca.gov/data/oes-employment-and-wages.html (Last Accessed: September 26, 2018).

[7] These survey data are from the 2016 Occupational Employment Statistics (OES) survey. The wages have all been updated to the first quarter of 2017 by applying the US Department of Labor's Employment Cost Index to the 2016 wages

[8] Average wage rate for San Francisco, San Mateo, and Santa Clara county workers in all occupations of $38.03, $38.03, and $37.94, respectively.

2022, 2027, 2033, 2040, 2050, 2060 and 2070 in the Baseline, Moderate, and High Growth scenarios. Roadway traffic conditions were assumed to remain the same beyond 2040. Ridership Benefits were calculated as the differences in the costs for Baseline Growth and Moderate Growth or High Growth.

The Project Team estimated parking costs for new Caltrain riders by multiplying the projected new ridership by the share of riders anticipated to use the parking facility at the station and the daily parking fee. There were also parking costs associated with automobile users traveling to certain destinations (e.g., downtown San Francisco). Parking costs for downtown San Francisco destinations were included. Table 5 presents assumptions related to parking costs and the percentage of riders who are accessing San Francisco destinations and pay a premium for parking.

The fuel and non-fuel vehicle operating costs were estimated for travelers who switch from personal vehicles to Caltrain service. It was assumed that 95 percent of new Caltrain users have switched from automobile. Fuel cost was calculated as the change in total avoided vehicle-miles traveled (VMT) between Baseline Growth and Moderate or High Growth multiplied by the fuel consumption rate in gallons per mile and monetized using the fuel price per gallon. Non-fuel costs were calculated by multiplying non-fuel per-mile cost (which accounts for maintenance and other vehicle ownership costs) by the reduction in total vehicle-miles between Baseline Growth and Moderate or High Growth. These costs made up the vehicle operating cost savings benefit generated by this investment. The assumptions used in the estimation of vehicle operating cost savings are summarized in Table 5.

TABLE 5: ASSUMPTIONS USED IN THE ESTIMATION OF OUT-OF-POCKET SAVINGS

Variable Name	Unit	Value	Source
Caltrain Station Parking Cost	Dollar per rider	$5.50	Caltrain rider information - parking ($5.50 parking fee as of July 1, 2018)*
Share of Riders Who Park at Station	Percent	12%	Input from project team
Downtown San Francisco Public Parking Costs	Cost per driver	$32	Average of parking cost
Percent of New Caltrain Riders with Downtown San Francisco Destinations	Percent	33%	Ridership model assumption (F&P)
Percent Of New Caltrain Riders Who Shift from Auto	Percent	95%	Ridership model assumption (F&P)
Percent Of New Caltrain Riders Who Shift from Bus	Percent	2%	Ridership model assumption (F&P)
Percent Of New Caltrain Riders Who Shift from Rail	Percent	3%	Ridership model assumption (F&P)
Fuel Cost (Excludes Tax) – Automobile	Dollars per gallon	$3.12	Project Team computation from AAA Daily Fuel Gauge Report
Non Fuel Vehicle Operating Cost – Automobile	Dollars per mile	$0.33	American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: A 2017 Update

PARKING COSTS

The Project Team estimated parking costs per Caltrain rider by multiplying the percentage of riders who park at rail stations by the set parking fee. This per-rider cost was then multiplied by the change in projected ridership between Baseline Growth and Moderate or High Growth to estimate a total parking cost to users.

The parking costs for automobile trips to downtown San Francisco was estimated only for travelers who switch from automobiles to Caltrain and have destinations in downtown San Francisco. The per-driver cost was multiplied by the number of people switching modes.

The Caltrain station daily parking fee in 2018 dollars is $5.50.[9] The average parking fee in downtown San Francisco in 2018 dollars is $32.00.[10]

The estimated percentage of riders who park at the station is 12 percent. The estimated percent of trips whose final destination is to Downtown San Francisco is 33 percent.

FUEL CONSUMPTION RATES

The Project Team estimated fuel consumption rates for automobiles from the Caltrans Cal-B/C model, which are based on data from the California Air Resources Board (CARB) Emission Factors 2014 (EMFAC2014) model. On December 30, 2014, the CARB updated EMFAC from the previous version, EMFAC2011. This revision is a minor update to the EMFAC2011 model and extends fuel and emission estimates through 2050. EMFAC2014 also improves upon EMFAC2011's modeling structure.

A single set of fuel consumption parameters that average figures for 2016 and 2036 were used to estimate fuel consumption for all years of the BCA. These are the rates available from Cal-B/C and the methodology is consistent with the one used by the CTC and Caltrans. Table 6 presents fuel consumption rates for automobiles.

TABLE 6: FUEL CONSUMPTION RATES (IN GALLONS PER MILE)

Speed (mph)	Auto
5	0.1024
10	0.0763
15	0.0584
20	0.0465
25	0.0384
30	0.0330
35	0.0296
40	0.0276
45	0.0266
50	0.0266
55	0.0275
60	0.0293
65	0.0325
70	0.0356

Source: California Air Resources Board, EMFAC 2014. 2016 and 2036 average.
Note: Five mph is the best estimate for idling.

FUEL COSTS

The Project Team estimated fuel consumption using the rates shown in Table 6 as well as avoided VMT, average speeds based on new Caltrain trips from the ridership model, and average distances between station pairings. Total fuel costs were estimated by multiplying the fuel consumption in gallons by the average fuel cost per gallon. The resulting figure represents the out-of-pocket fuel costs paid by consumers.

[9] Source: Caltrain rider information, parking: http://www.caltrain.com/riderinfo/Parking.html (Last accessed: September 18, 2018).
[10] Source: Average parking rate based on San Francisco Tourism Tips: https://www.sftourismtips.com/san-francisco-parking.html

Following standard practice, the fuel costs in the BCA excluded federal, state, and local taxes. These taxes are user fees for funding transportation improvements and transfer payments. They do not reflect actual public benefits generated by the project.

Fuel taxes can be broken into three components:

- Federal fuel excise taxes
- State fuel excise taxes
- State and local sales tax.

The Internal Revenue Service (IRS) collects the federal fuel excise tax (18.4 cents per gallon tax on gasoline and 24.4 cents per gallon tax on diesel fuel). These taxes are deposited in the Highway Trust Fund (HTF). California state excise tax on gasoline is 27.8 cents per gallon.[11] A 2.25 percent state sales tax and 0.5 percent county sales tax are also applied.

To calculate the per-gallon cost for fuel, the Project Team used the American Automobile Association (AAA) Daily Fuel Gauge Report.[12] For automobile fuel, we used an average price of regular fuel over two days ($3.671 per gallon on September 26, 2018 and $3.683 per gallon on September 27, 2018), adjusted to eliminate the taxes. The calculations below show the estimation of fuel costs:

$$Fuel\ Cost = \left[\frac{Two\ Day\ Average\ Price}{(1 + State\ Sales\ Tax + Average\ Local\ Sales\ Tax)}\right] - Federal\ Fuel\ Excise\ Tax - State\ Fuel\ Excise\ Tax$$

$$Gasoline\ Fuel\ Cost = \left[\frac{Average\ (\$3.671, \$3.683)}{(1 + 2.25\% + 0.5\%)}\right] - \$0.184 - \$0.287 = \$3.12\ per\ gallon$$

The BCA calculations use a value of $3.10 per gallon (prior calculation rounded to the nearest 5 cents).

NON-FUEL VEHICLE OPERATING COSTS

The Project Team estimated non-fuel vehicle operating costs as a fixed per-mile cost that includes tires, maintenance and repair, and vehicle depreciation for automobile users. Other costs, such as insurance and registration, are not included because they do not vary with vehicle mileage (or at least are not very sensitive). Non-fuel costs were separated from fuel costs because fuel consumption is sensitive to average vehicle speed, while non-fuel costs are not.

The Project Team used the same non-fuel costs as the CTC and Caltrans.[13] These non-fuel costs are based on the average of three sedan categories (small, medium, and large). The original source of this information is the 2016 American Automobile Associations (AAA) publication "Your Driving Costs":

- Maintenance, repairs and tires: 6.28 cents per mile
- Depreciation: 25.06 cents per miles.[14]

When summed, this results in a non-fuel cost of 31.34 cents per mile in 2016 dollars. Using the GDP deflator, this translates to 32.62 cents (31.34 cents * 110.2/105.9) per mile in 2018 dollars.

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[11]Source: Energy Information Administration 2018, Federal and state motor fuel taxes. Accessed via the following link: https://www.eia.gov/petroleum/marketing/monthly/xls/fueltaxes.xls. (Last accessed: September 18, 2018).

[12] Source: AAA Daily Fuel Gauge Report https://gasprices.aaa.com/?state=CA (Last accessed: September 18, 2018).

[13] Source: Caltrans Life-Cycle Benefit-Cost Analysis – Economic Parameters 2016: http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_cost/LCBCA-economic_parameters.html (Last Accessed: September 18, 2018).

[14] Ibid

The avoided vehicle-miles traveled (VMT) used to estimate the out-of-pocket cost savings benefits is presented in Table 7. This figure includes VMT changes due to new Caltrain riders shifting from personal vehicles and reflects Caltrain riders traveling longer distances on the improved Caltrain system. Over the period of analysis, Moderate Growth is expected to avoid 9.0 billion total VMT, while High Growth is expected to avoid 16.1 billion total VMT. The number of new Caltrain riders equals the number of two-way trips (i.e., number of one-way trips divided by two).

TABLE 7: OUTPUT GENERATED FROM OUT-OF-POCKET COST SAVINGS

Metric	Moderate	High
Total Avoided VMT	9,025,494,665	16,128,177,513
Total number of new Caltrain riders*	132,756,908	266,262,968

** Riders are calculated as the number of two-way trips.*

ACCIDENT REDUCTION SAVINGS

The Project Team estimated the accident cost savings generated as a result of automobile drivers electing to use Caltrain service. Accident reduction benefits were monetized by multiplying the vehicle-miles traveled by the avoided accidents per million vehicle-miles (MVM) for fatal accidents and injury accidents and their respective costs. The difference between monetized accident costs under Baseline Growth and Moderate or High Growth is the benefit (reduction in accident costs) of the scenario analyzed.

Districtwide accident rates were pulled from the Caltrans publication 2014 Collision Data on California State Highways. San Francisco, San Mateo, and Santa Clara counties are located in Caltrans District 4. Accident rates per 100 MVM, by severity, are provided in Table 8.

TABLE 8: ACCIDENT RATES PER 100 MVM, BY SEVERITY

Accident Severity	Units	Value
Fatal Accidents	Fatal Accidents / 100 MVM	0.48
Injury Accidents (Unknown Severity)	Injury Accidents / 100 MVM	80.00

Source: 2014 Collision Data on California State Highways; Accident Summary - Overall Summary by District for 2014 Prepared 03/06/17; Travel and Accident Summary for District 04 - Districtwide; (page 16)

Total accidents avoided were estimated using the rates in Table 8 and the total avoided VMT from new Caltrain riders shifting from personal vehicles (autos). The resulting reduction in accidents was monetized as a safety benefit using values from Caltrans, which are also consistent with USDOT value of life guidance.[15] Table 9 summarizes the accident costs we used to estimate safety benefits.

TABLE 9: ACCIDENT COSTS BY SEVERITY (IN 2018 DOLLARS)

Accident Severity	Accident Costs ($/Accident)
Fatal Accident	$11,239,605
Injury Accident	$154,857
Property Damage Only Accident	$10,095

Source: Caltrans. The Project Team converted the values from 2016 to 2018 dollars using GDP deflator.

[15] Source: Caltrans Life-Cycle Benefit-Cost Analysis – Economic Parameters 2016: http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_cost/LCBCA-economic_parameters.html (Last Accessed: September 18, 2018).

The estimated accident reduction savings are presented in Table 10. Over the period of analysis, Moderate Growth is expected to result in a reduction of 7,264 fatal/injury accidents. A reduction of 12,980 fatal or injury accidents are anticipated from High Growth.

TABLE 10: OUTPUT GENERATED FROM ACCIDENT REDUCTION SAVINGS

Metric	Moderate	High
Total number of fatal/injury accidents	7,264	12,980
Average annual reduction in fatal/injury accidents	242	432

HEALTH BENEFITS

The BCA captures public health benefits due to increases in active transportation (bicycling and walking) and a commensurate reduction in sedentary lifestyle. This benefit is limited to only new Caltrain riders who choose active transportation modes to access Caltrain.

Caltrans recently developed a method to estimate the public health benefits of active transportation due to reductions in absenteeism and mortality. This methodology (from the Cal-B/C AT model) was used to estimate the public health benefits.

Absenteeism was estimated from the average absence of employees based on data from the Centers for Disease Control and Prevention (CDC 2011). Thirty minutes of activity per day are expected to reduce sick days by 6 percent per year according to research from the World Health Organization (WHO 2003), which was the basis of the methods adopted by Caltrans.

$$Reduced\ Absenteeism = \left[\frac{Trips_N * P_C}{R}\right] * [S * P_{SL} * P_{SR}]$$

Where,

$Trips_N$ = Daily one-way journeys of new Caltrain users – active mode access
P_C = Proportion of new trips made by commuters
R = Roundtrip factor
S = Average absence at work of typical employees
P_{SL} = Percentage of absences accounted for by short-term sick leave
P_{SR} = Percentage reduction in sick days by being active

Mortality reduction was estimated using demographic age cohorts to estimate mortality reductions using data from the 2010-2012 California Household Transportation Survey. The average reduction in mortality per 365 annual cycling miles (4.5 percent) and 365 annual walking miles (9 percent) is based upon the WHO HEAT Model (WHO 2016). The mortality rates are based on those used in Cal-B/C AT, which are from 2010-2014 Death Rates from the California Department of Health.

$$Mortaility\ Reduction = \left[\frac{Trips_N * P_A}{R}\right] * [D * M * (1 - RR)]$$

Where,

$Trips_N$ = Daily one-way journeys of new Caltrain users – active mode access (walkers; cyclists)
P_A = Proportion of users in age cohort (walkers: Age 16-74; cyclists: age 16-64)
R = Roundtrip factor
D = Mean distance traveled per trip for users
M = Number of people per 100,000 who die each year from all causes

1-RR = Percentage mortality risk reduction for new active travelers

The public health benefits were calculated for both Moderate Growth and High Growth using the methodology described above and the assumptions presented in Table 11.

TABLE 11: ASSUMPTIONS USED IN ESTIMATING HEALTH BENEFITS

Variable Name	Unit	Value	Source
Access node share by station (bike)	%	13%	Fehr & Peers Access Mode by Station Breakdown (6/20/19)
Access mode share by station (walk)	%	33%	
Average absence of employees	Days/year	3.6	CDC, 2007 (Cal-B/C 62 Active Transportation Model)
Percentage covered by short-term sick leave	%	95%	UK TAG, 2014 (Cal-B/C 62 Active Transportation Model)
Percent of sick days reduced when active at least 30 min per day	%	6%	WHO, 2003 (Cal-B/C 62 Active Transportation Model)
Santa Clara/San Francisco/Mateo County average hourly wage rate	$/hour	$38	State of California Employment Development Department, OES Employment and Wages, 2017 1st Quarter
Average number of hours per day	Hour/day	8	Assumption
Value of reduced absenteeism	$/day	$304	Calculation (hourly rate x hours per day)
Percentage of cyclists aged 16-64 (Urban – North)	%	70.4%	2010-2012 California Household Transportation Survey (Cal-B/C 62 Active Transportation Model)
Percentage of pedestrians aged 16-74 (Urban – North)	%	70.4%	
Percentage reduction in mortality per 365 annual cycling miles	%	4.5%	WHO Heat Model, 2016 (Cal-B/C 62 Active Transportation Model)
Percentage reduction in mortality per 365 annual walking miles	%	9%	
Average distance to access station (bike)	Miles/trip	1.3	Fehr & Peers Access Mode by Station Breakdown (6/20/19)
Average distance to access station (walk)	Miles/trip	0.6	
Mortality Rate – All Causes; ages 20-64 (bike)	Deaths/100,000 people	266	California Dept. of Health, 2010-2014 Death Rate, Table 5.2 (Cal-B/C 62 Active Transportation Model)
Mortality Rate – All Causes; ages 20-74 (walk)	Deaths/100,000 people	395	
Reduced mortality cost	$/death	$11,239,605	Caltrans - Vehicle Operation Cost Parameters for a fatality (adjusted to 2018 dollars)

The estimated public health benefits are presented in Table 12. Over the 2040-to-2070 period of benefits, new Caltrain riders using active transportation modes to access the Caltrain stations are expected to reduce absenteeism by 29,940 and 67,128 total absent days, from Moderate Growth and High Growth, respectively. Similarly, the mortality rate is expected to be reduced by 66.7 and 149.6 total deaths, from Moderate Growth and High Growth, respectively.

TABLE 12: OUTPUT GENERATED FROM HEALTH BENEFITS

Metric	Moderate	High
Total number of absent days reduced from new active transportation users	29,940	67,128
Average number of absent days reduced per year	998	2,238
Total number of deaths reduced from new active transportation users	66.7	149.6
Average number of deaths reduced per year	2.2	5.0

2.4 PROJECT COSTS

The Project Team used cost estimates in 2018 dollars for each potential service improvement generated by the Integrated Business Model. The costs used in the BCA were incremental project capital costs (CAPX) and represented the Moderate Growth or High Growth costs net of the Baseline Growth costs, in 2018 dollars. Incremental CAPX spending was expected between 2022 and 2050, with capital costs realized according to an expenditure schedule established with Caltrain (see Caltrain Business Plan Capital Cost Memo).

The incremental change in annual operating costs (OPX) in constant 2018 dollars between Baseline Growth and Moderate Growth or High Growth were also used in the BCA. These costs are expected to increase from the Baseline due to additional rail service in the Moderate Growth and High Growth scenarios. The incremental change in OPX costs were also obtained from the IBM model. All costs were discounted at 4 percent to estimate a 2018 present value consistent with the discounting for the benefits (see Caltrain Business Plan Operating Cost Memo).

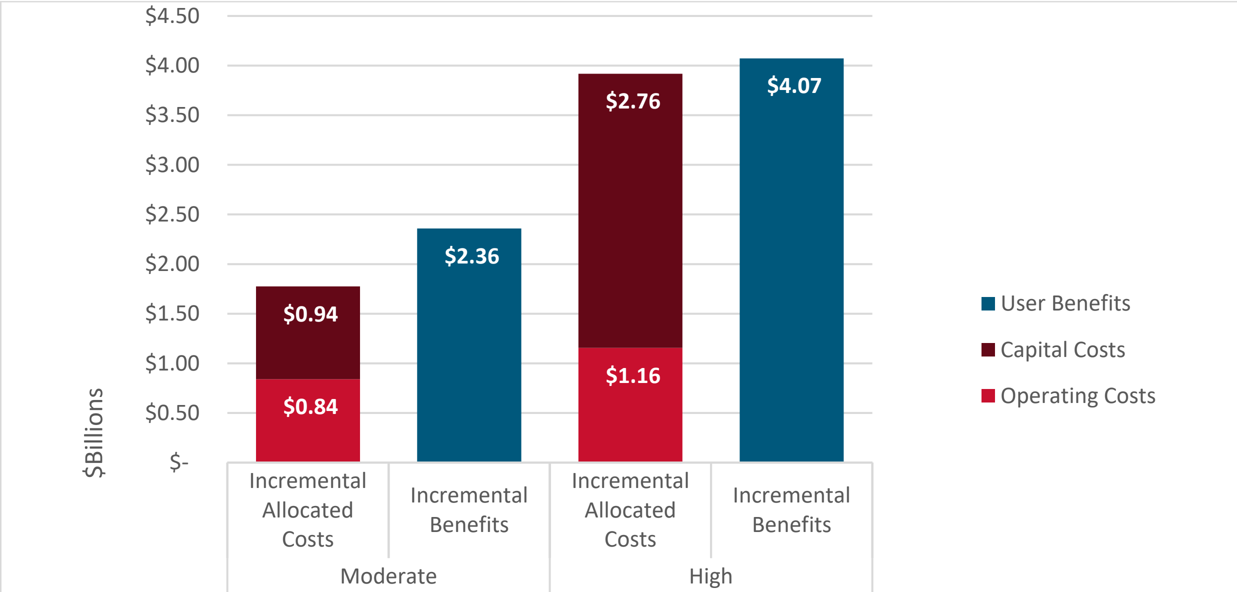
2.5 BENEFIT-COST ANALYSIS RESULTS

The BCA results were summarized for both Moderate Growth and High Growth passenger rail service scenarios using several measures including:

- **Present Value of Benefits (Total of Benefits Discounted to Base Year)** – These comprise travel time savings, vehicle operating cost savings, public health benefits, and accident cost savings discounted over the lifecycle of the analysis.
- **Present Value of Incremental Costs (Total of Incremental Costs Discounted to Base Year)** – The costs would include capital costs as well as operating and maintenance costs discounted over the lifecycle of the analysis. The incremental costs of a scenario are the costs of Moderate Growth or Higher Growth minus the costs of Baseline Growth.
- **Benefit-Cost Ratio** – The benefit-cost ratio (BCR) is the present value of the benefits divided by the PV of the incremental costs. If the resulting ratio is greater than 1, it implies that the benefits of the scenario outweigh the costs and that a $1 investment generates more than $1 in benefits.
- **Net Present Value** – The net present value (NPV) of a scenario is defined as the difference between the discounted benefits and the discounted incremental costs. If positive, the NPV provides a measure of the positive value of the improvements above the scenario's costs. If the NPV is negative, then scenario costs are greater than the monetized benefits attributed to the improvements.

Figure 2 summarizes the incremental user benefits, CAPX and OPX for both Moderate Growth and High Growth over Baseline Growth. Benefits and costs presented in Figure 2 are shown in billions of 2018 dollars using a discount rate of 4 percent. Sections 2.1.5 and 2.2.5 present a breakdown of results for Moderate Growth and High Growth, respectively.

FIGURE 2: SUMMARY OF INCREMENTAL LIFECYCLE BENEFITS AND COSTS



	Moderate: Incremental Allocated Costs	Moderate: Incremental Benefits	High: Incremental Allocated Costs	High: Incremental Benefits
User Benefits		$2.36		$4.07
Capital Costs	$0.94		$2.76	
Operating Costs	$0.84		$1.16	

MODERATE GROWTH SCENARIO RESULTS

Moderate Growth passenger rail service expansion and investment is expected to generate $2.4 billion in discounted benefits as a result of increased Caltrain ridership and improved passenger rail service. The undiscounted and present value of the primary benefits and incremental costs are presented in Table 13 and Table 14, respectively.

TABLE 13: ESTIMATED CALTRAIN BENEFITS, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

Benefits	Undiscounted	PV (Discounted @ 4%)
Safety benefits due to the increased use of Caltrain in lieu of driving	$1,605.1	$394.7
Cost savings from avoided auto trips (VOC and out-of-pocket costs)	$3,835.0	$943.0
Travel time savings for new Caltrain riders	$738.1	$181.7
Travel time savings for existing Caltrain riders	$2,635.2	$649.9
Public health benefits associated with active transportation to access Caltrain	$759.1	$189.0
Total Benefits	**$9,572.5**	**$2,358.3**

TABLE 14: INCREMENTAL CALTRAIN COSTS, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

Costs	Undiscounted	PV (Discounted @ 4%)
O&M Costs (OPX)	$3,374.8	$840.2
Capital Costs (CAPX)	$1,965.0	$935.3
Costs	**$5,339.8**	**$1,775.6**

Table 15 summarizes the BCA findings. Annual costs and benefits are computed over the lifecycle of the scenarios. As state earlier, benefits are expected to accrue during full operation, between 2040 and 2070. Considering all monetized benefits and costs, the estimated internal rate of return of the project is 7.4 percent. With a real discount rate of 4 percent, the $935.3 million capital investment in Moderate Growth would result in $2.4 billion in total benefits and a benefit-cost ratio of approximately 1.33. In other words, for every dollar invested one would expect to see $1.33 in benefits.

TABLE 15: SUMMARY OF KEY FINANCIAL METRICS, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

Key Financial Metrics	Undiscounted	PV (Discounted @ 4%)
Benefits Summary	$9,572.5	$2,358.3
Costs Summary	$5,339.8	$1,775.6
Net Present Value (NPV)	$4,232.7	$582.8
Return on Investment (ROI)	79%	33%
Benefit-Cost Ratio (BCR)	**1.79**	**1.33**
Payback Period (years)	9.5	14.1
Internal Rate of Return (IRR)	7.4%	

HIGH GROWTH SCENARIO RESULTS

High Growth passenger rail service expansion and investment is expected to generate $4.1 billion in discounted benefits as a result of increased Caltrain ridership and improved passenger rail service. The undiscounted and present value of the primary benefits and incremental costs are presented in Table 16 and Table 17, respectively.

TABLE 16: ESTIMATED CALTRAIN BENEFITS, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

Benefits	Undiscounted	PV (Discounted @ 4%)
Safety benefits due to the increased use of Caltrain in lieu of driving	$2,868.2	$701.6
Cost savings from avoided auto Trips (VOC and out-of-pocket costs)	$6,869.0	$1,680.3
Travel time savings for new Caltrain riders	$1,230.6	$301.9
Travel time savings for existing Caltrain riders	$3,919.6	$966.7
Public Health benefits associated with active transportation to access Caltrain	$1,702.0	$422.8
Benefits	**$16,589.4**	**$4,073.4**

TABLE 17: INCREMENTAL CALTRAIN COSTS, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

Costs	Undiscounted	PV (Discounted @ 4%)
O&M Costs (OPX)	$4,643.9	$1,156.4
Capital Costs (CAPX)	$5,618.7	$2,762.2
Costs	**$10,262.6**	**$3,918.6**

Table 18 summarizes the BCA findings. Annual costs and benefits are computed over the lifecycle of the project. Benefits are expected to accrue during full operation, between 2040 and 2070. Considering all monetized benefits and costs, the estimated internal rate of return of the project is 4.3 percent. With a real discount rate of 4 percent, the $2.7 billion capital investment in High Growth would result in $4.1 billion in total benefits and a benefit-cost ratio of approximately 1.04. In other words, for every dollar invested you would expect to see $1.04 in benefits.

TABLE 18: SUMMARY OF KEY FINANCIAL METRICS, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

Key Financial Metrics	Undiscounted	PV (Discounted @ 4%)
Total Benefits	$16,589.4	$4,073.4
Total Costs	$10,262.6	$3,918.6
Net Present Value (NPV)	$6,326.8	$154.8
Return on Investment (ROI)	62%	4%
Benefit-Cost Ratio (BCR)	**1.62**	**1.04**
Payback Period (years)	14.3	27.2
Internal Rate of Return (IRR)	4.3%	

3. EIA METHODOLOGY, PARAMETERS, AND RESULTS

The main objective of the economic impact analysis (EIA) is to determine the changes in regional economic activity due to the level of investment associated with the expansion of Caltrain passenger rail service. Passenger rail service expansion and investment can impact the economy in a number of ways. The first effects are the economic impacts directly related to the passenger rail system's construction, operation, maintenance, and usage. These expenditures are relevant to the existing system, as well as any future expansion. The direct expenditures generate "spin-off" effects through additional rounds of spending spurred by the initial, direct investment. To estimate the total economic and fiscal impacts generated by existing Caltrans service and future service scenarios, the Project Team used economic multipliers in combination with spending information related to Caltrain's rehabilitation, expansion, operations and maintenance activities.

These impacts are defined as:

- **Direct impacts:** economic activity occurring as a result of direct spending by Caltrain and its contractors (e.g., purchasing materials and services from suppliers for construction activities);
- **Indirect impacts**: economic activity resulting from purchases by Caltrain's local suppliers and its contractors (e.g., spending by suppliers on office rent, equipment, etc.); and
- **Induced impacts**: economic activity, over and above the direct and indirect effects, associated with increased labor income that accrues to workers and is spent on household goods and services purchased from businesses within the study area (e.g., Caltrain employees and their suppliers spending person income on food and other needs).

The indirect and induced effects are sometimes referred to as multiplier effects since they can make the total economic impact substantially larger than the direct effect alone. In theory, a larger multiplier will generate a larger overall response (total economic impact) to the initial change (direct effect). In reality though, while indirect and induced impacts always occur, the net impact on the total level of economic activity in an area may or may not be increased by the multiplier effects. That outcome depends on the study area and its ability to provide additional workers and capital resources, or attract them from elsewhere. As a result, the economic impact on the study area could be smaller than the impacts estimated in this analysis if some of the indirect effects occur outside the region.

Multipliers are often expressed in terms of employment. An employment multiplier measures the increase in jobs in the overall economy per new job created in a specific industry. For example, consider a general contractor that hires 10 new employees for constructing a transportation improvement proposed by Caltrain. If the employment multiplier for the construction industry in the study area is 1.9, 9 additional jobs would be created in the economy (as a result of the 10 positions created at the general contractor) for a total of 19 new jobs.

The economic multiplier is strongly influenced by the size of the study area. Generally, the larger the study area, the higher the multiplier since more of the spending would remain in the study area. However, it is theoretically possible for a multiplier to be smaller in a larger study area.

3.1 IMPLAN MODEL

The Project Team estimated the economic impacts using IMPLAN multipliers. IMPLAN is a commonly used, regional economic model. It consists of a software package and data files available at different geographic levels and updated every year. The IMPLAN data files include transaction information (intra-regional and import/export) on 536 industrial sectors (corresponding to four- and five-digit North American Industry Classification System [NAICS] codes) and data on more than 20 different economic variables, including industry output and labor income. The Project Team used the multipliers most relevant to San Francisco, San Mateo, and Santa Clara counties. Typically, economic impacts are quantified in terms of industry output, value added, employment, and tax revenue.

3.2 KEY PARAMETERS

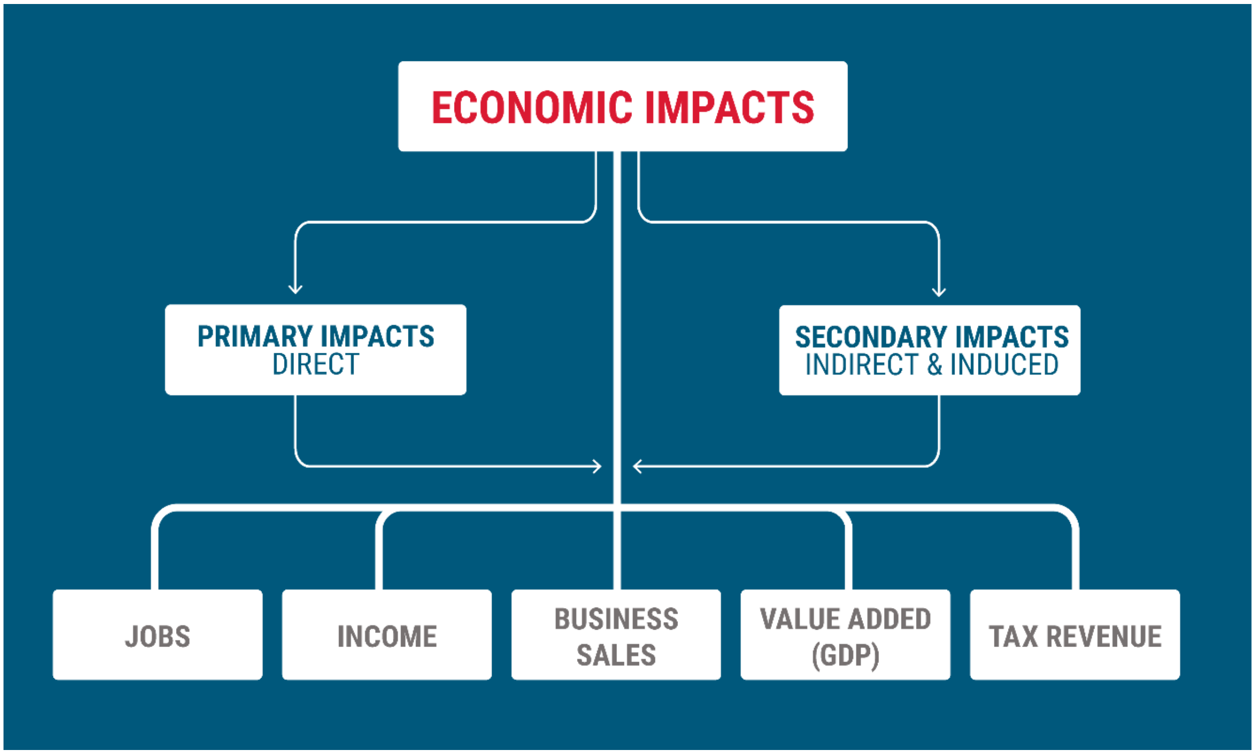
FUTURE SERVICE SCENARIOS

The Project Team identified spending required to construct, maintain and operate service expansion for the economic impact analysis of future service scenarios. In conducting this economic impact analysis, the Project Team used estimates of capital (CAPX) and operating (OPX) expenditures from 2018 to 2070, consistent with the BCA analysis.

The Caltrain economic impact analysis considered construction impacts due to the expenditure of transportation funding on construction and lifecycle operating costs.

Figure 3 illustrates the process used to conduct the EIA. The first step was to retrieve undiscounted, annualized cost outputs from the BCA results. The EIA considers what happens to the economy over time. It uses undiscounted outputs from the BCA because the economy operates in nominal dollars (i.e., not adjusted for a time value of money).

FIGURE 3: ECONOMIC IMPACT ANALYSIS PROCESS DIAGRAM



INDUSTRIAL SECTORS

IMPLAN uses sectors as a way of describing the industries impacted by the project. The sectoring scheme is based on NAICS codes, but represent differing levels of NAICS code rollups. For example, manufacturing sectors are four to five-digit NAICS, whereas agriculture and services sectors are three to four-digit NAICS.

The Project Team used the industrial sector codes from IMPLAN (shown in Table 19) to estimate the direct, indirect, and induced impacts for the corresponding CAPX and OPX expenditures in the EIA. It should be noted that a rail transit does not explicitly have an industrial sector code within IMPLAN. As a result, we chose Sector 56 – "Construction of New Highways and Streets" for use in the analysis. The only other category that would be an appropriate alternative for this type of project would be Sector 58 – "Construction of other new nonresidential structures." However, Sector 58 includes a variety of different facilities (e.g., waste disposal, oil fields), so the study team determined that Sector 56 was more appropriate to Caltrain.

TABLE 19: 2017 NAICS INDUSTRIAL SECTOR CATEGORIES USED IN ANALYSIS

IMPLAN Sector	NAICS Codes	Description	Expenditure
54	233240	Construction of new power and communication structures	Rail Construction Costs (CAPX)
56	233293	Construction of new highways and streets	Rail Construction Costs (CAPX)
58	2332B0	Construction of other new non-residential structures	Rail Construction Costs (CAPX)
62	230301	Maintenance and repair construction of non-residential structures	Infrastructure Capital Maintenance Costs (CAPX)
362	336500	Railroad rolling stock manufacturing	Fleet Capital Costs (CAPX)
412	485000	Transit and ground passenger transportation	Rail Operating Costs (OPX)

Source: IMPLAN Sectoring & NAICS Correspondences

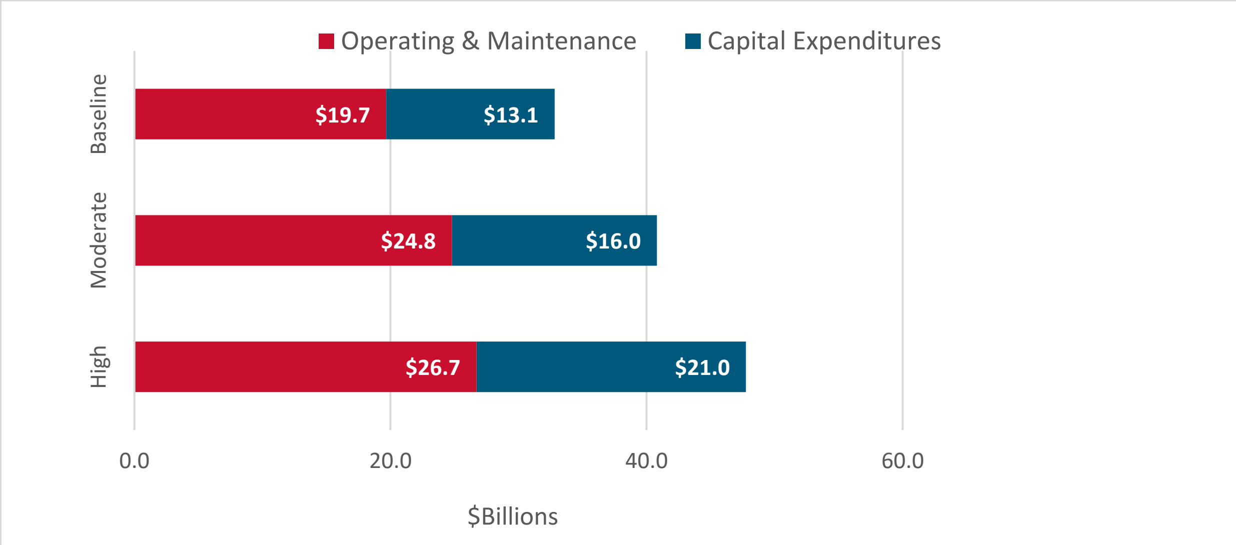
3.3 ECONOMIC IMPACT ANALYSIS RESULTS

IMPLAN produces economic impacts in terms of industry output, employment (jobs), and labor income. The EIA results were summarized using the following measures:

- **Industry Output** - Output is the broadest measure of economic activity and refers to the total volume of sales added to the local economy.
- **Value Added** – Value added is the value a company adds to a product or service. It is measured as the difference between the amount a company spends to acquire the product or service and its value at the time it is sold to other users. Thus, value added can be thought of as a measure of the contribution to the gross domestic product (GDP) made by an establishment or an industry.
- **Labor Income and Employment** - With respect to employment, two impact metrics are calculated: labor income and jobs. Labor income includes employee compensation and proprietor income. Employee compensation, in turn, consists of wage and salary payments as well as benefits (health, retirement, etc.) and employer paid payroll taxes (employer side of social security, unemployment taxes, etc.). Proprietor income consists of payments received by self-employed individuals (such as doctors and lawyers) and unincorporated business owners. The job impact measures the number of jobs created for a full year. These impacts should not be interpreted as full-time equivalent (FTE) as they reflect the mix of full- and part-time jobs that is typical for each industry. Strictly speaking, they should not be interpreted as permanent jobs either, but rather as job-years. A job-year can be defined as one person employed for one year, whether part-time or full-time.
- **Taxes** – Fiscal impacts include federal taxes and state/local taxes.

Figure 4 provides a side-by-side summary comparison of the estimated total industry output (direct, indirect and induced) for the Baseline, Moderate and High Growth scenarios. In order to generate the total industry outputs for each scenario, 2018 IMPLAN output multipliers were applied to the CAPX and OPX spending over the period of analysis from 2018 through 2070. Output values are presented in billions of 2018 dollars.

FIGURE 4: REGIONAL ECONOMIC IMPACT - TOTAL OUTPUT (IN BILLIONS OF 2018 DOLLARS)



As shown in Tables 20 to 22, CAPX spending from 2018 through 2070 for Baseline Growth, Moderate Growth and High Growth are expected to result $13.1 billion, $16.0 billion, and $21.0 billion in total output to the local economy, respectively. Similarly, Baseline Growth, Moderate Growth and High Growth are expected to generate 44.2 thousand, 51.5 thousand, and 68.6 thousand jobs16 within the region, respectively.

A summary of the resulting short-term economic impact from capital investment in Baseline Growth, Moderate Growth, and High Growth passenger rail service are presented below in Table 20,

, and Table 22, respectively.

TABLE 20: CAPX IMPACT, BASELINE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$9,058.1	$2,126.7	$1,955.6	**$13,140.4**
Value Added	$4,755.4	$1,471.4	$1,361.9	**$7,588.7**
Labor Income	$3,639.9	$1,053.6	$829.1	**$5,522.6**
Employment	30,949	4,965	8,294	**44,208**
Total Taxes				**$1,426.9**
State and Local Taxes				$987.0
Federal Taxes				$439.8

[16] Jobs should not be interpreted as permanent jobs, but rather as job-years. A job-year can be defined as one person employed for one year, whether part-time or full-time.

TABLE 21: CAPX IMPACT, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$11,009.1	$2,667.9	$2,331.6	**$16,008.6**
Value Added	$5,570.1	$1,844.1	$1,623.8	**$9,037.9**
Labor Income	$4,336.0	$1,341.2	$1,014.8	**$6,692.0**
Employment	35,947	5,877	9,643	**51,466**
Total Taxes				**$1,709.6**
State and Local Taxes				$1,179.0
Federal Taxes				$530.6

TABLE 22: CAPX IMPACT, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$14,450.6	$3,532.0	$3,059.3	**$21,041.9**
Value Added	$7,290.9	$2,432.8	$2,130.5	**$11,854.2**
Labor Income	$5,906.8	$1,843.6	$1,436.1	**$9,186.5**
Employment	47,660	8,146	12,853	**68,659**
Total Taxes				**$2,243.0**
State and Local Taxes				$1,547.8
Federal Taxes				$695.2

The incremental CAPX spending between Baseline Growth and Moderate Growth or High Growth was also evaluated as part of the economic impact analysis for this project and the anticipated incremental outcomes are presented in Tables 23 and 24. The incremental impact from both Moderate Growth and High Growth were included to highlight the economic impact that additional spending would generate for each planning scenario over the planned baseline investment. Lifecycle CAPX spending in Moderate Growth is expected to generate 7,258 more jobs (equal to $1.2 billion in added labor income) than CAPX spending in Baseline Growth. 24,451 more jobs (equal to $3.7 billion in added labor income) are anticipated from the incremental CAPX spending in High Growth over Baseline Growth.

TABLE 23: INCREMENTAL CAPX IMPACT, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$1,951.0	$541.1	$376.0	**$2,868.2**
Value Added	$814.7	$372.6	$261.9	**$1,449.2**
Labor Income	$696.1	$287.6	$185.7	**$1,169.5**
Employment	4,998	912	1,348	**7,258**
Total Taxes				**$282.8**
State and Local Taxes				$191.9
Federal Taxes				$90.8

TABLE 24: INCREMENTAL CAPX IMPACT, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$5,392.5	$1,405.3	$1,103.7	**$7,901.5**
Value Added	$2,535.5	$961.4	$768.6	**$4,265.5**
Labor Income	$2,266.9	$790.0	$607.0	**$3,663.9**
Employment	16,711	3,182	4,558	**24,451**
Total Taxes				**$816.2**
State and Local Taxes				$560.8
Federal Taxes				$255.4

Long-term, annually-recurring economic impacts resulting from OPX spending on each of the service scenarios are also expected to generate impacts in the local economy. During the operational phase, Baseline, Moderate and High Growth are expected to generate $401.0 million, $566.2 million and $628.2 million in total output per year, respectively.

A summary of the resulting long-term economic impact from OPX spending in Baseline, Moderate, and High Growth passenger rail service are presented in Tables 25 to

.

TABLE 25: ANNUAL OPX IMPACT, BASELINE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$264.2	$68.2	$68.6	**$401.0**
Value Added	$193.1	$46.2	$47.8	**$287.1**
Labor Income	$126.5	$33.6	$27.1	**$187.2**
Employment	3,361	312	353	**4,026**
Total Taxes				**$51.1**
State and Local Taxes				$35.9
Federal Taxes				$15.2

TABLE 26: ANNUAL OPX IMPACT, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$373.1	$96.3	$96.8	**$566.2**
Value Added	$272.7	$65.2	$67.4	**$405.3**
Labor Income	$178.5	$47.5	$38.3	**$264.3**
Employment	4,746	441	499	**5,685**
Total Taxes				**$72.2**
State and Local Taxes				$50.7
Federal Taxes				$21.5

TABLE 27: ANNUAL OPX IMPACT, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$414.0	$106.8	$107.4	**$628.2**
Value Added	$302.6	$72.4	$74.8	**$449.8**
Labor Income	$198.1	$52.7	$42.5	**$293.3**
Employment	5,266	489	553	**6,308**
Total Taxes				**$80.1**
State and Local Taxes				$56.2
Federal Taxes				$23.8

The incremental annual OPX spending between Baseline Growth and Moderate Growth or High Growth was also evaluated as part of the economic impact analysis for this project and the anticipated incremental outcomes are presented in Tables 28 and 29. Moderate Growth annual OPX spending is expected to generate an additional $165 million in industry output and 1,659 more jobs (equal to $77 million in annual labor income) than Baseline Growth annual OPX spending. Similarly, more than $227 million in additional industry output and approximately 2,282 more jobs (equal to $106 million in annual labor income) are expected from annual OPX spending in High Growth than Baseline Growth.

TABLE 28: INCREMENTAL ANNUAL OPX IMPACT, MODERATE GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$108.8	$28.1	$28.2	**$165.2**
Value Added	$79.6	$19.0	$19.7	**$118.3**
Labor Income	$52.1	$13.8	$11.2	**$77.1**
Employment	1,385	129	145	**1,659**
Total Taxes				**$21.1**
State and Local Taxes				$14.8
Federal Taxes				$6.3

TABLE 29: INCREMENTAL ANNUAL OPX IMPACT, HIGH GROWTH SCENARIO (IN MILLIONS OF 2018 DOLLARS)

	Direct	Indirect	Induced	Total
Output	$149.7	$38.6	$38.9	**$227.2**
Value Added	$109.4	$26.2	$27.1	**$162.7**
Labor Income	$71.7	$19.1	$15.4	**$106.1**
Employment	1,905	177	200	**2,282**
Total Taxes				**$29.0**
State and Local Taxes				$20.3
Federal Taxes				$8.6

Outreach Technical Memo

Prepared for:

Caltrain

May 2020

OK18-0254.00

Prepared by:

Fehr & Peers

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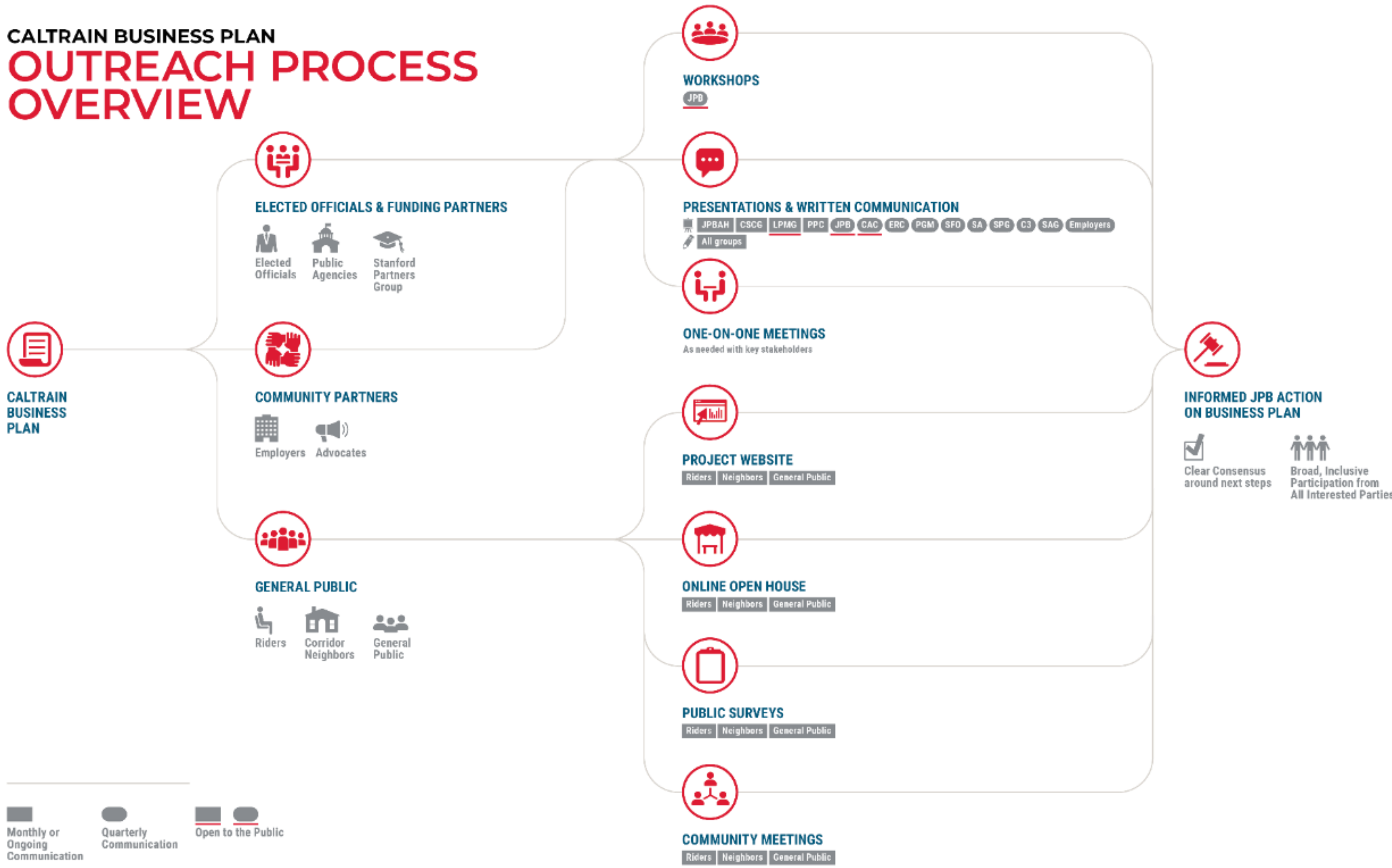
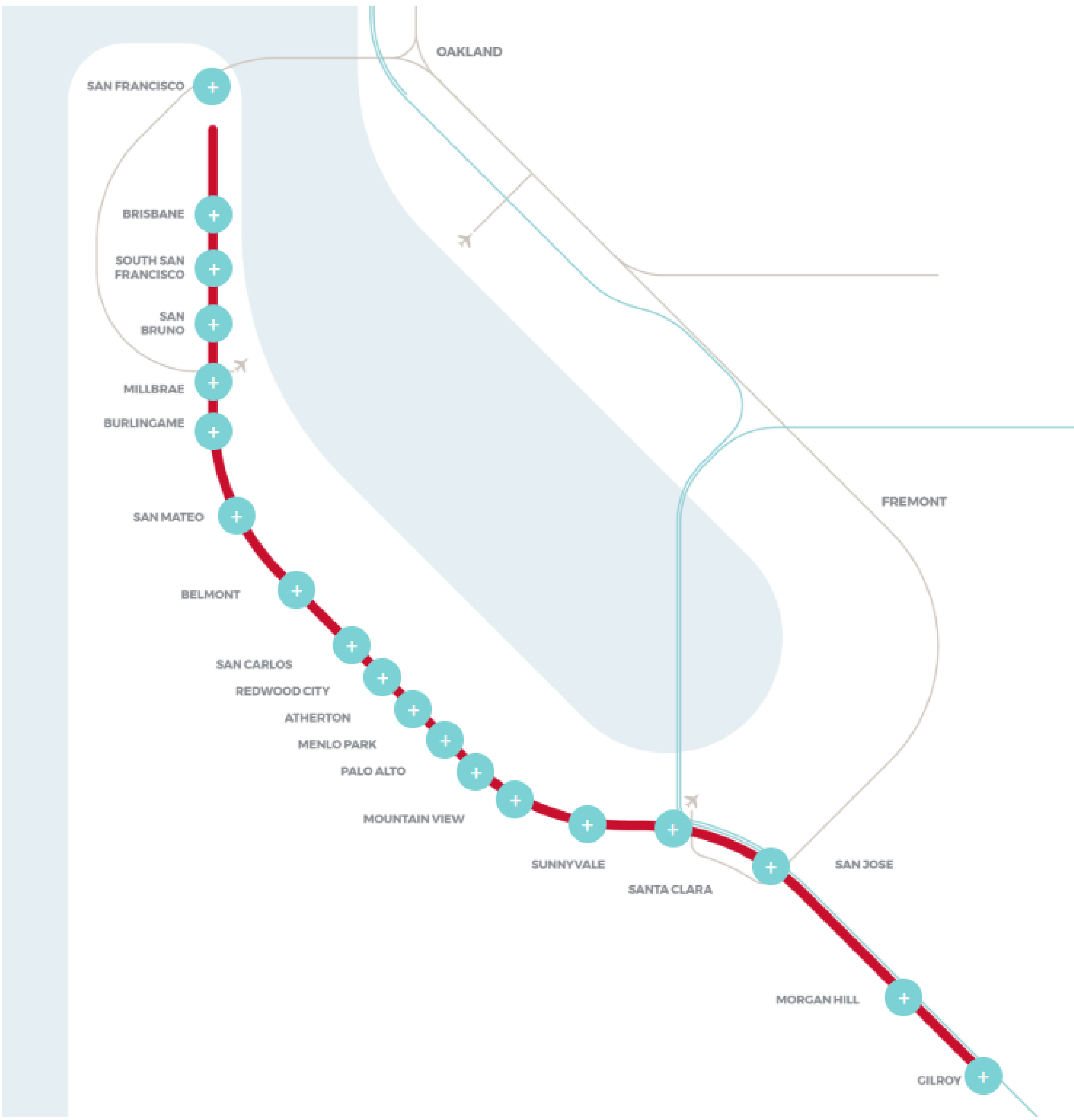
This memo describes the outreach efforts conducted as part of the Caltrain Business Plan (CBP) process through the summer of 2020. Outreach included significant public and stakeholder engagement regarding Caltrain's growth strategy, proposed service changes as outlined in the 2040 Service Vision, equity considerations, and infrastructure improvements. The following sections outline the outreach process and the various activities and topics addressed as part of the CBP outreach.

FIGURE 1: OUTREACH PROCESS



Caltrain

FIGURE 2: JURISDICTIONS ALONG CALTRAIN CORRIDOR



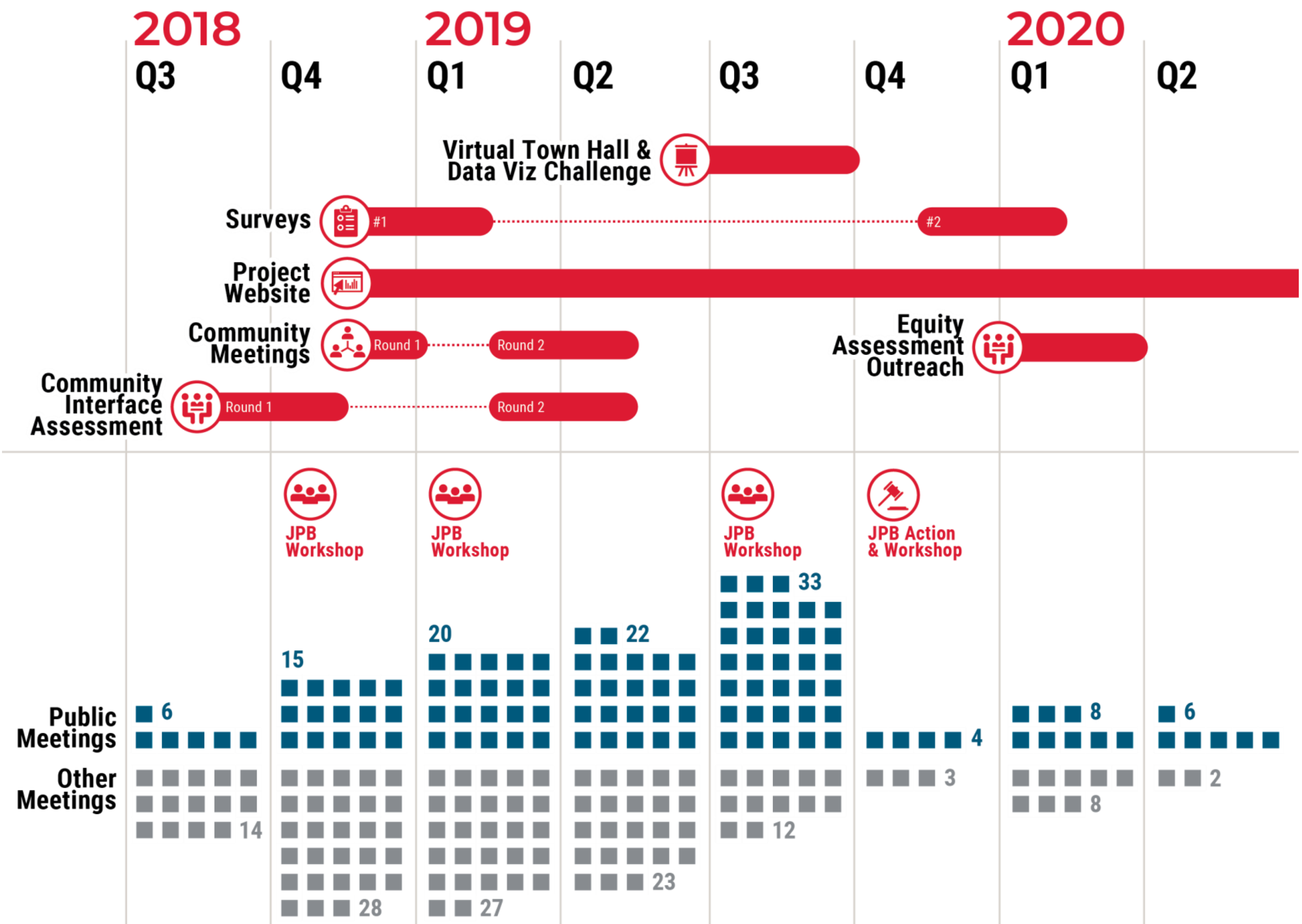
1. OUTREACH PROCESS

The Business Plan process touches on issues of wide interest to Caltrain's customers, as well as to a range of stakeholders within and beyond the Caltrain corridor. To ensure that it was comprehensive, inclusive, and representative, the process included an extensive outreach component. Caltrain educated, informed, and solicited feedback from city staff, transportation agency partner staff, policy makers, elected officials, riders, neighbors, and the general public throughout the planning process.

There were two distinct outreach tasks: stakeholder outreach and city/county outreach as discussed in the following sections. **Figure 3**, below, shows the overall outreach process; the city/county outreach falls into the one-on-one meeting category and stakeholder outreach covers all other activities. The outreach team prepared customized factsheets for the Community Interface Assessment for each of the jurisdictions shown in **Figure 2**. Thus, the city/county meetings entailed significantly greater preparation time than most other stakeholder meetings.

As discussed in section 3, all in-person, written, or phone/video communications received were logged by the outreach team. These communications were either addressed in real-time or summarized and shared in quick succession with the project management and technical teams. This feedback loop meant that input was incorporated as work progressed and responses were typically shared with stakeholders in the form of new work products in follow up meetings or website updates.

FIGURE 3: OUTREACH SCHEDULE



1.1 STAKEHOLDER OUTREACH

Stakeholder engagement included a robust schedule of outreach events, summarized below, with monthly and quarterly presentations to elected officials, project committees and other stakeholders, one-on-one meetings with community partners, a regularly updated project website, periodic public meetings, Caltrain Board workshops, and various online events.

STAKEHOLDER MEETINGS

The project team engaged with existing stakeholder committees regularly throughout the Business Plan development and convened new committees to focus specifically on the Business Plan. The committees included elected officials, public agency staff, institutions, employers, and community partners.

EQUITY STAKEHOLDER INTERVIEWS

Equity-focused outreach consisted of in-person interviews with two community stakeholders in each of the three Caltrain counties and a survey sent to corridor CBOs. Of the 11 total survey takers, six agreed to a follow-up phone interview and provided additional feedback on equity-related concerns. In-person and phone interviewees were compensated for their time with cash gift cards of $50 and $30, respectively.

PROJECT WEBSITE

The project website detailed the work of the Business Plan in a format that was engaging to a wide audience and helped facilitate meaningful, informed discussion of the policy issues under consideration. As the Business Plan progressed, the website was regularly updated with information about progress made, presentations given, supporting documentation, and upcoming meeting information. The website served as a receptacle of information previously presented in the public realm.

PUBLIC SURVEYS

Multiple public outreach surveys were developed and employed to gather general feedback from the community. The first survey asked the community to provide feedback on Caltrain service and their personal trip behaviors, which was integrated into the website and remained live through the first phase of public engagement. The survey was used to further understand the opportunities and challenges that Caltrain presents to communities. The second survey was used to share information and gather targeted feedback on the Service Vision prior to Board adoption. The survey was available through the project website and allowed visitors to step through key facets of the Service Vision and provide feedback.

RIDER ENGAGEMENT EVENTS

Two rounds of rider engagement events were held, and each round included a station pop-up in each county along the corridor. The first round of rider engagement events introduced the purpose of and process for developing the Caltrain Business Plan and promoted the project website, survey, and other ways the public can be involved in the process. The second round of events distributed a Project Factsheet summarizing the Service Vision recommendation to Caltrain riders, both at stations and as an on-board handout, and promoted engagement in the upcoming Online Open House.

ONLINE ENGAGMENT EVENTS

Virtual Town Hall

A Virtual Town Hall replicates traditional in-person town hall meetings but with more flexibility by offering interested listeners an opportunity to join online from anywhere they choose. Caltrain hosted a Virtual Town Hall meeting on YouTube prior to the Board’s adoption of the Service Vision. During the town hall, they presented a detailed summary of the of the Business Plan Evaluation and the staff recommendation for the Service Vision. Viewers were able to provide feedback and ask questions during the town hall presentation via the YouTube platform.

Data Visualization Challenge

The Caltrain Data Visualization Challenge was issued as a way to share Caltrain data and invite coders, programmers, designers and train enthusiasts to develop visualizations showing how Caltrain can meet the mobility needs of the Bay Area. Caltrain requested submissions to a virtual competition where entrants could use a downloadable set of data to develop a visualization, simulation tool, animation, map, or infographic to illustrate how people will use Caltrain in the future. The dataset included Caltrain's existing service, the corridor land use and geography, 2040 service plans for each of the three growth scenarios, and ridership forecasts. The goal was for entrants to develop a visually appealing data-driven way to tell a story about Caltrain and was open to anyone to enter, individually or as a group. The winning entry received Caltrain paraphernalia, a tour of a Caltrain maintenance facility, and a feature on the Business Plan website.

Reddit Ask Me Anything

Caltrain Business Plan staff participated in a live question and answer session on Reddit's Ask Me Anything (AMA) platform. Members of the public were able to join and submit questions about the Business Plan on the Reddit thread and get immediate responses. The Caltrain team answered approximately 30 questions during a one-hour session.

1.2 COMMUNITY INTERFACE ASSESSMENT CITY/COUNTY OUTREACH

Caltrain and the project team held one-on-one meetings with each individual jurisdiction (i.e., city, town, or county) along the corridor to discuss the Business Plan project and understand the specific relationship between each jurisdiction and Caltrain service. These meetings were part of the larger Community Interface Assessment effort to identify and define a holistic set of projects, plans, opportunities, and challenges that directly relate to the interface of Caltrain service with each community. Interface categories included safety, station amenities, environmental effects, track-crossings, and structures. The team met with representatives from each of the jurisdictions in two rounds of meetings. The first round of meetings was held in early fall 2018 and the second round in spring 2019. The following memo discusses, for each round, the purpose, the materials prepared, and the major outcomes and themes that emerged from the meetings.

ROUND 1

The purpose of Round 1 meetings was firstly to introduce staff members to the schedule and scope of the Caltrain Business Plan, and secondly, to record the full breadth of community interface topics that need to be considered under the Business Plan. Each meeting lasted one hour and started with an overview of the Business Plan followed by jurisdiction-specific discussion about the benefits and challenges of the Caltrain-community interface.

MEETING MATERIALS

Four documents were prepared for each Round 1 meeting:

1. A cover letter introducing the business plan and explaining the purpose of the in-person meeting.
2. A corridor-wide factsheet with systemwide statistics on ridership, mode of access, and trip purpose as well as a diagram showing all at-grade crossings in the corridor by city.
3. A jurisdiction-specific factsheet with statistics on ridership, station amenities, service levels, mode of access, and trip purpose; a map of corridor infrastructure and key destinations; a diagram of all at-grade crossing in the jurisdiction; and a list of existing or approved and funded Caltrain projects in that city.
4. A questionnaire for staff to help gauge relative importance of the benefits and challenges presented by the corridor-community interface and to understand future service priorities.

The corridor factsheets were created so that the community interface team and jurisdiction staff came to the meeting with the same baseline information about Caltrain operations and influence at the jurisdiction level. Factsheet information was derived from Caltrain ridership reports, previous Caltrain and MTC surveys, from Caltrain databases, and from California High Speed Rail documents and environmental analysis.

The purpose of the questionnaire was to help validate the draft list of corridor interface topics. Each jurisdiction has a unique relationship with the corridor, and it was important that we meet with each individually to produce a complete and thorough picture of the interface topics important to this corridor. Questionnaire responses were also used to prompt discussion at the in-person meetings and to understand the nuanced concerns and priorities of each jurisdiction.

QUESTIONNAIRE RESULTS & KEY THEMES

Results for each of the three questions are summarized in the figures below. The results indicate that the benefits and concerns presented to the jurisdictions are all important and all must be considered during the peer corridor assessment and in the selection and implementation of a future service plan. The responses to the service priorities question indicates that more commute service, increased frequency, and reduced travel times are the top service priorities for the greatest number of jurisdictions.

FIGURE 4: AVERAGE BENEFIT FOR JURISDICTIONS

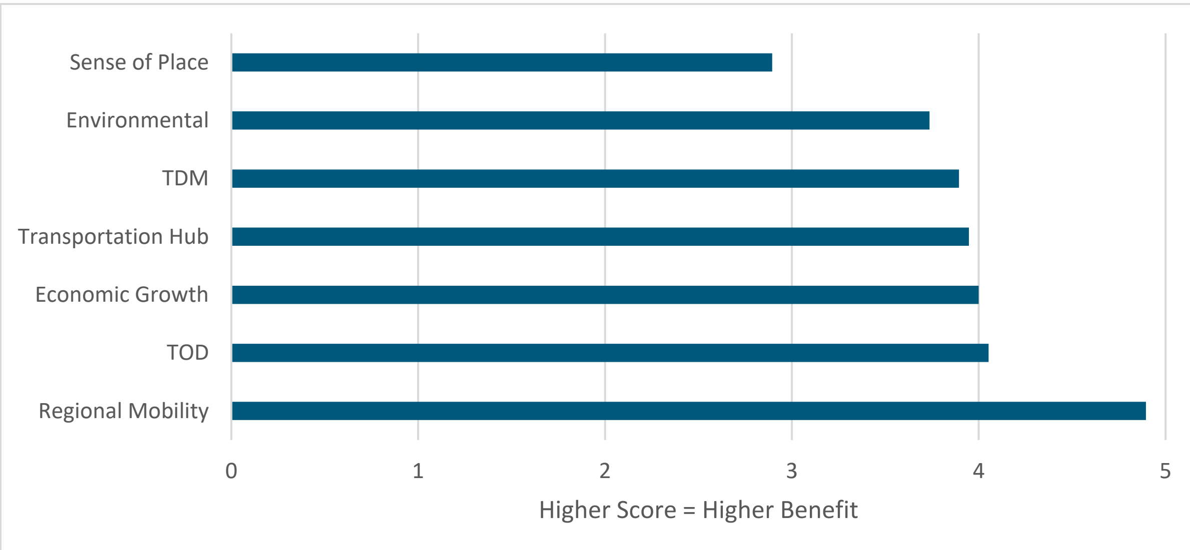


FIGURE 5: AVERAGE CONCERN FOR JURISDICTIONS

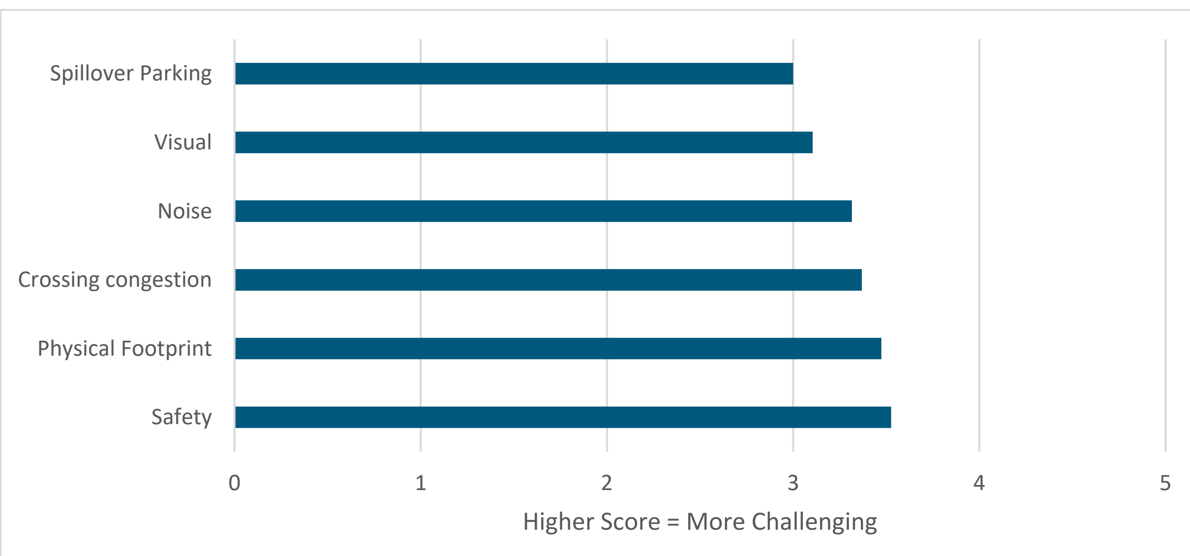
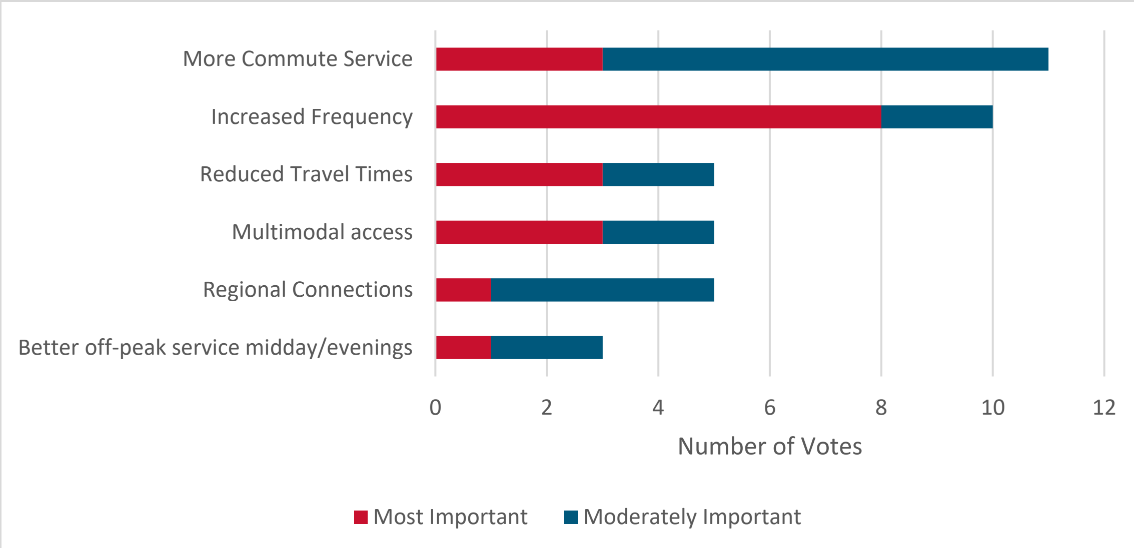


FIGURE 6: PRIORITIZED CALTRAIN SERVICE IMPROVEMENTS



Four broad themes emerged as top-of-mind for all jurisdictions:

1. **Service Levels & Schedules** – it is important for cities that Caltrain service meet the demand for peak period travel in and out of their community. Cities rely on Caltrain and other regional transit services to help meet their mode split goals and reduce existing and anticipated congestion on their roadways.
2. **Physical Corridor** – cities are impacted by the physical realities of the corridor including at-grade crossings, separated crossings, and the stretches of fencing, walls, and vegetation in between. These physical elements of the corridor create safety, nuisance, and connectivity challenges for community members living alongside or traveling across the corridor. Many cities want to improve connectivity and safety, but lack the financial, political, and organizational wherewithal to tackle these challenges on their own.
3. **Land Development** – it is important to cities that their community-initiated projects and Caltrain-initiated projects are well-coordinated, and that both types of projects are aligned with their community values. Land development concerns discussed at the meetings included placemaking, jobs-housing balance, transit-oriented development, and zoning changes.
4. **Station Connectivity & Access** – local first/last mile solutions are critical to expanding the influence and usefulness of the Caltrain corridor. Cities want to provide more of their residents and employees access than those immediately adjacent to the corridor, and they are looking for support and guidance from regional entities in how to do this most effectively.

ROUND 2

As a follow-up to the individual city/county meetings held in Fall 2018, a second round of in-person meetings was conducted with staff members from each city along the Caltrain corridor. Elected officials were invited to attend the meetings this round and, in many cases, did participate alongside staff members from their city. The purpose of these meetings was threefold:

- Update cities on the work done to-date in developing the three high-level growth scenarios
- Collect city input on the growth scenarios, and
- Build awareness of the Business Plan schedule and the communication channels available to cities (e.g. LPMG, CSCG, letters to the Joint Powers Board) to further voice their opinions on the growth scenarios and Business Plan process.

Meetings were held in March and April 2019 so that feedback could be incorporated into the materials and analyses prepared for the August Board Workshops on the 2040 service vision selection.

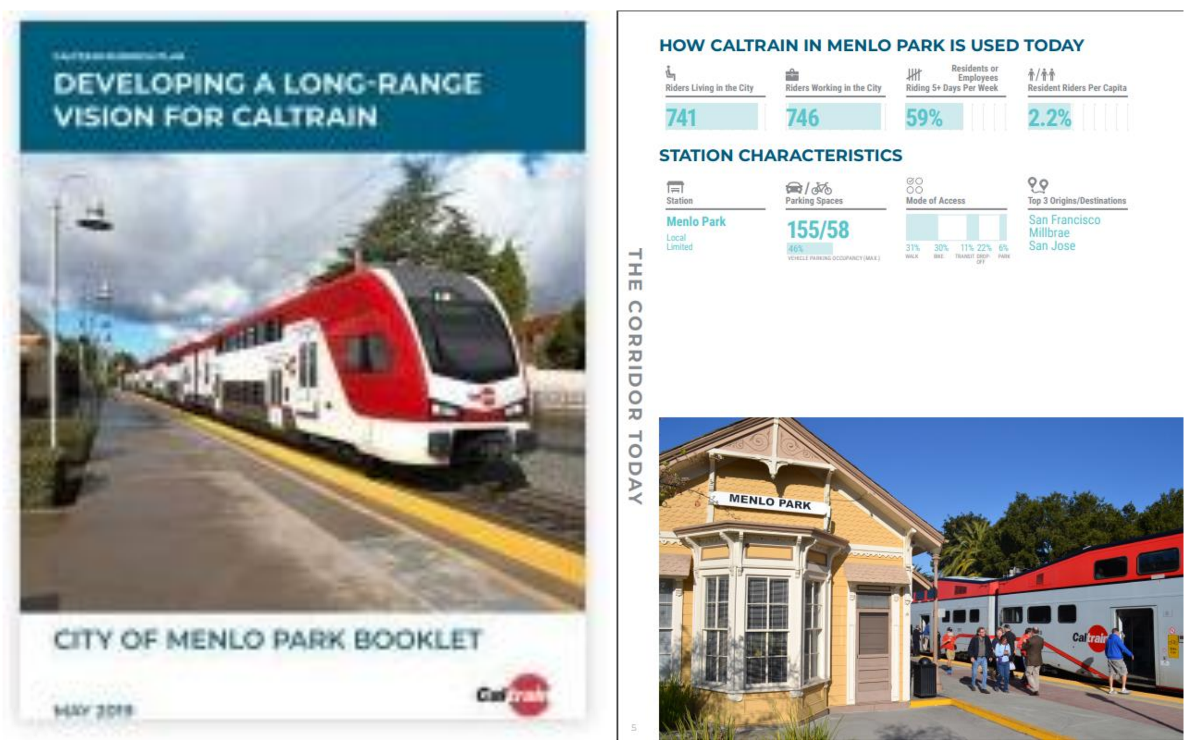
MEETING MATERIALS

Two documents were prepared for each Round 2 meeting:

1. A cover letter explaining the purpose of the Business Plan and the second in-person meeting.
2. A 12-page, jurisdiction-specific booklet with graphics and statistics explaining Caltrain operations under existing conditions as well as the three 2040 growth scenarios – baseline, moderate, and high growth. The booklets included information on service levels, ridership, travel times, mode of access, and trip purpose; a map of corridor infrastructure, key improvement projects, and key destinations; and a diagram of all at-grade crossing in the jurisdiction and projected gate downtimes under each scenario. The booklets can be reviewed on the Caltrain website: https://www.caltrain2040.org/community-interface/.

The booklets were created as a visual aid in discussing the growth scenarios and the implications for both the individual jurisdictions and the region (see figure below). Booklet information was derived from Caltrain ridership reports, previous Caltrain and MTC surveys, from Caltrain databases, California High Speed Rail documents and environmental analysis, and from Business Plan technical work.

FIGURE 7: SAMPLE PAGE(S) FROM CITY BOOKLETS



KEY THEMES

Four broad themes emerged as top-of-mind for all jurisdictions:

1. **Service Levels & Projected Growth** – Cities are eager to see a 2040 service vision that can accommodate the growth and increased trip generation anticipated in their city. All cities are anticipating some level of growth and responded positively to plans for increased Caltrain service.
2. **Infrastructure Uncertainties** – cities are impacted by the physical realities of the corridor including at-grade crossings, separated crossings, and the stretches of fencing, walls, and vegetation in between. Caltrain's physical footprint would need to be altered to varying degrees to achieve the service levels proposed in each of the growth scenarios. At this stage in the Business Plan, many of the specifics around the infrastructure needs, such as engineering specifications for grade-separations, exact placement of passing tracks, and development options for underutilized Caltrain parcels, are undetermined. This uncertainty made it difficult for many cities to confidently evaluate specific growth scenarios and highlighted the need for refinement of these scenarios in the next stage of the Business Plan.
3. **High-Speed Rail** – nearly half of the cities expressed concern related to schedule slippage and delays in the planned implementation of High Speed Rail (HSR) on the Caltrain corridor. While cities differed in their perspectives regarding HSR as a whole, many asked about the implication for the Business Plan should HSR alter or even abandon its plans to share the corridor. While the Business Plan assumes a blended system with HSR in 2040, the feeling of uncertainty among corridor cities supports exploration of alternative scenarios for how rail improvements could be phased if the implementation of HSR in the Bay Area were to be further delayed.
4. **Communication Protocols** – many cities felt unsure of the right communication channels or the right moment to coordinate with Caltrain staff on projects or voice their opinion on the Business Plan growth scenarios. Many of these questions were addressed during the in-person meetings and cities came away with a greater understanding of the Local Policy Maker Group venue and the timeline to weigh in on the growth vision and remaining Business Plan decisions.

2. OUTREACH AND ENGAGEMENT SUMMARY

Outreach team members kept track of all outreach activities and communications in the online tool EnviroLytical. The summaries below represent all activities and communications from the approximately two years that the CBP project was in active planning.

2.1 WEBSITE ACTIVITY

As of May 2020, the Business Plan website had been viewed by 14,700 visitors who engaged in 20,500 unique sessions with 47,000 page views.

2.2 STAKEHOLDER MEETINGS OPEN TO THE PUBLIC

Presentations or written updates regarding the Caltrain Business Plan were provided at the following stakeholder coordination and outreach activities. These were open to the public.

Table 1: Meetings Open to the Public

Stakeholder or Committee	Dates	Total Number
American Planning Association (APA) event	5/14/2019	1
Bay Area Council (BAC) Transportation Committee	4/24/2019	1
C/CAG Board of Directors (BOD)	3/14/2019	1
C/CAG Congestion Management & Environmental Quality (CMEQ)	2/25/2019	1
C/CAG Congestion Management Program Technical Advisory Committee	3/21/2019	1
Caltrain Accessibility Advisory Committee	7/24/2019	1
Caltrain Bicycle Advisory Committee (BAC)	11/15/2018; 1/17/2019; 5/16/2019; 9/19/2019; 5/21/2020	5
City Council meetings	4/9/2019 – Mountain View; 4/23/2019 – Belmont; 5/6/2019 – Redwood City; 5/13/2019 – Palo Alto; 6/3/2019 – Burlingame; 7/18/2019 – Brisbane; 7/23/2019 – Millbrae; 8/20/2019 – San Jose; 9/10/2019 – Sunnyvale; 9/23/2019 – San Carlos; 9/30/2019 – Menlo Park Rail Subcommittee	11
Friends of Caltrain	3/20/2019	1
Joint Powers Board (JPB) – written update	8/2/2018; 9/6/2018; 11/1/2018; 12/6/2018; 2/7/2019; 3/7/2019; 4/4/2019; 6/6/2019; 9/6/2019; 2/6/2020; 5/7/2020	11
Joint Powers Board (JPB) BOD – meeting or workshop	10/4/2018; 1/10/2019; 5/2/2019; 7/11/2019; 8/1/2019; 10/3/2019; 3/5/2020; 4/2/2020	8
JPB Citizen Advisory Committee (CAC)	8/15/2018; 10/17/2018; 1/16/2019; 2/20/2019; 5/15/2019; 8/21/2019; 4/15/2020	7
JPB WPLP	7/24/2019; 1/22/2020; 2/26/2020; 3/25/2020	4
Local Policy Makers Group – meeting	7/26/2018; 9/27/2018; 11/29/2018; 12/20/2018; 2/28/2019; 3/28/2019; 4/25/2019; 6/27/2019; 7/25/2019; 8/22/2019; 10/24/2019; 1/23/2020; 2/27/2020	13
Local Policy Makers Group – written update	8/23/2018; 10/17/2018; 1/24/2019; 5/23/2019; 9/26/2019; 11/21/2019; 12/19/2019; 3/26/2020; 4/23/2020; 5/28/2020	10
Monterey Corridor Working Group	8/22/2019	1

Stakeholder or Committee	Dates	Total Number
MTC Programming and Allocations Committee	5/8/2019; 9/4/2019	2
Public meetings	11/13/2018 – San Carlos; 11/14/2018 – San Francisco; 11/26/2018 – San Jose; 8/12/2019 – San Jose; 8/14/2019 – San Francisco; 8/29/2019 – San Carlos	6
Reddit Townhall	2/8/2019	1
Riding the Train - Business Plan Q&A	9/16/2019	1
SamTrans BOD	7/10/2019; 8/7/2019; 2/6/2019	3
San Francisco County Transportation Authority (SFCTA) BOD	3/19/2019; 9/24/2019	2
SFCTA CAC	3/27/2019; 9/4/2019	2
San Mateo County (SMC) Board of Supervisors	9/17/2019	1
San Mateo County Transportation Authority (SMCTA) BOD	11/1/2018; 6/6/2019; 6/18/2019; 9/5/2019	4
Santa Clara Valley Transportation Authority (VTA) BOD	2/7/2019; 8/1/2019	2
Santa Clara VTA - Safety, Security, and Transit Planning and Operations	11/16/2018	1
Santa Clara VTA Policy Advisory Committee (PAC)	5/9/2019	1
SMC Transit District Board	11/7/2018	1
SMCTA CAC Meeting	10/30/2018; 6/4/2019	2
SPUR public meetings or forums	1/15/2019; 1/22/2019; 6/19/2019	3
Station outreach	8/28/19 – San Francisco; 9/6/19 – Redwood City; 9/20/19 – San Jose	3
Transbay Joint Powers Association BOD	4/11/2019	1
YouTube Town Hall - Biz Plan Update	7/22/2019	1
TOTAL:		**114**

2.3 STAKEHOLDER MEETINGS CLOSED TO THE PUBLIC

The follow stakeholder coordination activities occurred that were not open to the public. This includes city/county meetings with individual jurisdiction staff.

Table 2: Stakeholder Meetings

Stakeholder or Committee	Dates	Total Number
City/County Staff Coordinating Group (CSCG)	7/18/2018; 8/15/2018; 9/19/2018; 11/14/2018; 12/12/2018; 2/20/2019; 3/20/2019; 4/17/2019; 6/19/2019; 7/17/2019; 8/21/2019; 3/18/2020; 6/17/2020	13
Commute.org Meeting	6/20/2019; 9/19/2019	2
Community interface meetings with individual jurisdictions	Two rounds of meetings from Sept. 2018 to April 2019	40
JPB Caltrain Business Plan Ad-Hoc Committee	7/23/2018; 8/1/2018; 9/17/2018; 10/1/2018; 11/1/2018; 12/1/2018; 1/9/2019; 2/1/2019; 3/13/2019; 4/15/2019; 5/13/2019; 6/10/2019; 7/8/2019; 8/12/2019	14
Mountain View Chamber of Commerce Meeting	10/9/2019	1

Stakeholder or Committee	Dates	Total Number
Project General Managers (PGM)	10/17/2018; 5/7/2019; 5/14/2019; 1/18/2019; 3/18/2020	5
Project Partner Committee (PPC)	6/25/2018; 7/31/2018; 9/4/2018; 10/2/2018; 10/26/2018; 11/6/2018; 12/4/2018; 12/18/2018; 1/8/2019; 2/5/2019; 3/12/2019; 4/23/2019; 5/7/2019; 6/18/2019; 7/9/2019; 9/10/2019; 10/1/2019; 12/3/2019; 1/7/2020; 2/19/2020; 2/20/2020; 2/21/2020; 3/3/2020; 6/2/2020	24
SAMCEDA HLUT Committee	8/13/2019	1
SAMCEDA Transportation Group	5/6/2019; 6/11/2019	2
San Francisco Capital Planning	12/3/2018; 9/30/2019	2
SMC City Manager's meeting	1/10/2019	1
San Mateo Leadership Class	6/7/2019	1
Santa Clara County City Managers Meeting	7/10/2019	1
Silicon Valley Economic Development Alliance Meeting	9/25/2019	1
Silicon Valley Leadership Group	5/1/2019	1
Silicon Valley Regional Rail	5/22/2019	1
Stakeholder Advisory Group (SAG)	10/23/2018; 1/23/2019; 5/15/2019; 8/8/2019; 3/17/2020	5
State and Federal Elected Officials (SFO)	10/15/2018; 1/18/2019; 5/17/2019	3
Total		**118**

2.4 CONTACTS

As of May 28, 2020, the EnviroLytical database includes 803 individuals and 156 organizations representing a variety of contact types. In the table below contacts may be associated with multiple categories.

Table 3: Contact Type inventory

Contact Type	Individuals	Organizations
Agency staff	66	24
Business, employer or business group	107	73
Committee member	280	126
Community or advocacy group	59	49
Elected body	117	22
Jurisdiction – city or county	254	50
Public or community member	310	N/A

3. COMMUNICATIONS SUMMARY

Comments were collected throughout the outreach activities and stakeholder committee meetings. The table below lists the frequency of each topic addressed in the comments.

- Total comments received through May 28, 2020: 1,374
- Sources include:
  - Blog post: 20
  - Email: 123
  - In-person - committee meeting: 814
  - In-person - community interface meeting: 62
  - In-person - community meeting: 131
  - Letter: 4
  - Website: 18

Individual comments addressed the topics described below. A single comment may address multiple topics.

Table 4: Topics Addressed

Topic	Number of times addressed
Organization / Governance	678
Service Characteristics	445
Community Impact	400
Ridership projections/growth	324
Transit integration	319
Service Concepts	257
Funding / Financing	203
Station Area / Station Access Planning	175
Grade crossing / Separation	164
Mode of Access	135
Station Amenities	119
Track widening	107
Capital Projects - External	99
Peak vs. off-peak service	99
Electrification	84
Equity	78
Fare or Fare System	73
Traffic / Congestion	62
Capital Projects - Caltrain	55
ADA Accessibility/Level Boarding	32
Service Structure	20
Cost - Capital	7
Rider Demographics	5
Cost - Operational	3

Equity Assessment Technical Memo

Prepared for:

Caltrain

May 2020

OK18-0254.00

Prepared by:

Fehr & Peers

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1. INTRODUCTION

This memo describes the equity assessment performed on both Caltrain's current service and 2040 Service Vision as part of the Caltrain Business Plan process. The memo first describes the many equity-related comments and suggestions received through community input, existing planning documents, and stakeholder interviews. This input, along with MTC and Title IV equity frameworks, informed the structure of the equity assessment, which sought to answer three primary questions:

- Does Caltrain ridership reflect corridor communities?
- Do travel patterns along the corridor vary by race or income level?
- What Caltrain-specific factors affect ridership diversity?

The conclusion of this exploration is an evaluation of the Service Vision through an equity lens and a set of recommendations to further improve equity outcomes for Caltrain riders and the corridor community.

APPLICATION IN THE BUSINESS PLAN

This assessment is intended to inform Caltrain's Joint Powers Board as they complete the Caltrain Business Plan process and move forward with implementation. The Service Vision is expected to result in more equitable access along the corridor and yet, there is more that Caltrain can do while implementing the Business Plan to further improve equity outcomes on the corridor. The equity assessment was performed for informational purposes and all recommendations are intended to inform future planning and policy work.

2. SETTING THE STAGE WITH COMMUNITY EXPERTISE

2.1 COLLECTION OF COMMUNITY INPUT

To gain a better understanding of current barriers to Caltrain, Fehr & Peers reviewed existing transportation plans along the corridor and conducted outreach with city staff, elected officials, and community-based organizations (CBOs). This feedback was critical in assessing how well Caltrain currently serves disadvantaged residents and how the Service Vision would either improve or perpetuate existing inequities.

REVIEW OF EXISTING PLANS

Several transportation plans have been completed along the corridor in the past 15 years that incorporate relevant community concerns and feedback regarding Caltrain. The following nine countywide, citywide, or community-based transportation plans and reports were reviewed to collect applicable feedback:

1. Bayview Community Based Transportation Plan (2019)
2. Redwood City Citywide Transportation Plan (2018)
3. Moving San Mateo County Forward: Housing and Transit at a Crossroads (2018)
4. San Bruno/South San Francisco Community-Based Transportation Plan (2012)
5. San Mateo County Transportation Plan for Low-Income Populations (2012)
6. East Palo Alto Community-Based Transportation Plan (2004)
7. Community-Based Transportation Plan for East San Jose (2009)
8. Community-Based Transportation Plan for Gilroy (2006)
9. Equitable Access to Caltrain: Mapping and Scheduling Analysis (2019)

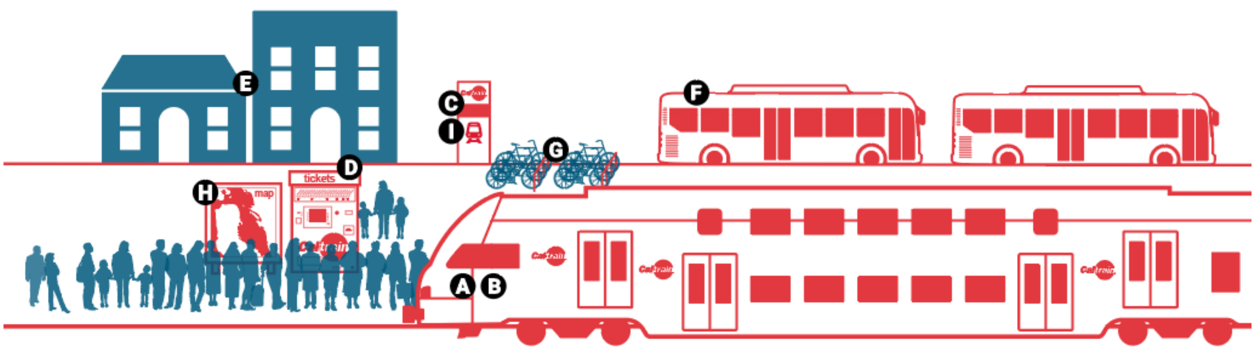
STAKEHOLDER ENGAGEMENT

Conversations with city staff, elected officials, and CBO representatives took place throughout three rounds of outreach between Fall 2018 and Spring 2020. The feedback gathered captures the experience of current riders, potential future riders, and non-rider community members. The first two rounds of outreach were city-specific meetings conducted with agency staff and elected officials. The first round focused on introducing the Business Plan and discussing existing benefits and challenges of Caltrain, while the second round focused on gathering input on the proposed Business Plan growth scenarios.

The third round of outreach consisted of in-person interviews with two community stakeholders in each of the three Caltrain counties and a survey sent to corridor CBOs. Of the 11 total survey takers, six agreed to a follow-up phone interview and provided additional feedback on equity-related concerns. These conversations revealed that Caltrain communities share several needs and concerns with respect to the railroad.

2.2 SUMMARY OF COMMUNITY FEEDBACK

A summary combining the lessons from the existing plans and stakeholder feedback is presented below. The following comments are opinions expressed by community members and it should be noted that not all of the community's recommendations are feasible in the specific format being recommended:



A. BETTER SERVICE FOR NONTRADITIONAL WORK SCHEDULES AND NON-WORK TRIPS

Currently, Caltrain is focused on traditional commute hours, whereas low-income and vulnerable populations are more likely to have commutes that fall outside of these times. Stakeholders would enjoy more mid-day, late evening, and early morning service [1 2 3 4 5] and better coordination with connecting services during non-typical commute times. [3 7 6]

B. MORE FREQUENT SERVICE

Upgraded service would offer more flexibility and choice to access the corridor and better connections to partner transit, making travel easier for those who need it. Increased service would be particularly useful during peak periods to meet demand. [3 5 6 7 8 7 8] For cities, peak period improvements are key in achieving mode split goals and reducing congestion on roads.

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[1] San Mateo County Transportation Plan for Low-Income Populations (2012)
[2] East Palo Alto Community-Based Transportation Plan (2004)
[3] Community-Based Transportation Plan for East San Jose (2009)
[4] Equitable Access to Caltrain: Mapping and Scheduling Analysis (2019)
[5] Community Stakeholder Interviews (2020)
[6] San Bruno/South San Francisco Community-Based Transportation Plan (2012)
[7] Moving San Mateo County Forward: Housing and Transit at a Crossroads (2018)
[8] Community-Based Transportation Plan for Gilroy (2006)

C. OPEN STATIONS IN COMMUNITIES OF CONCERN

Some residents living within Communities of Concern along the corridor would like to see [3 4 5 7 8 9 9] new stations or greatly improved access to Caltrain in their community.

D. DISCOUNTED FARES FOR LOW-INCOME RIDERS

Currently, Caltrain does not offer discounts for low-income riders and has a significantly lower share of low-income riders compared with other agencies along the corridor (Muni, VTA, and SamTrans). Stakeholders would like to see a reduced fare or subsidy program for low-income riders. Some respondents also recommended revisiting [3 5 6 7 8 9] the zone-based fare structure to make sure that it is not disincentivizing the use of connecting bus service. [3 8]

E. COORDINATED AND THOUGHTFUL LAND DEVELOPMENT

Cities want community-initiated and Caltrain-initiated land development near the rail corridor to be well-coordinated and aligned with community values. Land development factors of concern include placemaking, jobs-housing balance, transit-oriented development, and the zoning updates needed to facilitate and support these land use changes. As housing along the Peninsula is increasingly expensive and inaccessible to low-income and transit-dependent households, some stakeholders would like Caltrain to partner with jurisdictions along the corridor to prioritize developing affordable housing and implement anti-displacement or local preference policies near stations. [7 9]

F. BETTER CONNECTING BUS SERVICE

Stakeholders want to see more short-distance transportation connections ("first and last mile" connections) to and from Caltrain stations to expand the influence and usefulness of the Caltrain service. Existing, and potential Caltrain riders are poorly served by connecting bus services in San Mateo and Santa Clara Counties. Cities want to increase transit access for their residents and employees, and they need support from the region's transit providers to do this effectively. Respondents would like to see better schedule coordination with SamTrans and VTA to reduce the number of bus connections that result in long waits or insufficient (<5 minutes) transfer times, as well as more frequent connecting bus services to Caltrain stations.

G. BETTER BIKE & PEDESTRIAN CONNECTIVITY

Stakeholders are impacted by the physical realities of the railroad including separated rail crossings, at-grade rail crossings, and the stretches of fencing, walls, and vegetation bounding the railroad corridor. These physical elements of the corridor create safety, nuisance, and connectivity challenges for community members living alongside or traveling across the rail corridor. Many cities want to improve connectivity and safety around stations, but lack the financial, political, and organizational resources to tackle these challenges on their own. Furthermore, enhancing connections of low-cost modes like biking and walking could expand access to Caltrain services. To this end, stakeholders would like to see better bike facilities such as lockers and racks at stations, more separated bike and pedestrian crossings, and bike sharing opportunities at stations. [8 10]

H. BETTER RIDER INFORMATION

The fragmented nature of public transit service in the Bay Area makes it difficult for riders, especially those from marginalized and limited English-proficient backgrounds, to navigate myriad systems and agencies. Outreach respondents assert that Caltrain can address this by showing area-based maps and schedules at stations that show services from all agencies, ideally in multiple languages. [3 8] For particularly vulnerable groups, respondents recommend that Caltrain conduct outreach to teach people how to ride, perhaps with "captive audiences" such as ESL or citizenship classes. Finally, Caltrain could better utilize social media to advertise Caltrain service and connect with potential riders, especially youth. [10]

I. ACCESSIBLE STATION DESIGN

Some Caltrain stations are poorly lit, provide limited access to ADA riders, and feel uninviting to riders. Stakeholders would like to see amenities at stations that improve rider experience, such as more lighting, more substantial shelter

[9] Bayview Community Based Transportation Plan (2019)

[10] Redwood City Citywide Transportation Plan (2018)

from the elements, and seating. Some respondents also called for greater ADA accessibility through level boarding at stations. [7]

3. EQUITY ASSESSMENT KEY QUESTIONS

3.1 DOES CALTRAIN RIDERSHIP REFLECT CORRIDOR COMMUNITIES?

To assess whether Caltrain ridership reflects existing corridor communities, Fehr & Peers undertook a comparative demographic analysis of residents living within two miles of a Caltrain station and current Caltrain riders. Demographic data for existing residents were found using the 2013-2017 American Community Survey (ACS) 5-year Estimates for California block groups. Data from the 2019 Caltrain Triennial Survey were used to understand demographic characteristics of existing riders. This on-board survey amassed 5,500 responses that could be used for this analysis.

METHODOLOGY

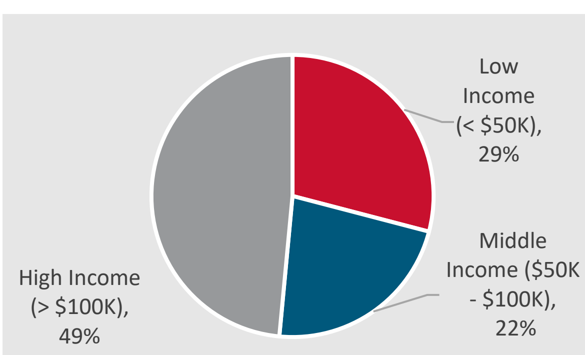
Fehr & Peers used the 2013-2017 ACS datasets for total population, total households, household income, and race by block group. Household income and race data were selected for this equity analysis because low-income people and people of color face significant socioeconomic barriers and disproportionately rely on transit service to travel. The demographic block group data was clipped to a 2-mile Caltrain station buffer in ArcGIS. Data for block groups only partially within the buffer were pro-rated, meaning the number of residents and households were reduced by the same percent reduction of the block group area only within the buffer. This extraction was then exported to Excel where household income and race percentages were calculated for the corridor.

Because the 2019 Triennial Survey asked riders for their household income and race, Fehr & Peers was able to calculate the percentage breakdown of household income and race of riders, which could then be compared to the census data described above.

CALTRAIN RIDERSHIP DOES NOT REFLECT CORRIDOR COMMUNITIES

Demographic analyses of residents living within two miles of a Caltrain station reveal that the corridor is diverse. As shown in **Figure 1**, households making less than $50,000 a year make up 29 percent of households in the study area, and 63 percent of residents identify as a person of color. Within a two-mile station area, about 20 percent of households are located within an MTC-designated Community of Concern (CoC) (2018). CoCs are designated as such due to high levels of households with minority or low-income status, seniors, people with limited English proficiency, or people with disabilities. Various regional and local agencies use CoC designation as a factor to prioritize transportation projects and funding. **Figure 2** below shows that all but a couple Caltrain stations are located within two miles of a CoC.

FIGURE 1: HOUSEHOLD INCOME LEVEL AND RACE OF RESIDENTS WITHIN 2 MILES OF CALTRAIN



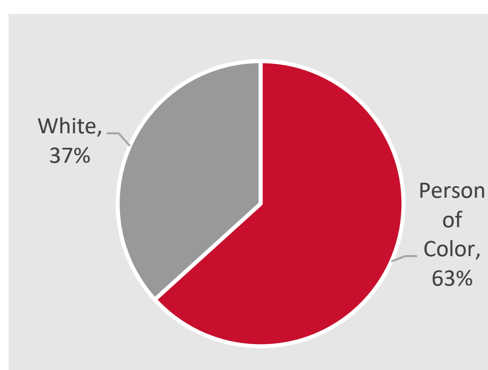
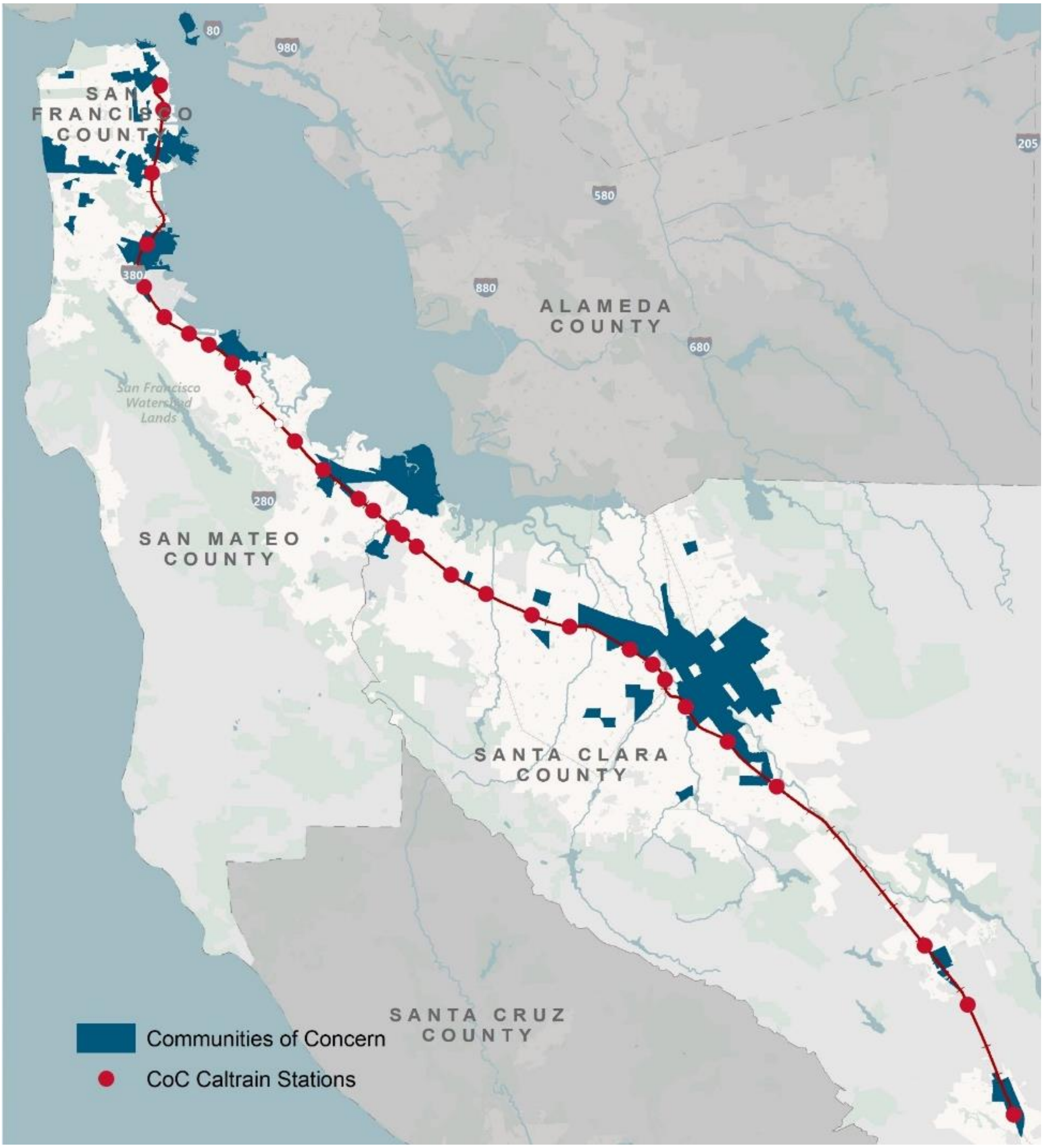


FIGURE 2: MTC COMMUNITIES OF CONCERN ALONG CALTRAIN CORRIDOR



The comparison charts in **Figures 3 and 4**, below show that Caltrain does not currently capture the diversity of adjacent neighborhoods. Low- and middle-income brackets are underrepresented in Caltrain ridership relative to the surrounding corridor. While 51 percent of corridor households make less than $100,000 a year, only 27 percent of Caltrain riders are in households making below $100,000. Discrepancies in racial breakdown can also be found when comparing Caltrain riders to corridor residents. White and Asian neighbors are overrepresented in Caltrain ridership and Hispanic neighbors are significantly underrepresented relative to the surrounding corridor. Although 27 percent of corridor residents identify as Hispanic, only nine percent of riders identify as Hispanic.

FIGURE 3: CALTRAIN RIDERS AND LOCAL RESIDENTS BY INCOME LEVEL

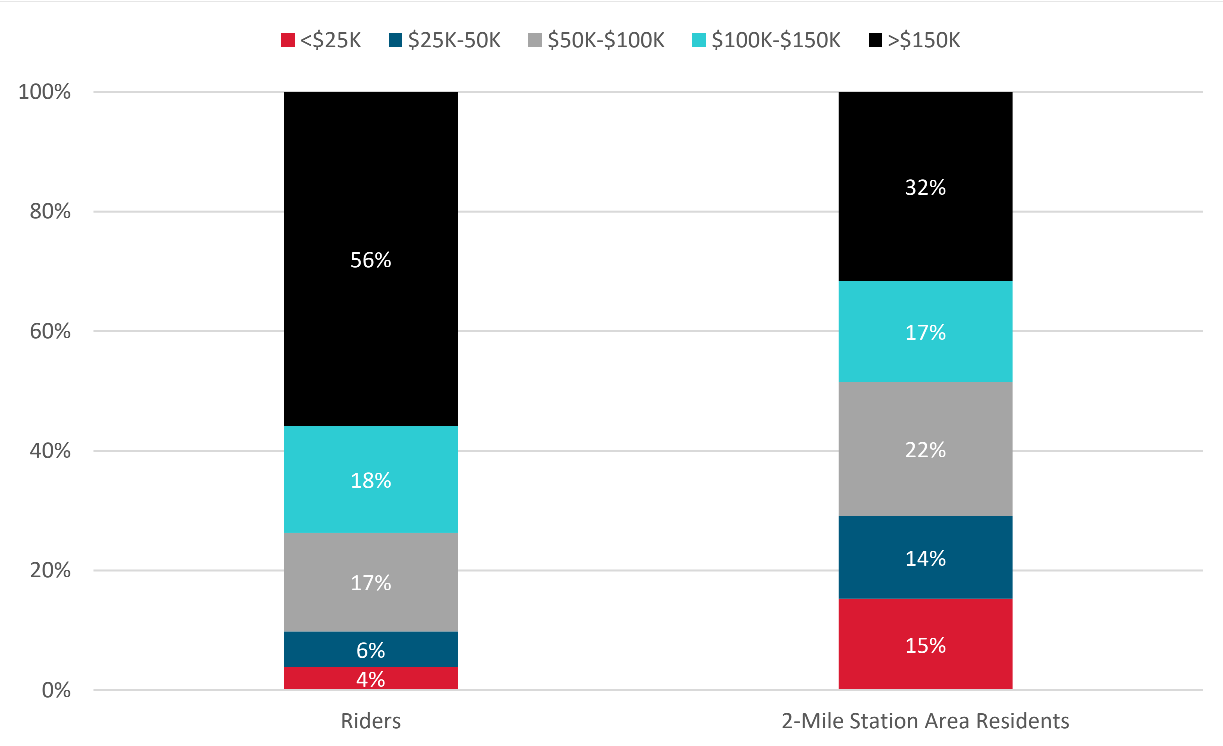
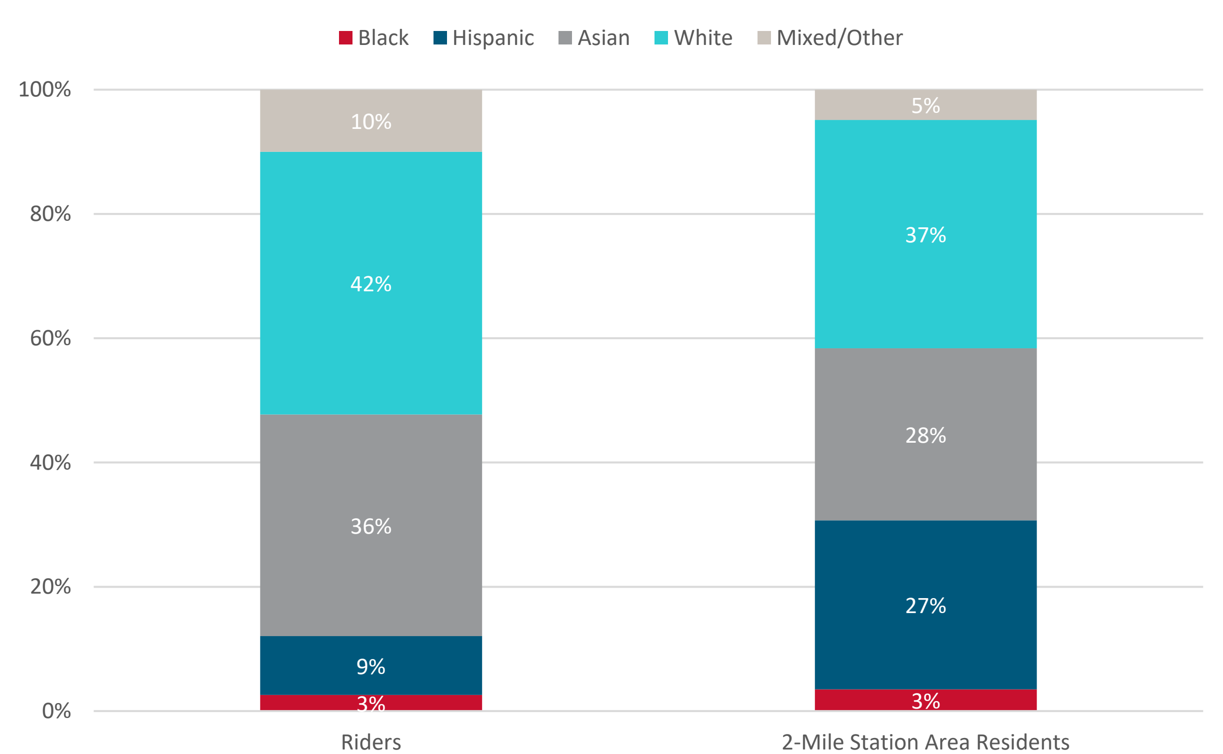


FIGURE 4: CALTRAIN RIDERS AND LOCAL RESIDENTS BY RACE



3.2 DO TRAVEL PATTERNS ALONG THE CORRIDOR VARY BY RACE OR INCOME LEVEL?

COMMUTE PATTERNS

The Census Transportation Planning Products (CTPP) dataset provides tabulated American Community Survey data for a wide range of demographics. This analysis used the 2012–2016 work travel flows dataset to understand existing travel patterns of workers who live and/or work within two miles of a Caltrain station—a subset of trips referred to as "corridor commute trips" for the purposes of this analysis. Workflows for individuals who live and work in the same city are disregarded in this assessment as it is assumed those individuals are unlikely to commute via Caltrain. Corridor commute trips were analyzed based on income and whether the worker lives within a Community of Concern (CoC) as defined by MTC. The CTPP data analysis sought to answer if commute travel patterns varied by income and by CoC status along the Caltrain corridor.

Methodology

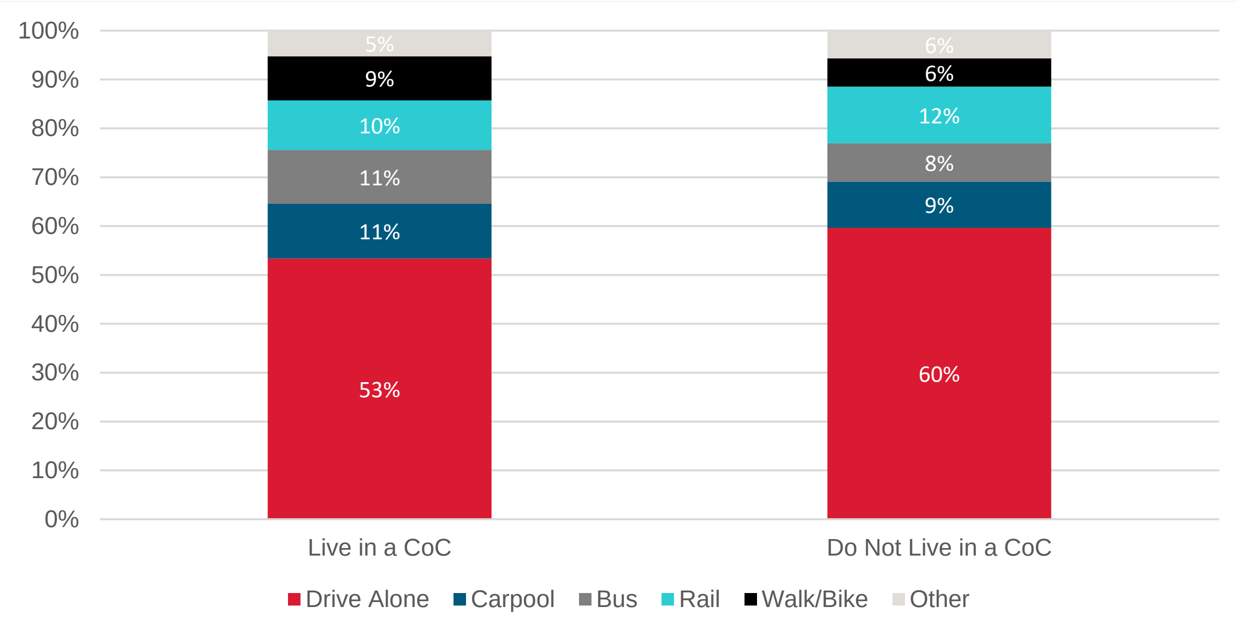
Table B303100 from the CTPP five-year ACS 2012–2016 data estimates the number of workers 16 years and over, divided into nine household income buckets, for each census tract. Fehr & Peers extracted estimates for those living and/or working in tracts in which a plurality of the tract area falls within two miles of a Caltrain station. Two miles is considered a reasonable catchment area for residents who may commute via Caltrain. Estimates were then grouped into five income categories as shown in **Table 1**.

Table 1: Income Brackets

Group	Range
Very Low	< $25,000
Low	$25,000 - $50,000
Medium	$50,000 – $100,000
High	$100,000 - $150,000
Very High	>$150,000

The commute mode of residents and workers near Caltrain is similar regardless of whether residents live within an MTC-designated CoC. **Figure 5** shows the commute mode share for workers that both live and work within two miles of a Caltrain station. A higher percentage of non-CoC commuters drive alone to work compared to those who live in a CoC. About 30 percent of corridor residents that live in a CoC take either transit or an active mode to get to work compared to 26 percent of those not living in a CoC. A slightly higher share of non-CoC residents commute via rail; the light rail mode share is equal, at 9 percent, for both populations whereas non-CoC residents are three times more likely to commute via heavy rail than those that live in a CoC.

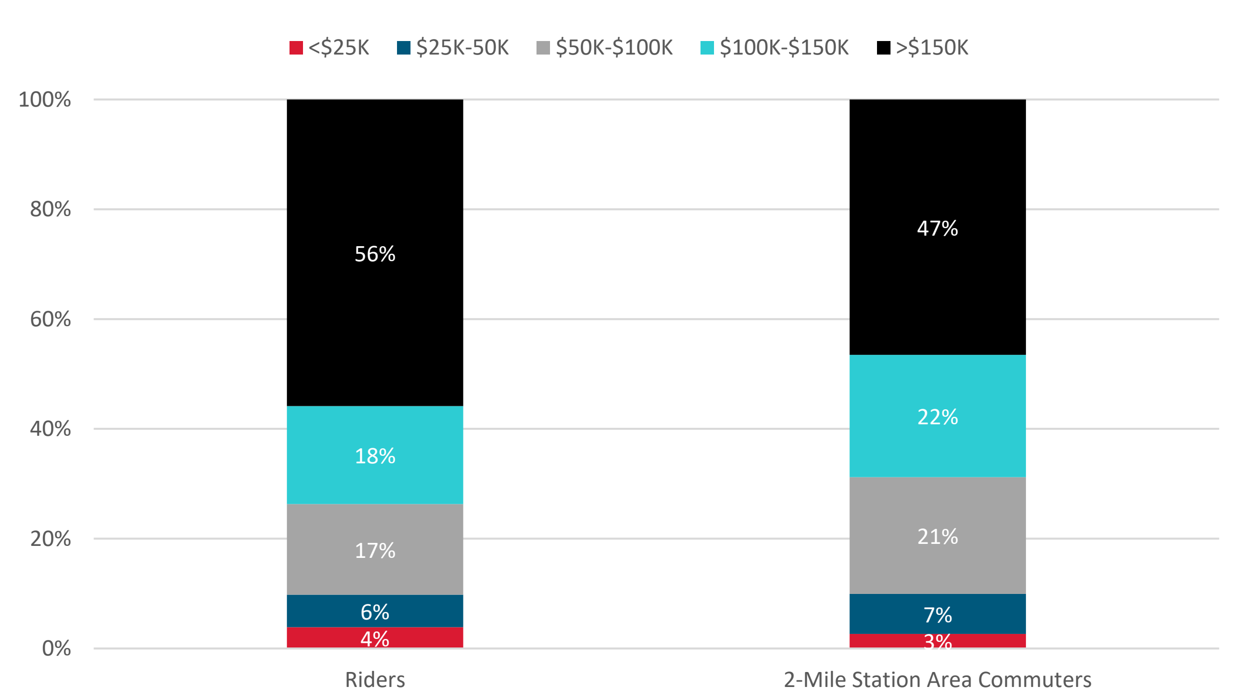
FIGURE 5: MODE SHARE FOR COMMUTE TRIPS WITH AT LEAST ONE END IN THE CALTRAIN CORRIDOR



Caltrain Ridership Does Reflect Local Commute Patterns

The CTPP data indicate that Caltrain ridership closely matches the income distribution of commuters that live and/or work within two miles of a Caltrain station, as indicated in **Figure 6**. The majority of both Caltrain riders and commuters within two miles of Caltrain stations are high income earners, with incomes over $100,000. Middle income residents, with incomes ranging from $50,000 to $100,000, are underrepresented in the Caltrain ridership profile while the ridership is closely representative of the low and very-low income commuter population.

FIGURE 6: CALTRAIN RIDERS AND CORRIDOR COMMUTERS BY INCOME LEVEL



TRAVEL ON PARALLEL TRANSIT CORRIDORS

Several transit agencies operate routes that parallel portions of the Caltrain corridor, including the San Francisco Municipal Transportation Agency (SFMTA), San Mateo County Transit (SamTrans), and Santa Clara Valley Transportation Authority (VTA). To determine whether disadvantaged corridor residents are using these parallel routes more than they are using Caltrain, Fehr & Peers identified parallel transit lines and conducted survey analysis of riders on those lines. Data from the 2018 SamTrans Triennial Survey, the 2017 VTA Rider Survey, and the 2017 SFMTA On-Board Survey were used for this analysis.

Methodology

Fehr & Peers first identified transit routes parallel to the Caltrain corridor that could serve as alternative transit options for corridor residents. The analysis only looked at longer distance or express routes that travel multiple miles on a route parallel to Caltrain. With a few exceptions this analysis tried to exclude routes that are local service only. The routes identified are listed in **Table 2**.

Table 2: Parallel Transit Service

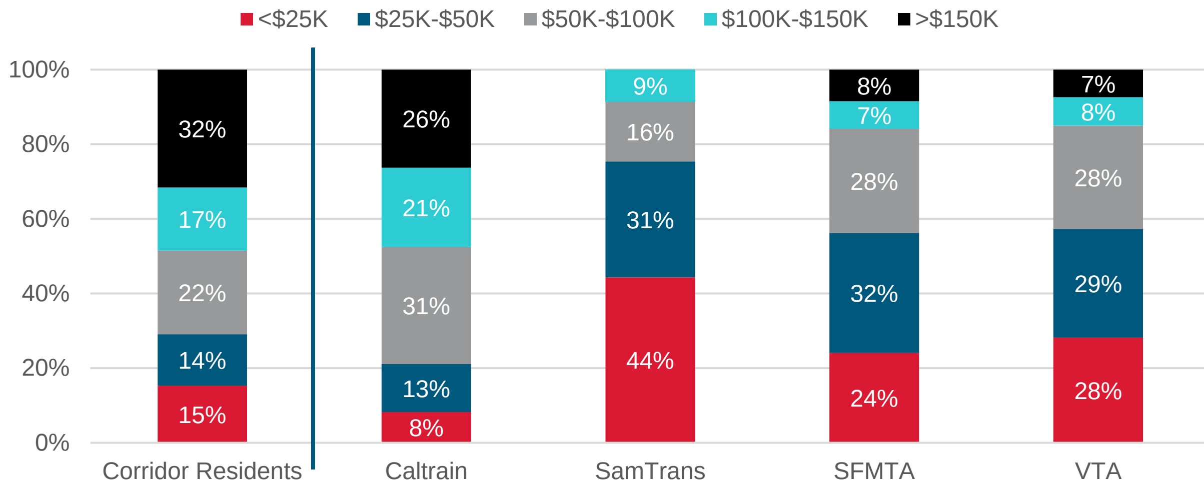
Agency	Routes
SF Muni	8, 8AX, 8BX, 9, 9R, T-Third Light Rail
SamTrans	ECR, ECR Rapid, 292, 398, 397 (OWL)
VTA	22, 66, 68, 102, 103, 121, 122, 168, 182, 185, 304, 522

Riders surveyed on these parallel routes were pulled from each agency's on-board surveys and analyzed to determine their household income and identified race. These demographic breakdowns were then compared to the breakdown of Caltrain riders, which were found through the methodology outlined in Section 3.1.

Parallel Transit Serves Disadvantaged Populations Better than Caltrain

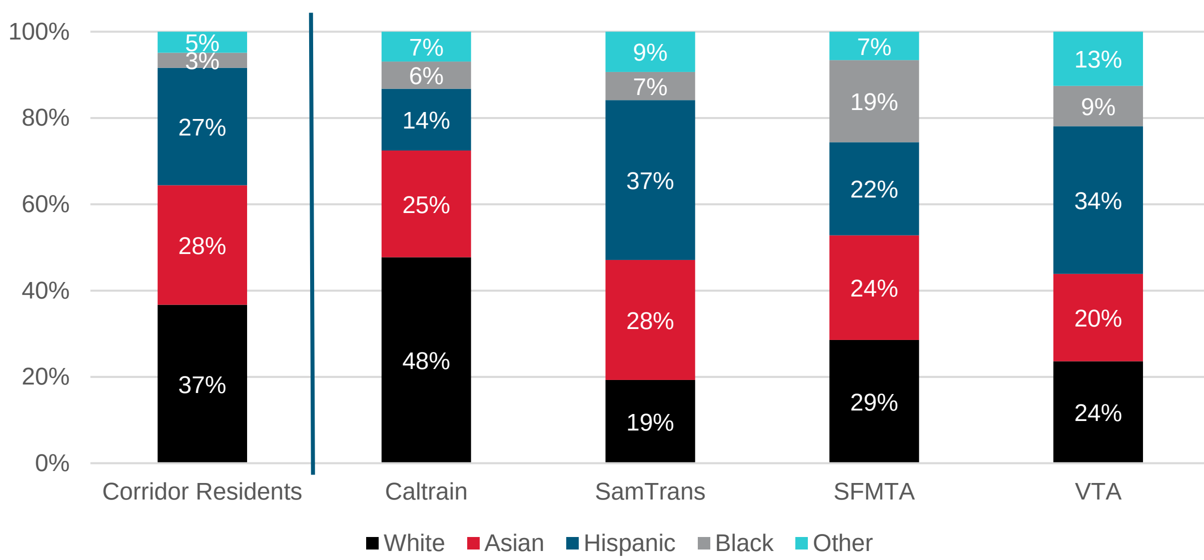
Analysis of parallel transit survey data revealed that proportionally more low-income riders are represented on parallel lines than on Caltrain, as shown in **Figure 7**. Over half of parallel routes riders are in the lowest income household brackets compared to ten percent of Caltrain riders. Almost 75 percent of Caltrain rider households make over $100,000 a year, yet riders in this category make up no more than 16 percent of riders on parallel transit agency lines. When comparing the racial makeup of Caltrain and parallel transit riders, the data in **Figure 8** indicate that Hispanic riders are disproportionately served by parallel transit routes. Over 30 percent of parallel transit riders are Hispanic on average, while only nine percent of Caltrain riders identify as Hispanic. Figure 7 and Figure 8 also reveal that parallel transit services are more than making up for Caltrain's lower low-income and Hispanic customer rates; low income and Hispanic ridership is proportionally higher than the rate at which these populations live in the adjacent corridor. This indicates that while Caltrain is not currently the mode of choice for these riders, transit is a hugely important transportation option for low income and Hispanic corridor residents. Parallel transit trips are typically less costly than Caltrain but take longer—sometimes two to three times longer. These are some of the tradeoffs discussed in the next section.

FIGURE 7: CORRIDOR RESIDENTS, CALTRAIN RIDERS, AND PARALLEL TRANSIT RIDERS BY INCOME LEVEL



Notes: $100K and above is the highest income level used in SamTrans' on-board survey.

FIGURE 8: CORRIDOR RESIDENTS, CALTRAIN RIDERS, AND PARALLEL TRANSIT RIDERS BY RACE



3.3 WHAT CALTRAIN-SPECIFIC FACTORS AFFECT RIDERSHIP DIVERSITY?

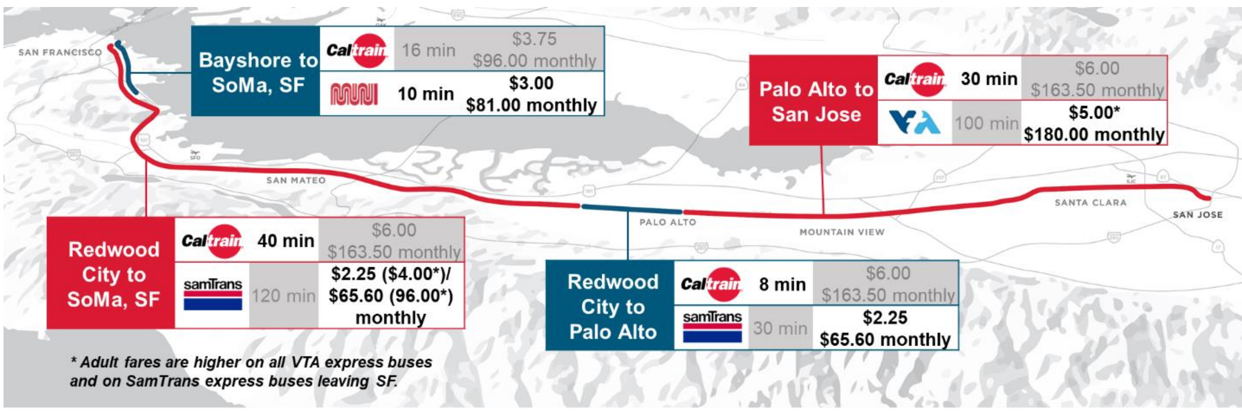
Fehr & Peers completed a comparative assessment of Caltrain and other regional transit services to understand the differences in fare structure, service plans, and access, and how these differences may impact ridership diversity. This assessment consisted of agency research, ridership analysis, and Caltrain mode of access analysis through the 2019 Caltrain Triennial Survey. The findings were compiled with the input received from community stakeholders to build a clearer picture of the transportation tradeoffs facing low-income communities and people of color.

FACTORS AFFECTING CALTRAIN RIDERSHIP DIVERISTY

Fare Structure

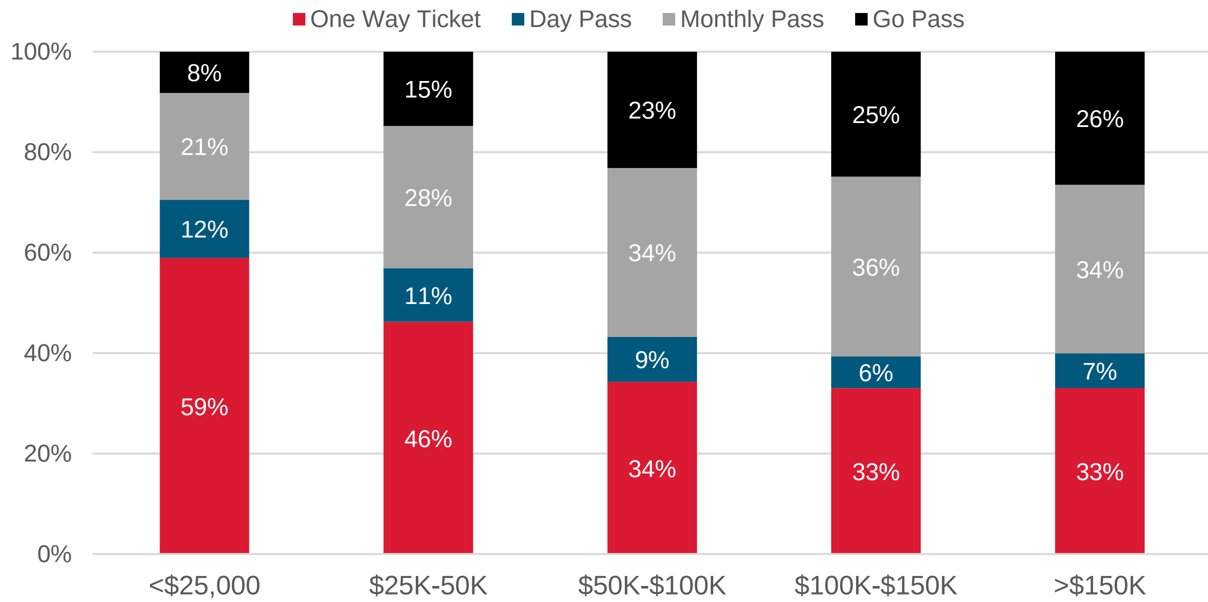
While Caltrain service is typically faster than parallel transit routes, Caltrain fares are often higher, as seen in **Figure 9**. The cost of riding Caltrain was one factor shared by community stakeholder to be a barrier to entry for low-income riders. With Caltrain's zoned-based fare structure, costs increase with distance travelled, but not always proportionally. Caltrain's fare system has evolved over time to meet historic needs on the corridor but zone-based fares may not be the ideal fare structure moving forward. Additional research is needed to understand the ridership, station access, and equity implications of sticking with the zone-based structure over switching to a distance-based, time-of-day, flat-fare, or other structure. Express bus service along parallel routes use flat rates.

FIGURE 9: TRAVEL TIME & COSTS ON PARALLEL TRANSIT VS. CALTRAIN



Caltrain offers several ticket types, including variations on the one-way ticket, day pass, and monthly pass. According to Caltrain's 2019 Triennial Study, the most common overall fare types were the Monthly Pass purchased on Clipper Cards (33 percent) followed by GoPasses (24 percent) and one-time Clipper Cash payments (23 percent). The Monthly Pass and GoPass fare options are the most heavily discounted fare products available for Caltrain riders. In October 2016, the average Go Pass customer paid $2.89 per trip, while the average non-Go Pass customer paid $5.96. While low-income riders stand to benefit most from these discounted passes, low-income riders are the least likely to use a Caltrain Go Pass or Monthly Pass, as shown in **Figure 10**.

FIGURE 10: FARE PAYMENT OPTION BY INCOME LEVEL



Muni is the only transit provider in the corridor offering a discount for low-income riders at the time of this analysis. Given underlying funding constraints, Caltrain must maintain a high farebox recovery ratio compared to most other transit providers along the corridor, as shown in **Table 3**. However, Caltrain is slated to test a means-based fare program starting in 2020. In May 2018, MTC adopted Clipper START, a 12- to 18-month pilot program to offer a 20 to 50 percent fare discount to eligible low-income adults traveling with participating transit agencies. Caltrain will be participating with a 20 percent discount to eligible riders. To qualify, individuals must earn no more than 200 percent of the federal poverty level and use Clipper for fare payment.

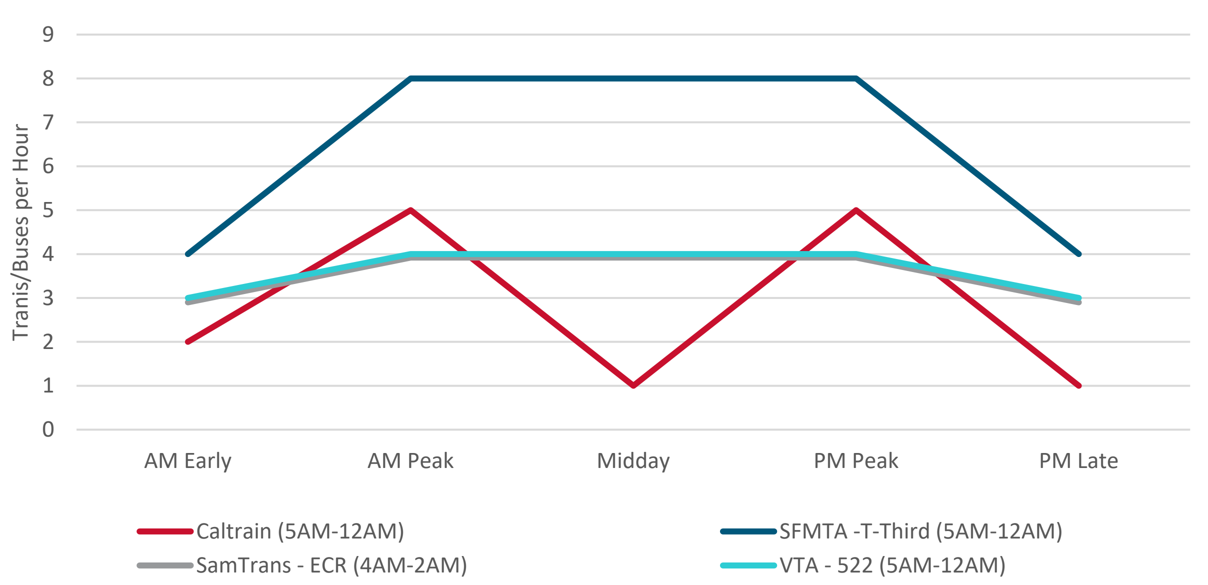
Table 3: Fare Structure of Parallel Transit and Caltrain

Transit Agency	Discount Programs				Approximate Farebox Recovery
	Youth	Senior	Disabled	Low-Income	
Caltrain	✓	✓	✓	20% discount starting 2020	70%
BART	✓	✓	✓		70%
SFMTA	✓	✓	✓	50% discount	25%
SamTrans	✓	✓	✓	X	15%
VTA	✓	✓	✓	X	11%

Service Plan / Schedule

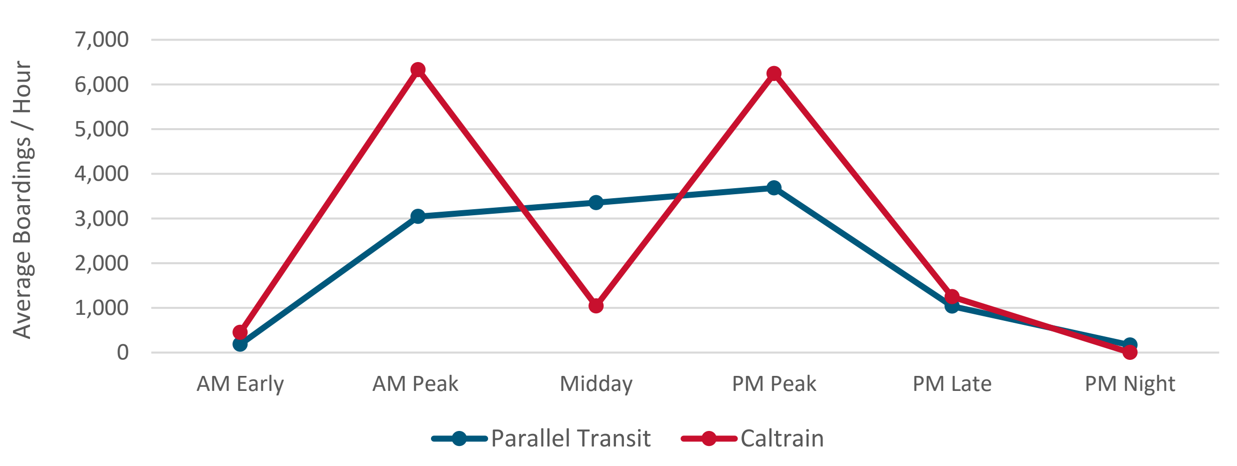
Because low-income workers are more likely to work during off-peak hours (weekends, early morning, and late evening), Caltrain's lack of service during these periods presents a barrier to low-income riders. Parallel transit service, on the other hand, runs consistent headways through the peak and midday hours, as seen in **Figure 11**. Fehr & Peers performed a parallel transit ridership analysis to understand how ridership by time of day on the parallel routes identified in section 3.2 compares to Caltrain ridership by time of day. Ridership, calculated as total boardings, is summed for all the parallel routes by time of day and compared to Caltrain's total boardings in each period of the day. **Figure 12** demonstrates that parallel transit routes maintain service level ridership counts through the midday period indicating that there is demand for midday long-haul transit service.

FIGURE 11: SERVICE FREQUENCIES ON PARALLEL TRANSIT BY AGENCY



Source: SFMTA LRV (Spring 2016), SFMTA Bus (Fall 2019), SamTrans (Fall 2018), VTA (Fall 2019), Caltrain (2018). Notes: a representative route was selected from each of the parallel agencies to illustrate service frequency. Caltrain frequency accounts for the combined effect of local, limited, and baby bullet service.

FIGURE 12: DAILY RIDERSHIP ON PARALLEL TRANSIT VS. CALTRAIN



Source: SFMTA LRV (Spring 2016), SFMTA Bus (Fall 2019), SamTrans (Fall 2018), VTA (Fall 2019), Caltrain (2018)

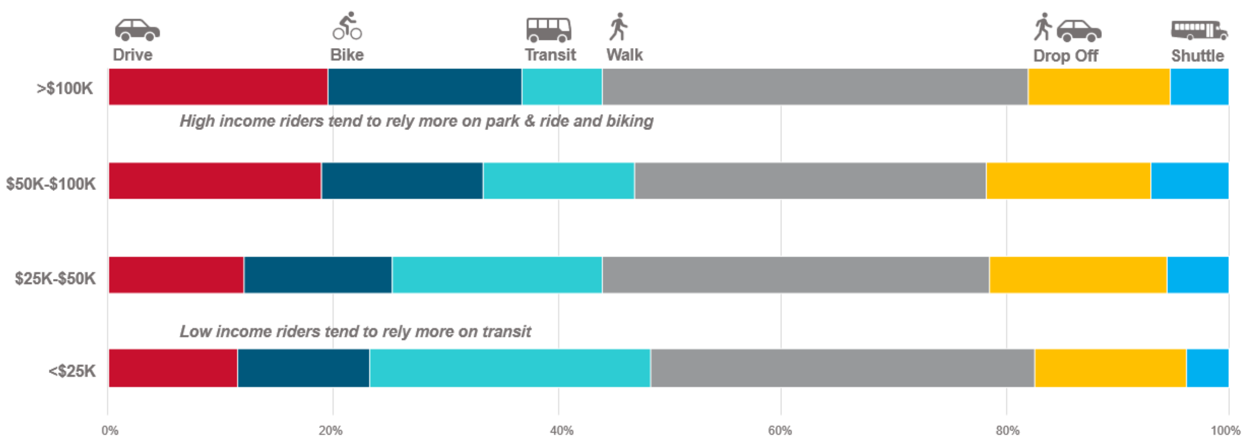
As explored above, parallel transit corridors proportionally serve more low-income riders and people of color (particularly Black and Hispanic riders) than Caltrain currently does today (shown in **Figure 7** and **Notes:** *$100K and above is the highest income level used in SamTrans' on-board survey.*

Figure 8**)**. Although many factors are at play when choosing a mode of travel on the peninsula, schedule is likely one of the strongest drivers. Given the ridership and demographic trends explored in this analysis, Caltrain may be able to serve more non-work trips with implementation of off-peak service increases, and by doing so, may serve more low-income riders and people of color.

Station Access

Low-income riders tend to rely more on transit to connect to Caltrain (25 percent) than any other income group, as seen in **Figure 13**. Today, Caltrain's highly customized schedule prevents regular coordinated transfers (~5 minutes) with bus and rail services at most stations. This puts low-income riders at a disadvantage when trying to access stations as compared to higher income riders who are more likely to use Caltrain's heavily subsidized parking lots and bike storage. Furthermore, Caltrain does not offer a fare discount for transfers *from* another mode of transit. For transfers *to* Muni, SamTrans, VTA, and Dumbarton Express, free or discounted fares are only available to Caltrain Monthly Pass holders. And as was revealed above, low-income riders are least likely of all income groups to purchase a Monthly Pass.

FIGURE 13: HOW PEOPLE GET TO AND FROM CALTRAIN STATIONS BY INCOME LEVEL



The results of the analysis described in this chapter reveal that Caltrain's existing service has room for growth in attracting a more racially and economically diverse set of riders. While this chapter provides an equity assessment on existing service, the following chapter looks ahead to how the proposed service vision would perform based on an equity evaluation framework.

4. SERVICE VISION EVALUATION

4.1 EQUITY EVALUATION FRAMEWORK

The Joint Powers Board adopted the 2040 Service Vision in October 2019, which calls for more trains per hour, a local/express stopping pattern, clock-face schedules, and timed transfers. Fehr & Peers utilized an equity evaluation framework to assess the impacts that this Service Vision could have on ridership accessibility and communities along the corridor. The evaluation framework seeks to answer four key questions outlined in **Table 4**. The measure themes in **bold** are the focus for this evaluation as these are elements that will be altered through the Service Vision. Unbolded measure themes are central to equity but are not elements that would inherently be altered or changed as a result of the Service Vision.

Table 4: Evaluation Framework

Key Questions	Measure Themes
How does Caltrain provide service?	Infrastructure Quality
	Fare Structure+
	Transit Service (Service Planning)+
	Network Completeness
Who benefits or is burdened from those services?	Station Access
	Affordability*
	Safety
	User Perceptions
	Distribution of Construction/Supportive Infrastructure
How does Caltrain impact surrounding land use?	**Displacement Risk***
	Equitable TOD
	Environmental Impacts*
	Accessibility of Destinations*
How are decisions made?	Stakeholder Representation
	Distribution of Funding
	Quality of Engagement

*Themes in **bold** are focus themes for the Caltrain Service Vision Equity Evaluation.*
**MTC Equity Focus Areas; +Title VI Equity Focus Area*

4.2 KEY MEASURE THEMES

TRANSIT SERVICE

Three components of transit service were analyzed: peak period service frequency, hours of operation, and travel time. The following sections describe the equity implications of Service Vision changes in these areas as well as further considerations and options for Caltrain.

Peak Period Service Frequency

Increasing service frequency is a primary goal of the Service Vision. Along with a clock-face schedule, this results in "show-up-and-go" transit service, allowing passengers to use the system without needing to reference the schedule. Not only does this reduce wait times, but it also makes the system easier to use. Stations within a CoC will experience 91 percent higher peak period service compared to today; similarly, service frequency at stations in non-CoC areas will increase by 105 percent. As service frequency increases are spread throughout the corridor, this Service Vision outcome results in an equal impact to all Caltrain riders, neither improving nor deteriorating equitable access outcomes.

Offering better service along the corridor may lead to higher property value premiums that can contribute to higher housing costs near stations. Conversely, more frequent service and predictable timed transfers are critical improvements for the 20 to 25 percent of lower income riders who access Caltrain using a connecting transit service.

Hours of Operation

Caltrain currently provides the greatest service frequency during peak periods and intends to increase off-peak service by about 200 percent according to the Service Vision. Lower-income residents would benefit most from an expansion of off-peak Caltrain service; these communities travel proportionally more during off-peak hours and make more non-commute trips than higher income communities. Off-peak service can better capture trips made by students, older adults, and people working multiple jobs or non-traditional work schedules.

Off-peak service is most accessible to lower-income populations if transit transfers are coordinated; the Service Vision's intention of shifting to a standardized schedule is critical for providing timed transfers. These changes in schedule and off-peak service transition Caltrain from a commuter railroad to an all-day transit service. In order to capture the attention of potential off-peak customers, the rollout of new off-peak service must be preceded by a comprehensive and community-assisted outreach campaign.

Travel Time

The Service Vision's skip-stop schedule spreads travel time savings throughout the system, benefiting all groups equally. On average, riders will experience an approximately 15 percent decrease in onboard travel time, completing their trips more quickly. Wait times will also be shorter due to timed transfers and more standardized schedules improving connectivity between Caltrain and other transit providers.

SAFETY

Safety improvements will primarily accrue in communities that complete grade separations and reduce the number of conflict points between trains and crossing vehicles, pedestrians, and bicyclists. The Service Vision plans for $9.4 billion in grade separation projects but does not select grade separation locations or define an order in which separations should be completed.

If a framework is developed to prioritize grade separation projects and locations, Caltrain should ensure it includes neighborhood demographic information as a factor in the scoring system. At-grade crossings in CoCs that also experience high traffic volumes and high collision rates should be prioritized for grade separation projects.

DISTRIBUTION OF CONSTRUCTION/SUPPORTIVE INFRASTRUCTURE

In addition to grade separation projects, the Service Vision requires construction of passing tracks, new maintenance facilities, and other pieces of supportive infrastructure. A preliminary, conceptual distribution of this infrastructure was developed for Business Planning purposes, but final locations, project design, and site-specific impacts remain to be decided. The duration, scale, and type of construction required for each piece of supportive infrastructure imposes a burden on the surrounding community. It will be important to distribute the burden in a thoughtful way and to ensure that the least amount of harm is imposed on communities that already have a limited safety net.

Lower income business districts and employees have the potential to be dramatically impacted by lengthy construction efforts, more so than affluent business districts or office environments. It will be important to develop safety nets and implement thoughtful outreach processes to mitigate the disruptions to lower income residents and CoCs caused by construction of supportive infrastructure.

DISPLACEMENT RISK

Additional train service under the Service Vision will make Caltrain an even better tool for helping to manage development and mitigate traffic impacts; however, it may also bring increased development pressure and increases in land value around stations that may or may not be in line with local policy goals to preserve housing affordability. The increase to land value within one mile of a station due to the Service Vision is estimated at $37 billion in total across the corridor. This is an overall increase of approximately 4.5 percent. Increases in property values can create opportunity for depressed communities, but small and local business and cultural spaces can also be pushed out by this change, and housing can become even more expensive.

Land value increases and displacement pressures are likely to be most pressing at stations that experience large increases in service levels under the Service Vision. Caltrain does not own much developable land itself and, therefore, should focus on supporting jurisdiction-specific affordability policies in coordination with its own TOD Policy development to limit displacement risk.

ENVIRONMENTAL IMPACTS

Both greenhouse gas emissions and noise levels impact communities living along the Caltrain corridor. The Service Vision adds the equivalent capacity of 5.5 new freeway lanes and in doing so results in 825,000 fewer miles driven and 110 fewer metric tons of CO_2 emissions each day. The emissions reductions are spread throughout the system but have the greatest impact on those living closest to the US-101 corridor. Similarly, the Service Vision will result in overall reduced noise levels due to quieter electric trains, more grade separations requiring less frequent use of the horn, and more quad gate quiet zones. However, there will be more trains per hour and so more frequent noise. The noise reductions are spread throughout the system but benefit most dramatically those living closest to the Caltrain corridor.

ACCESSIBILITY OF DESTINATIONS

Low income riders tend to rely on transit connections to access Caltrain stations more than middle- or high-income riders do; therefore, coordinated transfers benefit low-income communities most. Reliably timed transfers with BART, Muni, SamTrans, and VTA can be achieved through increasing Caltrain service frequency and adhering to a standardized, clock-face schedule. Future connections such as AC Transit at the Salesforce Transit Center or the proposed Dumbarton Rail link further improve access to Caltrain. Improving Caltrain's accessibility by following a clock-face schedule with timed transfers is an equitable outcome of the Service Vision.

Caltrain's accessibility could be made more equitable by considering two additional improvements currently not addressed in the Service Vision. First, Caltrain could participate in a coordinated, integrated fare system and offer transfer fare discounts. As described previously, Caltrain does not offer discounts to riders transferring from another transit system, while many parallel operators such as Muni, SamTrans, and VTA do offer discounts for riders transferring from Caltrain. Accessibility could also be made more equitable by prioritizing bus or shuttle first/last mile connections for CoCs along the corridor. Not all corridor communities currently have direct access to a Caltrain station. Providing greater connecting services would help bridge the first/last mile gap.

5. NEXT STEPS

5.1 RECOMMENDATIONS

As a recipient of Federal Funding, Caltrain must conduct periodic Title VI compliance assessments to ensure that the level and quality of transit services is provided in a nondiscriminatory manner, that full and fair participation in public transportation decision-making occurs without regard to race, color, or national origin, and to ensure meaningful access to transit-related programs and activities by persons with limited English proficiency. The JPB is required to submit a Title VI Program every three years and to document that services and benefits are provided in a non-discriminatory manner. Caltrain completed its most recent Title VI Compliance Report in 2019 and will continue this practice which includes the following elements:

- List of Investigations, Complaints, or Lawsuits
- Public Participation Plan
- Limited English Proficiency (LEP) Language Assistance Plan
- Record of Ethnicity of Members of Non-elected Committees
- Service Standards and Policies – Monitoring Program Results
- Summary of Public Engagement for Policy Development
- Title VI Equity Analyses

The equity assessment aims to expand the scope of Caltrain's equity efforts beyond Title VI compliance. The following planning and policy recommendations would further improve equitable outcomes beyond implementation of the Service Vision. In order to actively promote equity as part of the Service Vision implementation, Caltrain should consider and further evaluate the following recommendations as various future policy initiatives, services and projects are advanced.

Table 5: Service Vision Equity Considerations and Recommendations

Topic Areas	Identified Issue	Equity Recommendation
Schedule	Low-income corridor residents are more likely to need to travel during off-peak hours	Before implementing any new service changes, consider increasing early-morning, midday, and late-night service.
Schedule	Capacity constraints will limit the number of people who can ride and will limit Caltrain's ability to implement a means-based fare program while also maximizing farebox recovery	Before implementing any new service changes, consider stopping patterns and service types that prioritize load spreading. Employ capacity management techniques and look for incremental capacity increases.
System Interface	Some riders – particularly women and older adults – feel uncomfortable at Caltrain stations	As part of all station redesign efforts, implement the following safety and accessibility measures to accommodate increased ridership: • Pedestrian-scale lighting • Expanded shelter from the elements • Level boarding • Station platform seating • ADA accessibility to both platforms
System Interface	Some riders – particularly limited-English-proficiency and newer customers – have difficulty interpreting signs and schedules	Use intuitive iconography, multiple languages, and auditory messages in designing station wayfinding and develop: • Area-based maps at stations that show services from all connecting transit agencies • Clear and real-time information on transit transfer arrivals and departures • Increased wayfinding presence at all stations and on blocks surrounding stations

Table 5: Service Vision Equity Considerations and Recommendations

Topic Areas	Identified Issue	Equity Recommendation
System Interface	The fare structure and schedule are difficult to understand	As a near-term priority, develop a trip planner tool (similar to the BART example) that makes trip costs, train schedules, and travel times more transparent. Incorporate the ability to compare cost options across days, weeks, and months.
System Interface	Many stakeholders expressed confusion with how the Caltrain schedule and system work. The system is perceived as only for white-collar commuters and as being uninviting for other populations	Conduct outreach with vulnerable populations such as low-income populations, seniors, youth, ESL populations, and people with disabilities. Outreach efforts should "meet people where they are" rather than require travel. Outreach opportunities include: • "How to Ride" workshops with captive audiences at ESL classes, high school and community college classes, senior center activities, and community events • Media campaigns tailored to and directed at vulnerable populations such as low-income, ESL, youth, and senior populations to advertise Caltrain service and connect with potential riders Caltrain outreach teams should, whenever possible, partner with community-based organizations to understand the messages and Caltrain services that will most resonate with particular user groups and populations
Access	Low-income corridor residents are more likely to access stations using a transit transfer	Monitor transfer times with BART, SamTrans, and VTA and work towards reducing the number of bus connections that result in long waits or insufficient (<5 minutes) transfer times • In the near term, prioritize timed transfers for routes that serve Communities of Concern
Access	Low income residents are less likely to drive or bike to access a Caltrain station. This limits access for neighborhoods more than a mile away when transit or shuttle connections do not already exist	As funding is available, support multimodal connections to Communities of Concern between one and three miles from a station that do not have direct access to a station • In the near term, prioritize first/last mile shuttle funding or public transit enhancement in Communities of Concern with longstanding requests for better transit access
Cost & Fare Structure	The fare structure currently results in low-income riders paying the highest average cost per ride	Work towards a fare structure where low-income riders are paying the lowest cost per ride • Evaluate the results of Clipper START pilot to inform and implement a permanent means-based fare program • Consider revising the payment plans for discount passes so that the full amount can be paid out over the course of the plan period • Continue to seek a diverse set of funding sources to offset the need for high farebox returns
Access / Cost & Fare Structure	Low-income corridor residents are more likely to access stations using a transit transfer	Offer transfer discounts with partner transit agencies, including Clipper, BART, SFMTA, SamTrans, and VTA, and work together to develop an integrated fare system
		Revisit the zone fare structure to incentivize the use of connecting bus service
Community Interface	Safety concerns are largely tied to at-grade crossings.	Develop a grade-separation prioritization framework that includes neighborhood demographic information as a factor in the scoring system In the near-term, separate crossings in Communities of Concern that also experience high traffic volumes and high collision rates

Table 5: Service Vision Equity Considerations and Recommendations

Topic Areas	Identified Issue	Equity Recommendation
Community Interface	Lengthy construction projects are, at best, disruptive to local communities, and at worst, destructive for small businesses and property owners.	Develop financial safety nets, minimize impacts to vulnerable properties, and implement thoughtful outreach processes to mitigate the disruptions to lower income residents and small business owners caused by construction of supportive infrastructure
Community Interface	Increased Caltrain service may increase property value premiums and displacement risk around stations	Provide corridor-wide guidance and support for communities developing affordable housing and anti-displacement policies for station-area developments. • Focus near-term efforts on stations that will experience the largest service increases with electrification and incremental service improvements in the early 2020s
Community Interface	Equity is addressed on an ad-hoc basis in Caltrain's current public participation and decision-making structure	Establish Equity as a focus area for the Citizens Advisory Committee. The CAC should have a standing agenda item for equity-related topics at every meeting and should evaluate the equity impacts of all proposed service, planning, or organizational changes

Station Access, Amenities, and Circulation Memo

Prepared for:

Caltrain

May 2020

OK18-0254.00

Prepared by:

Fehr & Peers

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1. INTRODUCTION

This memo describes station access planning for the Caltrain Business Plan including existing access patterns and facilities, scenario planning for the 2040 Service Vision, and station access priorities to accommodate ridership growth.

CONTEXT

The Service Vision plans for ridership to triple over the next two decades, which also means tripling the riders accessing Caltrain stations. Caltrain must decide how to invest in first- and last- mile programs and prioritize the use of resources to improve access and connectivity to the system. This assessment considers how station access needs may change over time, and potential paths forward to realizing the service vision.

FINDINGS

Although Caltrain riders access stations by a variety of means, Caltrain's existing station facilities do not serve all modes of access effectively. As ridership grows over time, Caltrain will need to expand its ability to get riders to and from its stations. Based on modeling efforts completed using Caltrain's Station Management Toolbox, improvements in active transportation, passenger loading, and transit connections present the greatest upside to capture future ridership demand. Such programmatic and infrastructure improvements would require Caltrain to expand its organizational management of station access planning and implementation systemwide.

APPLICATIONS IN THE BUSINESS PLAN

Station access facilities and programs affect capital costs, operating costs, and revenues for Caltrain, as well as organizational needs.

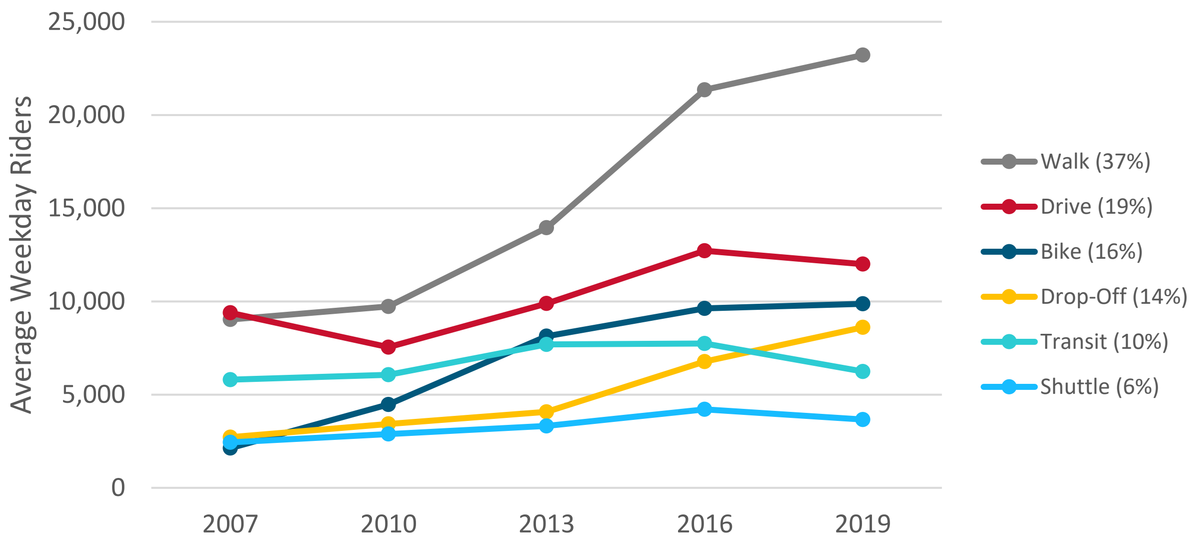
WHAT'S IN THIS MEMO

- Section 2 describes how people presently access Caltrain stations
- Section 3 provides an overview of Caltrain's station access programs
- Section 4 covers circulation and amenities at Caltrain stations
- Section 5 analyzes future demand for station access facilities
- Section 6 evaluates station access scenarios to serve future demand
- Section 7 provides recommendations on station access priorities

2. HOW PEOPLE ACCESS CALTRAIN STATIONS

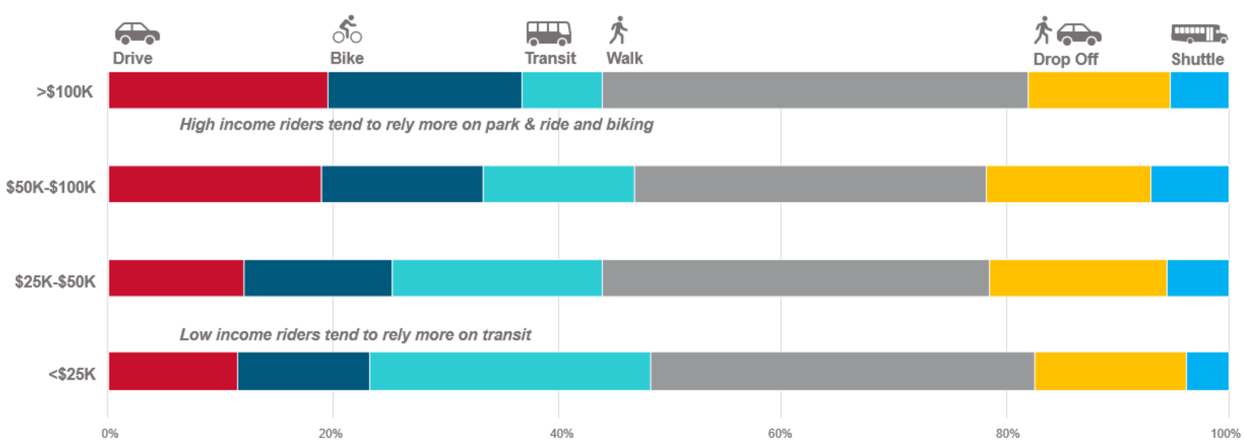
Caltrain riders travel to and from stations by a variety of means. As shown in Figure 1 below, more people walk to Caltrain than any other mode, while park-and-ride, bicycling, and auto pickup/drop off, bus or rail services and shuttle services account for the remainder of trips to and from stations. Despite the perception that Caltrain is primarily a park-and-ride system, park-and-ride trips represent a relatively small fraction of trips at most stations except for those south of Diridon Station. The proportion of rides arriving via park-and-ride and transit has decreased over time while the proportion of walking, bicycling, and getting dropped-off has increased. Caltrain riders' rate of bicycle use is also high compared to peer railroads and is especially high at stations like 4th & King, Palo Alto, Mountain View, Diridon, and Menlo Park. Access facilities for all modes are often cramped, particularly at high ridership stations where vehicle and bicycle parking, passenger loading areas, and bus or shuttle bays are in high demand.

FIGURE 1: HOW PEOPLE GET TO AND FROM CALTRAIN STATIONS, BY YEAR



Caltrain station access differs by income level. As shown in the figure below, high income riders tend to rely more on park-and-ride and biking while low-income riders tend to relay more on transit. Today, Caltrain's highly customized schedule prevents regular coordinated transfers with bus and rail services at most stations. This puts low-income riders at a disadvantage when trying to access stations as compared to higher income riders who are more likely to use Caltrain's heavily subsidized parking lots and bike storage. Furthermore, Caltrain does not offer a fare discount for transfers *from* another mode of transit. For transfers *to* Muni, SamTrans, VTA, and Dumbarton Express, free or discounted fares are only available to Caltrain Monthly Pass holders, who are less likely to be low income riders. The relationship between station access and equity is discussed in greater detail in the following sections.

FIGURE 2: HOW PEOPLE GET TO AND FROM CALTRAIN STATIONS BY INCOME LEVEL



3. CALTRAIN'S STATION ACCESS PROGRAMS & FACILTIES

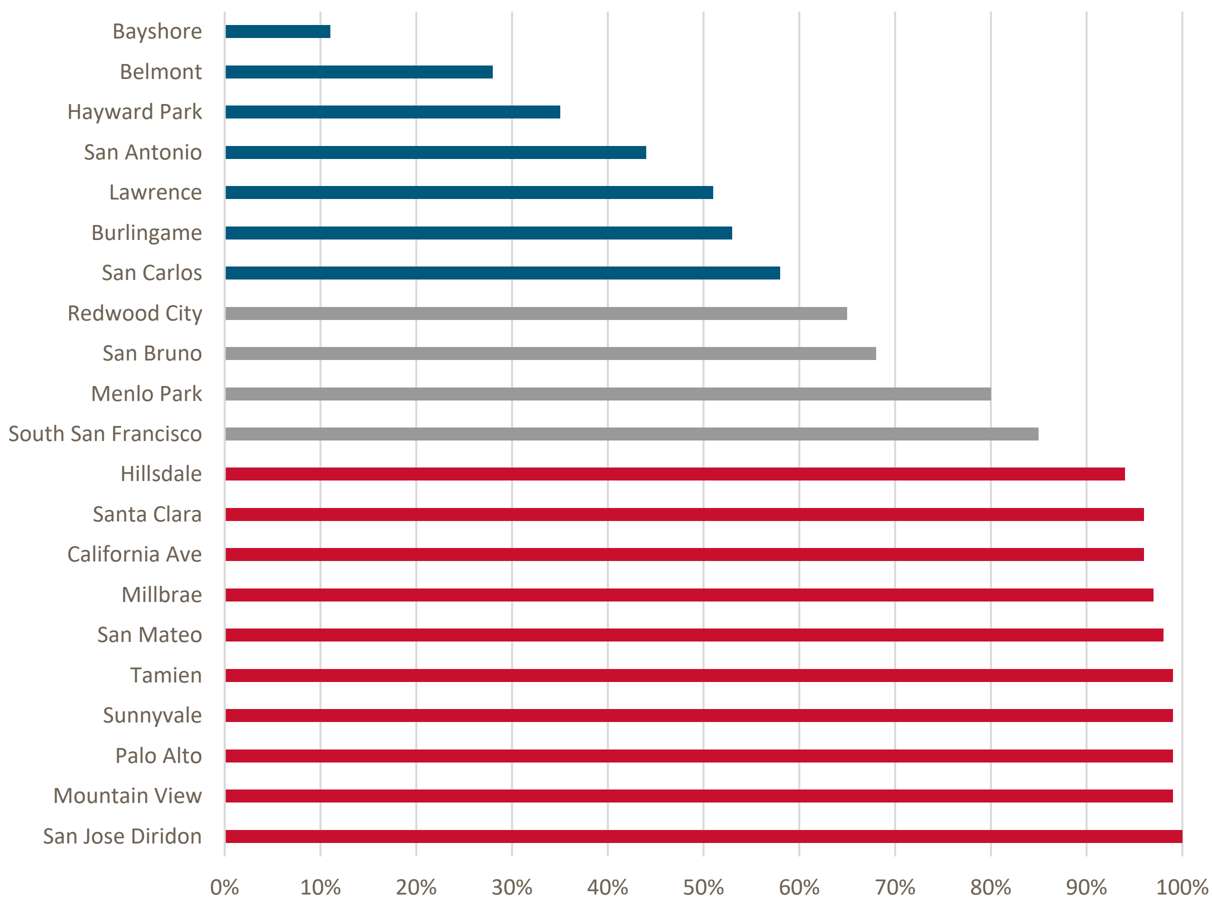
Today Caltrain plays a limited and uneven institutional role in providing and coordinating access to the system. While it plays some roles around vehicle parking, bicycle parking, and shuttle operations, the agency largely defers station access policy decisions to its funding partners (MUNI, SamTrans and VTA), cities, and at times employers and institutions. This section reviews Caltrain's current programs, facilities, and roles as it relates to station access.

3.1 PARK AND RIDE

Caltrain manages 5,400 parking spaces located at all stations with regular weekday service between Bayshore and Diridon, charging a flat rate of $5.50 per day or $82.50 per month. No Caltrain-specific parking is provided at 4th & King or 22nd Street, although some on-street and garage parking is available near each station. South of Diridon, VTA manages approximately 2,200 free parking spaces.

While Caltrain charges a flat parking fee across the system, occupancy at individual stations varies widely. Of the 21 stations with regular weekday service, ten experience typical occupancies of 90 to 100 percent, while seven experience occupancies of under 60 percent (the systemwide average is about 80 percent). Parking demand tends to correlate with service frequency. Relative to prices at nearby public and private lots, Caltrain charges parking fees that are 30 to 80 percent lower. For example, daily parking fees at nearby lots in Menlo Park are $10 per day, and $25 per day in Palo Alto. Although parking revenues account for about $5.6M of annual revenues, they could be higher overall if Caltrain charged market rates.

FIGURE 3: PARKING OCCUPANCY BY STATION (RED = OVERSUBSCRIBED; BLUE = UNDERSUBSCRIBED)



By charging a flat rate, Caltrain presently underprices parking at high-demand stations and overprices parking at low-demand stations. The result is affordable station parking overall, with uneven use of parking resources and some frustrating rider experiences. Moreover, as illustrated in the previous section, the benefits of this underpriced parking tend to accrue to high-income riders who are more likely to park at stations.

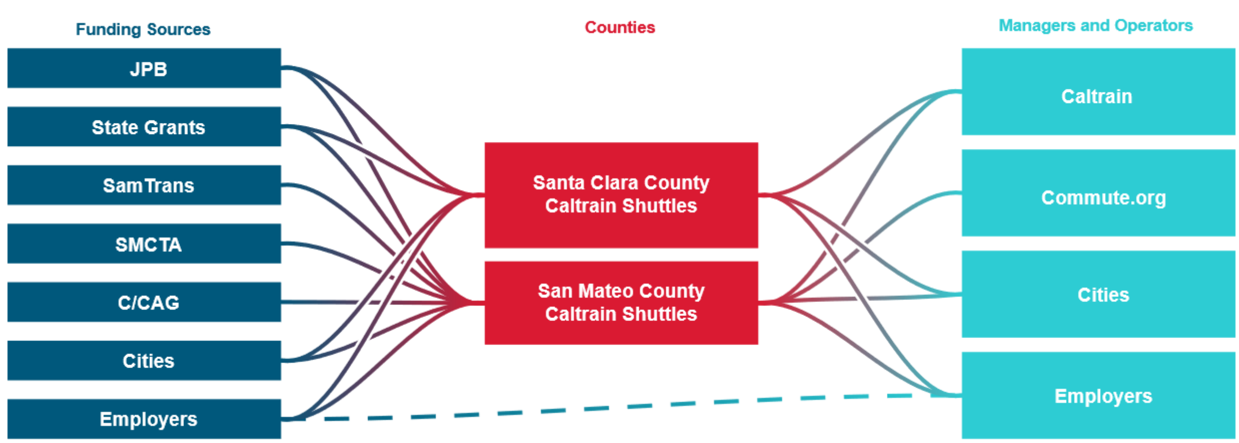
3.2 FIRST/LAST MILE SHUTTLES

Caltrain's shuttle access program emerged out of the difficulty in coordinating Caltrain's highly customized schedule with standardized clockface schedules operated by VTA and SamTrans, as well as the mismatched land use environment of large employers located in lower density office parks. Consequently, shuttles offer free, timed connections to Caltrain, whereas buses usually do not have coordinated schedules or a comparable level of fare integration.

A shuttle at the Millbrae BART/Caltrain station

Caltrain is involved in funding and managing a complex first/last mile shuttle program in San Mateo and Santa Clara counties in partnership with SamTrans and the San Mateo County Transportation Authority. Caltrain funds about $500,000 of the program's $4.2 million annual cost, with the remainder being split between employer contributions and the San Mateo County Transportation Authority (with some state grants and other local funds also factoring in). Of the roughly 30 public shuttles in this jointly run program serving Caltrain stations, Caltrain oversees grant reporting and administration for 20 shuttles and directly manages the operation of seven shuttles. Other shuttles are directly managed by employers, Commute.org, cities, and other entities, while employers like Genentech operate their own services independent of the program.

FIGURE 4: SHUTTLE FUNDING STRUCTURE

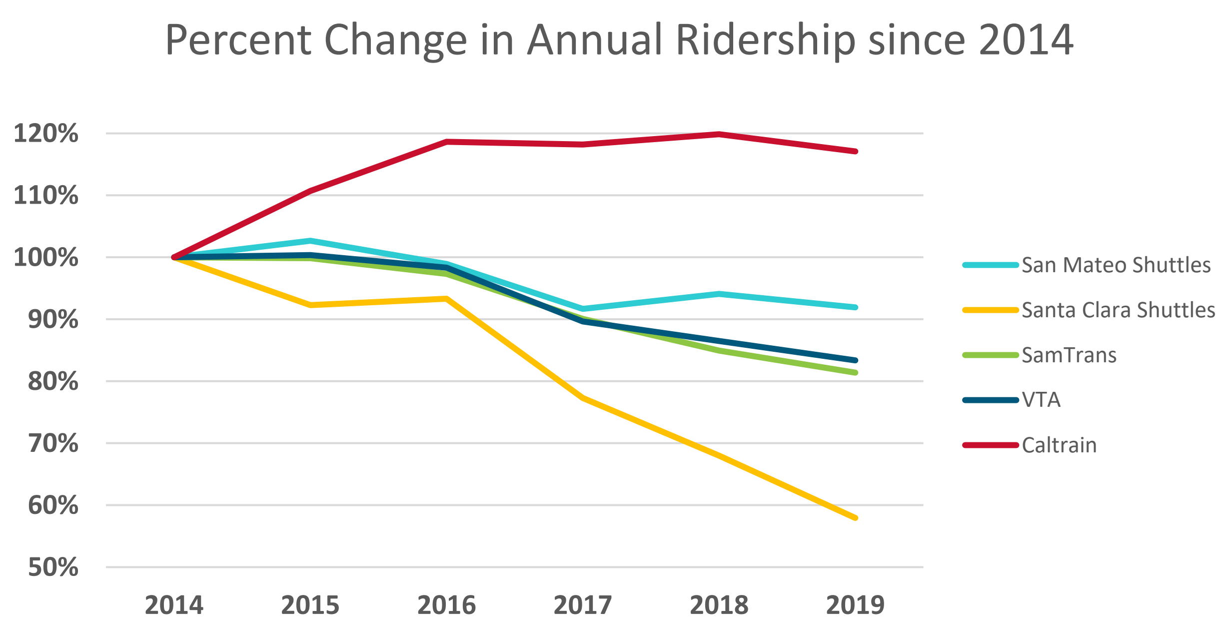


Caltrain's shuttle connections tend to be oriented toward maximizing first/last mile access as opposed to maximizing productivity. Over the past several years, the shuttle program has seen about a 20 percent decline in ridership even as

Caltrain ridership grew by nearly 20 percent as shown in Figure 5. Three quarters of shuttle routes serving Caltrain saw a ridership decline during this period, especially routes in Santa Clara County where 80 percent of Caltrain's discretionary shuttle funding is expended. Several issues contribute to this decline in performance, including declining reliability associated with driver shortages, long travel times due to circuitous routes, and competition from private shuttle services independent of the program. However, there are some notable success stories within the program: for example, Stanford University's Marguerite shuttle has continued to see ridership gains fueled by its TDM program and high service levels.

Shuttle program ridership tends to mirror Caltrain ridership as a whole, mostly serving riders who work in the technology and biotechnology industries and earn moderate to higher incomes. Fewer low income riders ride shuttles, in part because most shuttle routes are oriented toward bringing riders to employers rather than bringing residents to Caltrain. Nonetheless, the subsidized free fares associated with most shuttle routes tend to accrue to moderate- and higher-income riders.

FIGURE 5: CHANGE IN RIDERSHIP, 2014-2019 – CALTRAIN VS. CALTRAIN SHUTTLE PROGRAM



Due to the organizational complexities of the shuttle program, Caltrain's level of influence over shuttle planning varies widely by route. In parallel to the Business Plan, Caltrain is working with partner agencies to overhaul the shuttle program to help scale service levels and ridership in tandem with the Service Vision.

3.3 BUS AND RAIL CONNECTIONS

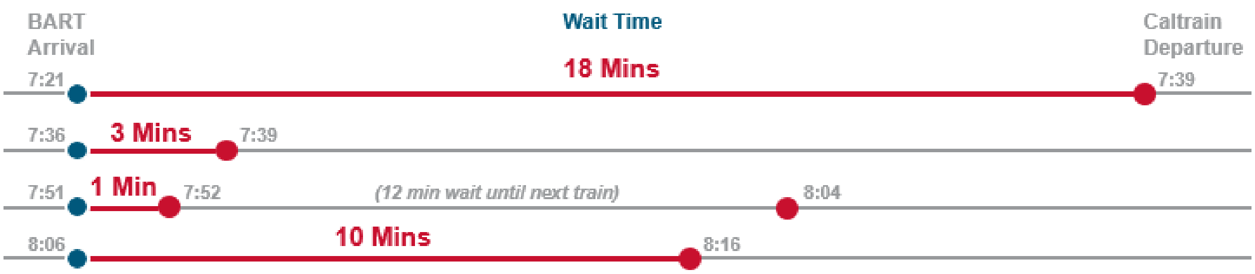
Caltrain provides connections to several transit operators, including:

- Muni (San Francisco stations)
- BART (Millbrae)
- SamTrans (San Mateo County stations)
- Commute.org (San Mateo County stations)
- VTA (Santa Clara County stations)

- Highway 17 Express (Santa Cruz to San Jose Diridon)
- County Express (San Benito County to Gilroy)
- Monterey-Salinas Transit (San Jose Diridon to Salinas and King City)

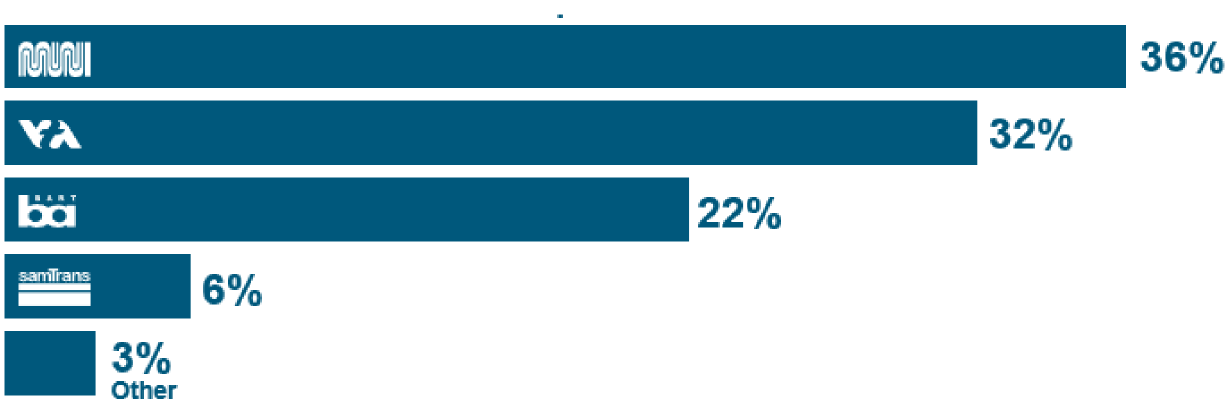
Bus and rail access to Caltrain has remained stagnant over time. While Caltrain ridership has doubled over the past decade, the total number of transit trips connecting to/from Caltrain has essentially remained unchanged due to a range of factors such as insufficient schedule and fare coordination as well as low service levels and incompatible low density land use environments. A prominent example of schedule of coordination issues occurs at Millbrae (Figure 6), where peak hour wait times for passengers transferring from BART to Caltrain vary train by train from one minute to 18 minutes, and riders must pay full fares for both operators. Most Caltrain stations lack conveniently-located bus bays, so transfers (particularly to SamTrans) are also hindered by sometimes long walks between train platforms and bus stops.

FIGURE 6: BART TO CALTRAIN TRANSFER TIMES, AM PEAK HOUR



Transfers to other transit operators primarily occurs at a few stations: 4th & King (Muni buses and light rail), Millbrae (BART), Mountain View (VTA light rail and some buses) and Diridon (VTA light rail and some buses). As shown in Figure 7, transit trips accessing Caltrain are split across Muni (36 percent), VTA (32 percent), BART (22 percent), SamTrans (6 percent) and other regional operators (three percent).

FIGURE 7: TRANSIT TRANSFERS



Caltrain offers some fare coordination with other transit operators (Figure 8). For VTA and SamTrans, most Caltrain monthly pass holders receive free local bus trips, but no discounts are available for one-way and other fare products. For Muni, riders transferring with a Clipper Card receive a 50 percent fare discount, but do not receive discounts for paper tickets. No transfer discounts are available for BART or for riders transferring from a one-way or monthly bus fare product to Caltrain without a Caltrain monthly pass (for SamTrans or VTA).

FIGURE 8: FARE COORDINATION

- ✓ 50 cent fare discount to all riders using a Clipper Card
- ❑ No discount on paper tickets

- ✓ Free local rides for two-zone or greater Monthly Pass holders
- ❑ No discount for one-way fares and other products

- ✓ Free local rides for two-zone or greater Monthly Pass holders
- ❑ No discount for one-way fares and other products

- ❑ No discounts

The complexity of partial fare integration and lack of schedule coordination means that many riders transferring between Caltrain and other transit operators often experience longer wait times and either do not qualify or do not realize that fare discounts are available. This disconnect poses a challenge for equitable access to Caltrain since lower income riders are more likely to access Caltrain via other transit services.

3.4 PICKUP & DROPOFF

Pickup and dropoff activity has tripled at Caltrain stations over the past decade as parking availability has become limited and Uber and Lyft usage has increased. Caltrain's role in pickup and dropoff activity is focused on providing adequate curbspace at stations. However, only half of Caltrain stations include dedicated passenger loading zones, and many of these facilities are undersized relative to existing demand. Consequently, most activity occurs in existing surface parking lots, bus or shuttle stops, and adjacent streets.

3.5 BICYCLE PARKING & BIKE SHARE

Caltrain provides on-board and wayside bicycle facilities. As described in Caltrain's *Bicycle Parking Management Plan,* the vast majority of Caltrain passengers accessing the system via bicycle bring their bikes on the train, while use of Caltrain's wayside bike parking facilities is generally low. As Caltrain has experienced rapid and sustained ridership growth over the last decade, the number of passengers accessing the system via bicycle has also grown, and many peak hour trains do not have sufficient space to accommodate total demand for bicycles on board. About 5,200 passengers bring bicycles on board trains on a typical weekday.

The agency has seen mixed progress in terms of improvements to the bike parking system due to staffing shortages, funding challenges, and management difficulties. Caltrain offers about 2,200 bicycle parking spaces with a mix of bike racks, keyed lockers, and secured facilities. However, utilization tends to be less than 50 percent on a typical weekday. The need to use a bicycle on both ends of a trip and safety and security concerns about leaving bikes at stations represent the primary reasons for low wayside bike parking utilization.

Although bike share and scooter share use has grown in recent years for 4th & King, 22nd Street, and Diridon Stations, they collectively represent a small share (four percent) of trips to and from these stations. Bike share and scooter share is not available at any other stations.

3.6 BICYCLE & PEDESTRIAN ACCESS

Caltrain is responsible for pedestrian connections between station platforms, park-and-ride lots, transit facilities, and surrounding streets, as well as bike facilities at stations and onboard as described in the prior section. Although this represents a short length of most walking and biking trips between stations and nearby communities, Caltrain does not have jurisdiction around pedestrian and bicycle facilities beyond the stations themselves. Consequently, Caltrain has historically deferred offsite bicycle and pedestrian access planning to local jurisdictions with mixed success – some station areas are very walkable and bikeable, while others experience barriers that discourage walking and biking such as large arterial roadways, lack of bike lanes, and missing crosswalks or sidewalks. As a result, Caltrain has opportunities to continue growing pedestrian and bicycle mode share, but such improvements continue to occur at a relatively slow and uncoordinated pace.

4. STATION CIRCULATION AND AMENITIES

4.1 STATION CIRCULATIONSTATION AMENITIES

Caltrain lacks many basic station amenities necessary to comfortably accommodate the volume of ridership it serves today. Although Caltrain ridership tripled over the past 20 years, Caltrain's stations have remained mostly the same. While most stations offer some small kiosk spaces for shade and weather protection, coverage extends to less than ten percent of total platform space overall; consequently, a majority passengers do not have access to shelters when it rains or during a heat wave. The passenger experience also suffers from a lack of wayfinding signage, and pedestrian-scaled lighting, which can make navigating stations difficult. Pedestrian facilities at stations vary widely in quality: some stations are very walkable, with direct paths to adjacent land uses and transfer facilities; others include circuitous paths, narrow tunnels, or walkways interrupted by parking lots. Some stations lack direct pedestrian walkways connecting platforms and station entrances or lack access from one side of the station entirely. Payment facilities are not well equipped to handle demand: sparse and irregularly spaced Clipper readers can cause queueing for passengers entering and exiting trains, while Caltrain lacks Clipper-integrated ticket machines for riders to directly manage Clipper payments. Caltrain station designs also affect train performance: the lack of level boarding lengthens dwell times and creates delays when accommodating riders using wheelchairs.

5. FUTURE DEMAND FOR STATION ACCESS

The Service Vision will result in triple the number of passengers accessing and circulating within Caltrain stations. Caltrain would experience demand for approximately 185,000 weekday riders by 2040. Ridership growth would vary greatly by station depending on changes in service levels, development activity, and changes to station access connections: some stations may function similar to today with modest gains in the hundreds of riders, while others may experience exponential growth adding thousands of riders.

In most cases, substantial improvements in onsite and offsite facilities are needed by Caltrain and its partners to accommodate ridership growth. These access and circulation improvements will support the changing ways that riders use Caltrain and help maximize Caltrain's ability to attract new riders.

6. EVALUATING FUTURE STATION ACCESS AND TOD SCENARIOS

There are several paths forward that Caltrain and its partners may take by prioritizing investments in certain modes over others as well as transit oriented development (TOD). As shown in Figures 9 and 10 below, each mode of access implies different levels of capital cost, operating cost, scalability, and sustainability. Overall, walking and biking improvements are the lowest cost, most scalable, and most sustainable; buses and shuttles are scalable and sustainable but come at a higher cost, and park and ride facilities are the highest cost and least scalable.

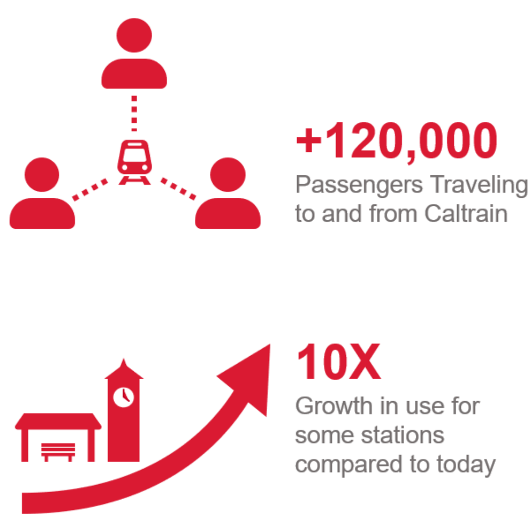


FIGURE 9: CAPITAL & OPERATING COST COMPARISON

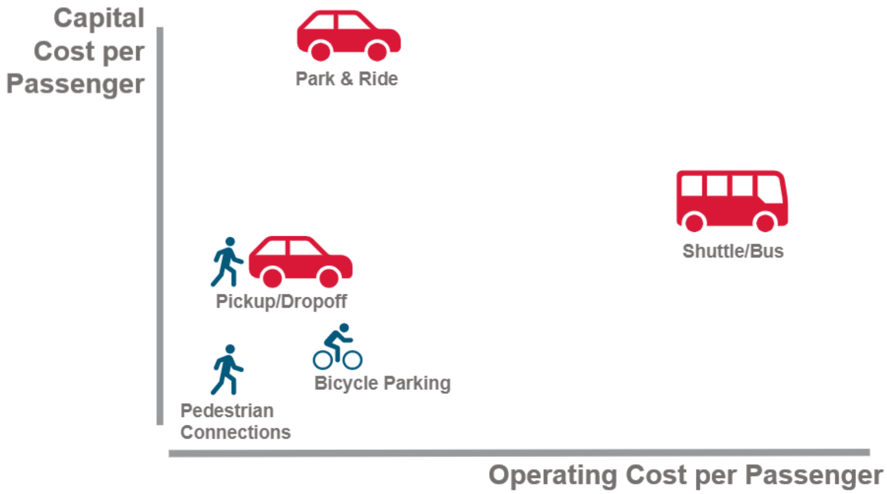
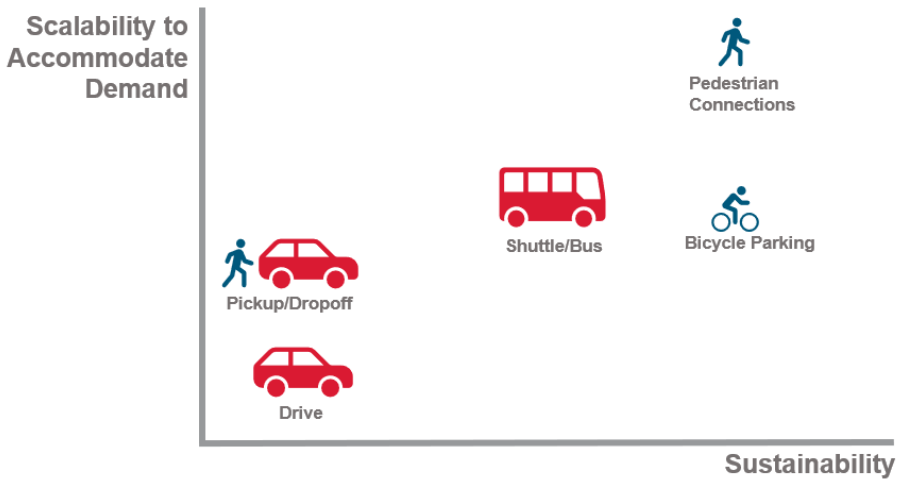


FIGURE 10: SCALABILITY & SUSTAINABILITY COMPARISON



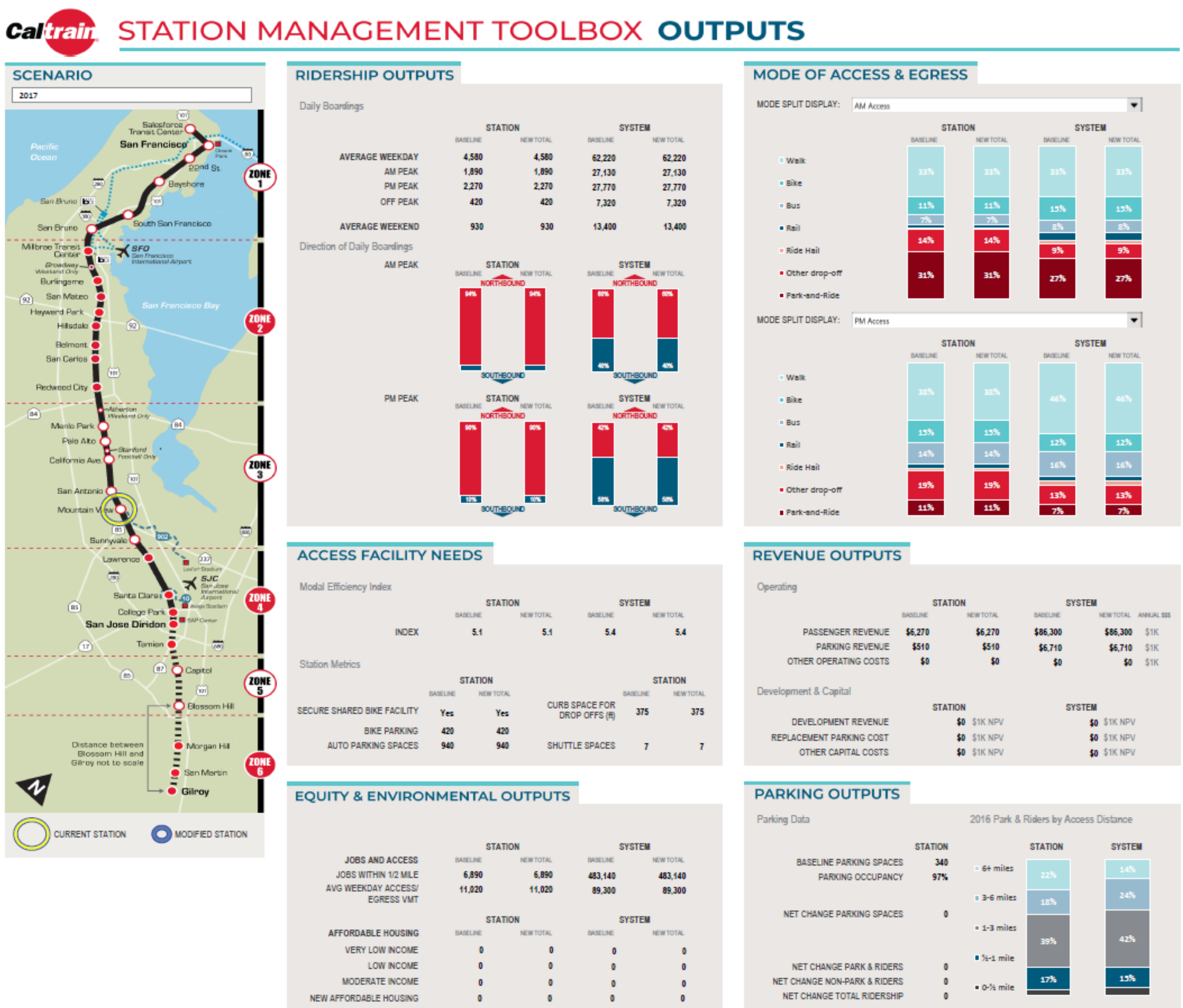
Three station access scenarios were considered for the 2040 Service Vision using Caltrain's Station Management Toolbox. The toolbox (Figure 11) considers station-level and system-level changes to ridership and mode of access depending based on changes to access facilities and joint development. Three scenarios were considered, as described in Table 1. The results from this analysis are summarized below in Figures 12 and 13.

Table 1: Toolbox Scenarios

Scenario Description	Scenario Assumptions
1. An ad-hoc baseline approach, in which investments and programs continue to occur as funding becomes available without a system-level vision – Caltrain would remain mostly agnostic to the types of investments that occur similar to today	• 1.5x increase in parking supply • No change to shuttle services • Moderate improvement to bike/ped access • Moderate joint development intensity at feasible sites with all impacted parking replaced • New parking assumed to cost $75,000 per space due to garage and parking replacement costs

Scenario Description	Scenario Assumptions
2. Expanding parking supply, in which parking would grow in proportion to ridership and Caltrain becomes more proactive in building new parking garages and acquiring land for such facilities as needed	• 3x increase in parking supply • No change to shuttle services • Minimal improvement to bike/ped access • No new joint development • New parking assumed to cost $100,000 per space due to garage, parking replacement, and land acquisition costs
3. Prioritizing non-auto access and joint development, in which investments and programs focus on all modes other than park & ride – Caltrain would become more proactive in bus and shuttle integration, active transportation, and joint development	• No new parking supply • 3x increase in shuttles service • Substantial improvement to bike/ped access • High intensity joint development at all sites without replacement parking

FIGURE 11: STATION MANAGEMENT TOOLBOX – SAMPLE OUTPUTS



Figures 12 through 15 compare the performance of these access scenarios. As shown in Figure 12, prioritizing park-and-ride access shifts more passengers to driving but results in lower ridership than investing in other modes. Maximizing joint development, active transportation, and transit access results in higher ridership and less driving, as shown in

Figure 13. Figure 14 shows the very high cost of parking relative to investing in non-auto modes, while Figure 15 shows the higher revenue potential associated with maximizing joint development.

FIGURE 12: APPROXIMATE CHANGE IN RIDERSHIP

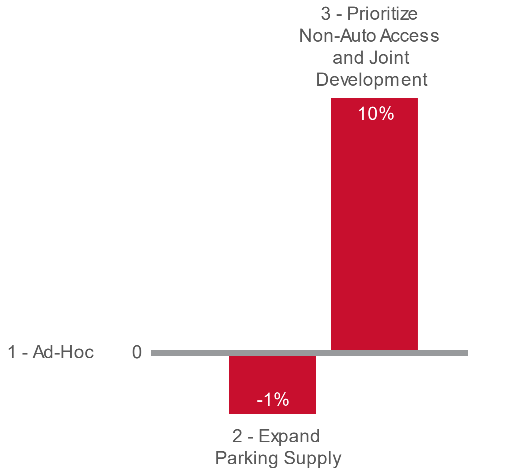


FIGURE 13: APPROXIMATE CHANGE IN MODE OF ACCESS

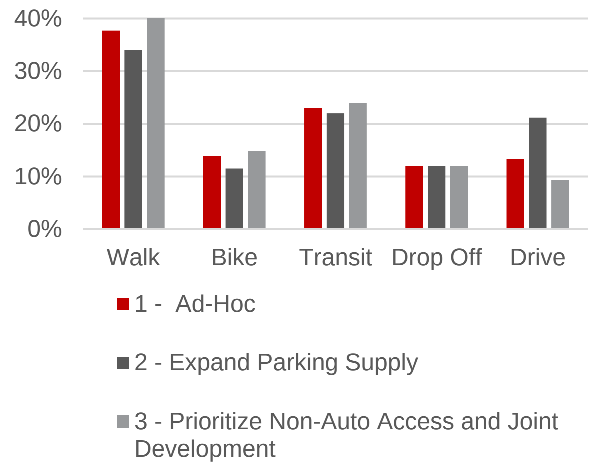


FIGURE 14: ESTIMATED COSTS OVER 50 YEARS

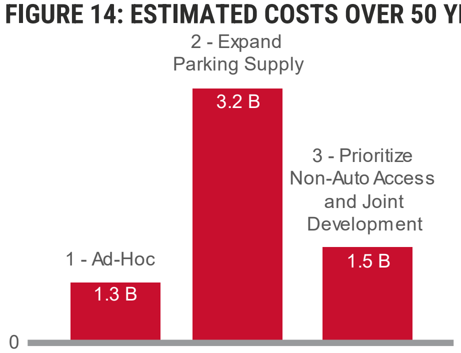
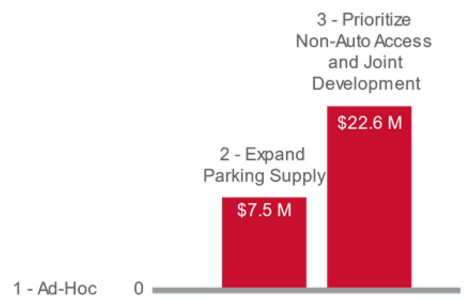


FIGURE 15: APPROXIMATE CHANGE IN ANNUAL REVENUE



These results present several policy questions for Caltrain moving forward:

1. Is more parking worth the investment? Parking garages are costly, and building new garages may come at the expense of housing and office TOD. Increasing parking supply is less effective in supporting ridership growth than investments in other modes.

2. How should Caltrain address shuttle and bus connections? There is substantial demand to scale shuttle/bus service to match growth of Caltrain service and development. However, organizational and operational challenges may limit the potential for expansion, and ongoing operational subsidies are high.

3. What is Caltrain's Role in Bike/Ped Access? Improving bicycle parking and shared use at stations represents a key opportunity to accommodate long-term ridership growth. Addressing offsite barriers to pedestrian and bicycle access are necessary to accommodate ridership growth, but these areas are typically outside Caltrain's jurisdiction and influence.

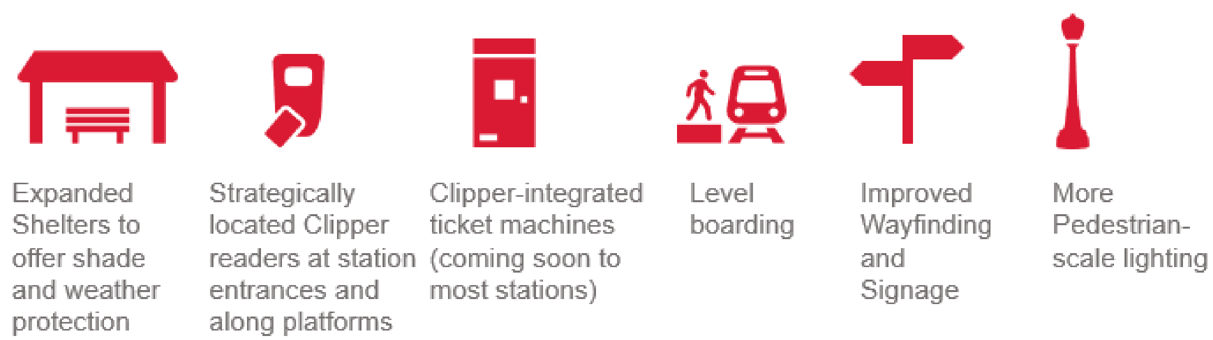
7. STATION AMENITIES, ACCESS & CIRCULATION PRIORITIES TO SUPPORT THE SERVICE VISION

In order to reach its full ridership potential, Caltrain will need to make a variety of programmatic access improvements across all stations. Based on the results of the Station Management Toolbox Analysis described in Section 4, it is clear that Caltrain can most cost effectively scale station access by focusing on transit, active transportation, and pickup/dropoff activity and maximizing joint development. Nonetheless, the scope and scale of these improvements may vary by station depending on land use context and change in ridership over time. This section summarizes programmatic improvements that are generally transferrable across all station contexts.

7.1 IMPROVE PASSENGER FACILITIES & PEDESTRIAN CIRCULATION

Perhaps the greatest change affecting all Caltrain stations will be a substantial increase in walking trips circulating within station facilities and to adjacent land uses as ridership increases. These trips will be driven by increased mode share from station area uses, densification of land uses adjacent to stations, and increased volumes of passengers connecting between Caltrain and other modes. In order to accommodate expected circulation needs, Caltrain and its city partners will need to prioritize a seamless passenger experience in which pedestrian access to the station is prioritized over other modes. Moreover, Caltrain will need to evaluate station circulation and essential station amenities such as expanded shelters, strategically-located Clipper readers, level-boarding, improved wayfinding and signage, and more people-scale lighting.

FIGURE 16: PASSENGER FACILITY NEEDS



7.2 EXPAND BICYCLE PARKING AND COORDINATE BICYCLE ACCESS IMPROVEMENTS

In order to scale bicycle access to stations, Caltrain will need to substantially increase wayside bicycle parking supply and proactively manage bike parking facilities given that onboard demand will exceed capacity in the short-term and long-term. A four-million-dollar investment is already underway focusing on expanding e-lockers throughout the system as an initial step. To meet the long-term demand associated with the Service Vision, most stations will need to develop secure shared facilities similar to those at Palo Alto, Mountain View, and 4th & King stations as well as those located across the BART system. While stations represent a major area for improvement, Caltrain may also consider taking a more active role in encouraging cities to address offsite gaps in bicycle connections that inhibit bicycle access.

7.3 COORDINATE TRANSIT CONNECTIONS AND EXPAND BUS INFRASTRUCTURE

The Service Vision enables timed connections to the regional transit network – repeating patterns "pulsed" out of major stations on regular intervals. These service patterns provide excellent opportunities for seamless, coordinated connections with other transit services because other transit providers will be able to align their schedules at major transfer stations to facilitate short wait times. This solves an issue with connections today, which are hard to coordinate due the bunched and irregular intervals of train service associated with the current timetable. The ability to time connections makes the service more efficient for operators and riders as there is less time spent waiting in stations and queueing for trains. Muni, BART, SamTrans, and VTA to provide feeder services.

With the ability to time transfers, Caltrain will be able to rely more heavily on local bus providers – particularly SamTrans and VTA – to provide feeder services in lieu of Caltrain-sponsored shuttle services to scale access over time. The volume of passenger demand is likely to exceed what smaller shuttle vehicles have the capacity to provide, and the corridor lacks dedicated funding sources to continue scaling the shuttle program in its current form.

A greater reliance on local bus services as a mode of access would require several changes relative to today. First, Caltrain would need to partner with cities to expand bus stop capacity within and adjacent to Caltrain stations, as stations today lack space or convenient locations for increased bus operations. Second, Caltrain and transit providers would need to better coordinate schedules and develop protocols for how to handle late train arrivals. Third, Caltrain and transit providers would need to further efforts toward coordinating and/or integrating fares to incentivize transit use as a mode of access.

7.4 ACTIVELY MANAGE CURBSPACE AND PARKING RESOURCES

It is neither practical nor efficient for Caltrain to increase the share of riders using park-and-ride facilities to access stations, let alone maintain the current mode split. While limited increases in station parking may occur in some contexts, adding new parking structures is generally the most costly and least effective means of serving ridership growth. Focusing on other modes of access presents a more viable path forward.

A market-based parking approach presents an opportunity to better manage limited parking resources while increasing Caltrain revenue for other access improvements. By pricing parking based on station service characteristics and demand patterns to achieve a target occupancy, Caltrain could better spread parking demand across stations, preserve some availability for riders, and encourage non-auto access.

Nonetheless, there will be passengers for which walking, biking, or transit use is not practical under all circumstances. Caltrain should prioritize expanding passenger loading facilities to serve such access needs, whether for Uber/Lyft trips or other dropoff and pickup activity. Such facilities would need to be added to many stations and increased in scale at others.

8. NEXT STEPS

In order to scale station access to meet the needs of the 2040 Service Vision, Caltrain will need to play a larger role in providing and coordinating access to its system through organizational and policy changes. By expanding its organizational capacity to more proactively manage its station access needs, Caltrain can improve greatly improve access and invest strategically to serve the greatest number of passengers.