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THE CALTRAIN CORRIDOR VISION PLAN

How to keep the Bay Area's innovation economy moving

Contents

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The Caltrain Corridor Vision Plan

How to keep the Bay Area's innovation economy moving

Executive Summary

The Caltrain Corridor, home of the Silicon Valley innovation economy, holds much of the San Francisco Bay Area's promise and opportunity, but its transportation system is breaking down. Along this corridor — which includes Highway 101, Caltrain rail service and all the cities connected by those systems from San Francisco to San Jose — the typical methods of getting around have become untenable.

Growth in jobs, uncoordinated land uses, underinvestment in transit and inefficient infrastructure are straining the corridor's transportation network. Caltrain railcars are overcrowded during peak commute hours and service is limited at other times, making it an unreliable option. Driving — especially on Highway 101 — is now synonymous with congestion, an outcome closely tied to the corridor's low density and high rates of car ownership. Bus ridership in the corridor has declined, as buses are not time-competitive with driving. The continued unbalanced growth in housing and jobs in the area will only exacerbate the current inefficiencies.

The Caltrain Corridor needs to be able to move more people, provide greater convenience and better connect to the rest of the region. How can we transform today's underperforming system — which undermines the region's economy and threatens its ability to meet sustainability goals — into what the corridor needs?

Our Vision for the Caltrain Corridor

In our vision of the future, the Caltrain Corridor is shaped by an outstanding rail system. Caltrain and high-speed rail provide the backbone of the corridor and offer modern, attractive rail service. Growth is concentrated around transit stations, which reinforces the use of transit, biking and walking. Highway 101 includes an express high-occupancy/toll lane with dynamic pricing for buses and carpools, and it's possible to reach more parts of the Peninsula by ferry. People rely much more on non-driving options because they are convenient, functional and reliable and feel like one easy-to-use system — a result of collaboration among the cities and transit agencies in the corridor. Because of the decrease in driving, California is poised to reach its climate goals.

How do we achieve this vision?

It won't be easy. The corridor faces key challenges: Caltrain lacks a dedicated source of funding and is financially unstable; the fragmentation of transportation agencies makes it difficult to take a corridor-wide approach to planning; and rail growth is hampered by the impacts of railroad infrastructure on local cities.

At the same time, there are a number of opportunities we can leverage to reinvent the Caltrain Corridor. Caltrain's plans to switch its train fleet from diesel to electric power will dramatically improve rail capacity, comfort and reliability and allow Caltrain to become cost-efficient. High-speed rail, which is expected to arrive as soon as 2025, will add capacity and create statewide connections. The private and public sectors are actively pursuing real alternatives to driving alone. And new technologies are transforming the transit passenger experience, providing new options for safer, more efficient and more convenient transportation.

With these opportunities and challenges in mind, we recommend policies, projects and programs to achieve our vision for the Caltrain Corridor.

Develop reliable, frequent all-day rail service with enough capacity to meet demand.

As driving becomes less convenient, transit is poised to become a reliable and efficient transportation solution to get to and from Caltrain Corridor cities. Caltrain should plan to grow its ridership to nearly five times what it is today by offering an attractive, competitive rail schedule, pursuing system and infrastructure upgrades that support additional capacity, and extending the rail corridor to reach downtown San Francisco. Caltrain should also develop a business plan and use the period before electrification to pursue near-term improvements that can manage demand and attract riders.

Offer quick and intuitive connections at modern, high-amenity stations.

As Caltrain grows and extends its service offerings, stations should be upgraded to attract and accommodate more riders. Well-designed multi-operator stations can attract riders to transit and help them feel comfortable and informed. Station access will also need to be upgraded and should prioritize easy access by travel modes other than driving. Accomplishing this will require advancing the right street, parking and pricing policies and designating a responsible party to manage access at each station. Caltrain and other agencies should set aside funds to modernize stations.

Move more people on Highway 101, with less delay.

Highway 101 needs to support transit, not just private cars. It should have continuous high-occupancy/toll lanes with dynamic pricing for buses and carpools. These toll lanes should be converted from existing lanes, as new construction is costly and likely to be counterproductive. Funds raised from the tolls should go toward increasing public transit services. Equity policies and programs need to be adopted to make sure that using toll lanes provides a net benefit to low-income travelers. Changes and enhancements to 101 will only succeed if paired with policies and programs that address demand for driving alone.

Establish public ferry service for Peninsula travelers.

Ferry service should be added to get more people to and from the Peninsula. Ferries add redundancy and provide a way to reach new markets that are difficult to reach with rail, such as the North Bay or East Bay. We recommend establishing a ferry terminal at the Port of Redwood City for both private and public ferry service.

Sergio Ruiz

Create a coordinated and convenient transportation network.

For transit use to grow, the passenger experience must be convenient and attractive. The corridor's many transit agencies should coordinate their services so they work together as one rational, easy-to-use network. Transit information should be presented consistently across agencies, and transit riders should have the option to plan, book and manage their trips on a single mobile platform. To maximize ridership, transit operators should work together to develop a shared fare payment system and structure. Clipper technology will need to be upgraded to support these functions.

Develop a strategy to fund this vision.

The Vision Plan will cost between $16 billion and $21 billion to implement, and we recommend a funding plan to make these changes happen. Funding strategies include using fares and tolls to cover transit operating costs, dedicating funds from county sales taxes, developing new regional and state funding, and identifying opportunities for private investments and private-public partnerships.

See pages 56-57 for a plan of action identifying the parties who can implement the vision plan's recommendations.

The Caltrain Corridor Is Poised for Transformation

The Caltrain Corridor is home to the world's innovation economy — but its transportation system is falling short.

As the San Francisco Bay Area grows in population, its transportation network is in need of significant upgrades. It must be able to carry many more people, and it must also become much more convenient and appealing in order to serve as a truly viable option for most travelers. These changes are necessary if we want to improve our quality of life, reach our sustainability goals and maintain our strong economy. This vision plan focuses on what we are calling the Caltrain Corridor: the transportation corridor along the San Francisco Peninsula, which includes Highway 101,[1] Caltrain rail service and all the cities connected by those lines, from San Francisco to San Jose.

The Caltrain Corridor is the most dynamic economic corridor in the world, home of the Silicon Valley innovation economy and headquarters to valuable companies like Google, LinkedIn, Facebook, Adobe, Box, Salesforce, Tesla, Apple, Genentech and Twitter, to name just a few. The corridor also includes major global institutions and destinations, such as Stanford University, University of California San Francisco, San Francisco International Airport (SFO) and stadiums for the San Francisco 49ers, San Francisco Giants, San Jose Sharks and, soon, the Golden State Warriors. It passes through San Francisco, San Mateo and Santa Clara counties and is home to 19 cities and 3 million people.[2]

However, job growth, uncoordinated land use, underinvestment in transportation and inefficient use of infrastructure are leading to breakdowns in the Peninsula's transportation system. Highway 101, Caltrain, BART, Interstate 280 and El Camino Real — the major pieces of transportation infrastructure in this corridor — are increasingly unreliable and crowded. Because of the Peninsula's land use pattern and high rate of car ownership, its transportation system is largely based on driving. Even that option is failing for many, as stop-and-go traffic becomes the norm for many hours of the day. Transit has had a long history in this corridor, and though it lost its market to the car during the 20th century, trains and buses are now poised for a comeback as a convenient and efficient way to get to and from Caltrain Corridor cities.

A severe shortage of affordable housing in this corridor is pushing workers farther away as they search for affordable places to live, putting additional demands on the transportation system. The large expanse of the San Francisco Bay, which separates the Peninsula from other communities, exacerbates the housing and transportation challenges. Demographic changes also call for new solutions: Younger generations have a less favorable attitude about driving, and an aging generation will also need ways to get around without driving.[3] There is growing recognition that significant changes must take place or else the corridor, and the region, will cease to function.

In a world of economic competition between regions, those with more efficient transportation systems have an advantage.[4] In order to keep people moving, major transportation investments, innovation and policy changes are required. The corridor's transportation system needs more services, more capacity and more space-efficiency — and it needs to connect with the way cities are planning to grow. In order to benefit the entire Bay Area, we must enable more people to access the rich economic and social opportunities that continue to grow along the Caltrain Corridor.

These moves are also needed to address the growing threat of climate change: We must reduce our reliance on automobiles, the single greatest source of carbon emissions produced in the Bay Area and California. Our region aims to grow while decreasing our contribution to climate change, and we are starting to succeed.[5] Now it is time for us to lead once again.

In addition to their climate impacts, automobiles are also an inefficient use of space. The cities along the Caltrain Corridor are confined between the Bay and the coastal mountains; cars and parking consume precious space needed for housing, jobs, parks and schools. There simply is not enough space for people to continue to drive to meet all their needs. The future of Silicon Valley requires transit, biking, walking and on-demand services (such as carpools or taxis) to work well and work together. This means a transportation experience that is as comfortable, available and intuitive as driving one's own car.

We Need a Bigger Vision for the Corridor

Despite the Peninsula's obvious transportation needs, the solutions we have underway now will not offer significant enough results to fix the problems. Plans to manage Highway 101 and make it work better for transit riders are only now being developed. The immediate projects to improve Caltrain — switching the train fleet from diesel to electric power — though very significant, will result in only a 20 to 25 percent increase in capacity above today, which means service may continue to fall short of demand. And even if we do increase Caltrain capacity and provide better options than driving alone on Highway 101, we need sufficient services and routes to get people to and from transit stations.

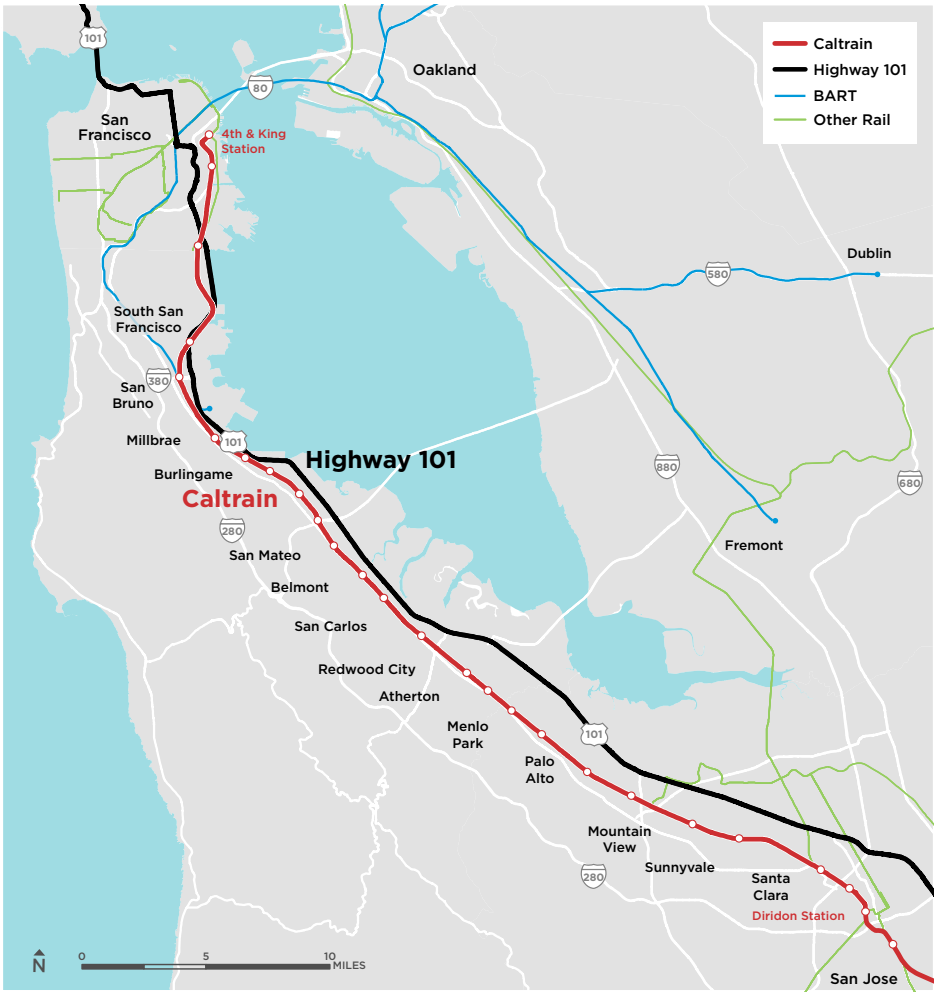
Four leading Bay Area institutions — SPUR, Silicon Valley Leadership Group, Stanford University and the San Mateo County Economic Development Association — joined forces to develop the Caltrain Corridor Vision Plan. This plan explains the investments and policy changes that civic leaders, transportation agencies, cities, businesses and the general public will need to lead together to ensure that this corridor becomes more connected, more livable and more sustainable as the region grows. We also recommend a funding plan to make these changes happen.

FIGURE 1

The Caltrain Corridor

The Caltrain Corridor, with a population of 3 million, is the home of the Silicon Valley innovation economy. Transit is poised to become a convenient, efficient transportation solution to and from Caltrain Corridor cities. The existing railroad presents an outstanding opportunity to shape transportation.

Source: Produced for SPUR by Arup



A Corridor Shaped by an Outstanding Rail System

Our vision plan research focused on defining how Caltrain and high-speed rail can play a much bigger role in the corridor's transportation system and communities, as well as how both highways and rail can work as one system.

There are two possible paths for growth in the Caltrain Corridor. The first is to grow and build around the transit system, which reinforces using transit, biking and walking. In this scenario, transit isn't only used for shuttling commuters to burgeoning job centers; it's useful to all kinds of people, for all kinds of trips, during all hours and days of the week. The vision plan imagines a completely new quality of transit experience in this corridor: frequent and reliable Caltrain service, with quick, all-day connections to and from stations; an attractive high-speed rail service; an express high-occupancy/toll lane on Highway 101 for buses and carpools; and new ferry service to the Peninsula from other points on the Bay. Making transit and other nondriving options work well in the corridor will build confidence that we can grow our communities without adding to gridlock.

The second option is to continue on the current path, with some development near rail stations and significant growth farther away from stations, reinforcing the use of cars to accommodate growth and leaving transit capacity underutilized. In this scenario, growth becomes difficult to manage because there are few attractive or efficient transportation options, and locations in this corridor become less, rather than more, connected to the rest of the region. To avoid this outcome, we must work to build the system described in the first scenario. We outline our vision for the Caltrain Corridor in Chapter 2.

CHAPTER 1

How We Got Here

The corridor's transportation system was built for a different era.

A mural at the San Mateo Caltrain station recalls the history of Peninsula transportation.

Today's Caltrain Corridor was shaped first by the construction of a railroad and then by the construction of highways. Before the railroad, cities were linked primarily by various paths used by horse-based transportation. (Many of these, including El Camino Real, later became roads and highways for cars.) In the 1800s, ferries connected San Jose and San Francisco, using the Bay to transport goods and people.

The 49.5-mile San Francisco and San Jose Railroad — the forebear of today's Caltrain — was first proposed in 1851 and opened for service in January 1863. The privately developed $2 million system was paid for in part with $600,000 in bonds issued by Santa Clara, San Mateo and San Francisco counties. The railroad cut the eight-hour steamboat or stagecoach trip to just three and a half hours. For the next 90 years, this railroad, which merged with the Southern Pacific Railroad in 1870, was the primary mode of transportation over long distances on the Peninsula.

Towns and villages grew around the railroad stations, forming a string of walkable, mixed-use downtowns that characterize Peninsula cities to this day. Until World War II, these towns were mostly small, with productive farmland at their edges. The Santa Clara Valley, dubbed "the Valley of Heart's Delight," produced food and goods that were transported by freight trains to San Francisco and its ports.

Passenger service on the railroad began in 1863. Local streetcar networks complemented the rail line, including the San Mateo Interurban line, providing service from South San Francisco to San Mateo starting in 1892, and the Peninsular Interurban, providing service from San Jose to Palo Alto starting in 1902.[6] The railroad led to the emergence of bedroom communities along its route: small towns where businesspeople who worked in San Francisco lived. Inter-regional trains also used the corridor, including some that traveled to Los Angeles.[7]

Southern Pacific's Peninsula Commute Service, which was focused on getting workers to and from San Francisco, hit its postwar peak in 1954, with 9.2 million annual boardings — a number that would not be surpassed for nearly 50 years.[8] The end of World War II brought major shifts in both passenger and freight travel patterns in the corridor. Beginning in the 1950s, suburban housing, office parks and factories for the defense, technology and research industries — later known as "Silicon Valley" — began to replace agricultural lands.

During this period, employers often located their offices in places with ample land for production — and parking. Most of the locations that saw growth — such as Stanford Industrial/Research Park (1951) in Palo Alto and NASA Ames Research Center (1958) and Fairchild Semiconductor (1959), both in Mountain View — were far from train stations and oriented toward the car. The 1962 completion of the eight-lane Bayshore Freeway (Highway 101) further eroded the importance, and revenues, of the railroad. Passenger rail volumes

Streetcar lines and the Southern Pacific railroad predated automobiles in the Caltrain Corridor. Many towns on the Peninsula grew up around these systems.

reached their nadir in 1977, with 4.4 million annual boardings — less than half the ridership of 23 years prior.[9]

The combination of a postwar explosion in car ownership, increasing federal and state investment in highways, and new car-oriented neighborhoods and offices chipped away at both passenger and freight rail usage. As jobs and stores left the traditional downtowns, the overall development pattern rendered rail less practical. People began to find driving an easier, or necessary, way to get to the store or even just have lunch on the other side of a busy street. Smaller rail lines were replaced with roads, as happened when the branch rail line to Los Gatos became the Foothill Expressway in 1964.

During the 1920s and 1930s, the first segments of the new Bayshore Highway, now Highway 101, were built, eventually connecting San Francisco and San Jose with a road that was wide, smooth and solely focused on cars (unlike El Camino Real, which was used by streetcars, horse-drawn carriages and pedestrians). In the 1940s and 1950s, at the dawn of the highway era, the California Department of Public Works (the predecessor to Caltrans) began converting the Bayshore Highway into the 10-lane freeway we know today.

While development patterns and auto-focused transportation investments were undermining the traditional rail-oriented communities of the Peninsula, the companies located in the corridor were reinventing the economy. Starting with defense contracts, the area has ridden a series of innovation waves, from the integrated circuit and semiconductors to the personal computer, biotech, genomics, the internet and social media. The core strength of Silicon Valley is the area's combination of innovative research with venture capital and the entrepreneurial know-how to turn ideas into companies.

When BART was first planned in the 1950s, it was designed to connect San Francisco, San Mateo and Santa Clara counties as part of a loop around the Bay. However, in 1962, San Mateo and Santa Clara county leaders opted out of the BART District, citing the existence of the Southern Pacific Railroad among other reasons. Both counties went on to create new public transit districts, the San Mateo County Transit District (SMCTD) and the Santa Clara Valley Transportation Authority (VTA).

The Emergence of Today's Caltrain

In 1977, Southern Pacific petitioned the California Department of Transportation (Caltrans) to discontinue passenger service, motivated by dropping ridership and revenue. The state and the three counties worked out an agreement for Caltrans to take over operation of the railroad in 1980, with the state supplying half of the operating funds and the three transit agencies in the corridor (Muni, SamTrans and the Santa Clara County Transit District) providing the other half, keeping Southern Pacific as a contract operator of train service. The Caltrain brand began with the 1985 purchase of new branded train cars, which replaced old Southern Pacific equipment.

Around the same time, several planning studies about the future of Peninsula rail were conducted. One was the 1977 Peninsula Transit Alternatives Project created by the Metropolitan Transportation Commission, which focused on preserving rail service and connecting it with downtown San Francisco. The California Legislature then asked for a comprehensive mass transit plan for the Peninsula. The resulting 1985 Peninsula Mass Transit Study evaluated nine systems-level solutions to Peninsula transportation demand, including rail, BART and bus-only transit. The study recommended extending Caltrain to downtown San Francisco and extending BART to SFO.[10] The project led to the 1987 creation of the Peninsula Corridor Study Joint Powers Board, composed of officials from the three counties with Caltrain service (Santa Clara, San Mateo and San Francisco counties). This entity was the predecessor to today's Peninsula Corridor Joint Powers Board (PCJPB), which owns the railroad and operates Caltrain.

In 1991, PCJPB purchased the 51.4-mile railroad right-of-way from Southern Pacific for $220 million, taking over control from the state. PCJPB extended its Caltrain service to Gilroy through the $4 million purchase of track usage rights from Union Pacific.[11] PCJPB gradually acquired new equipment, rehabilitated existing facilities, completed several grade separations and added two new stations and new services to the schedule.

Starting in the 1980s, new rail lines connected with Caltrain, including Muni's light-rail line to the 4th and King Caltrain station and VTA's light-rail service to the Diridon and Mountain View Caltrain stations. In 2003, San Mateo County and SFO opened an 8.7-mile extension of BART from Colma to the airport, which connects with Caltrain at Millbrae Station. The study's other recommendation,

Starting in the 1980s, new rail lines connected with Caltrain, including Muni's N Judah in San Francisco.

to extend Caltrain to downtown San Francisco, is only now being realized as part of the construction of the Transbay Transit Center.

In 2004, the PCJPB introduced Caltrain's Baby Bullet service, which offered faster travel times that were competitive with driving. The service was facilitated by the construction of new passing tracks (which enabled Baby Bullet trains to overtake slower trains), new train engines and cars, and a new signaling system. Weekday ridership more than doubled between 1997 and 2015, from 24,600 to 62,400.[12] This dramatic increase resulted from the new services, continuing growth in housing and jobs in the corridor, and related congestion on highways. Today, three Baby Bullet stations near job centers — San Francisco, Palo Alto and Mountain View — handle about half of all passengers on the line. (See Figure 4 on page 10.)

The Caltrain Corridor Today

Caltrain cars are increasingly crowded during peak hours.

Caltrain riders are experiencing increasing crowding during peak commute hours, though this overcrowding is not spread evenly across all trains. Large differences in ridership exist between different tiers of service (local, limited and Baby Bullet), times of day, directions and seasons.[13]

In summer, the busiest season, peak-period northbound trains run at as much as 58 percent over capacity while similar southbound trains run at up to 49 percent over capacity. On these trains, up to 37 percent of passengers (378 people) are unable to get a seat. Meanwhile, the overall number of "full" trains — defined by Caltrain as trains at 95 percent seated capacity or above — continues to increase.[14] In 2015, 22 trains (out of 96 total) ran at full capacity per day, up from 15 the previous year. Special events, such as baseball and football games, add more people to already crowded trains. Another factor affecting train car capacity is bicycles, which are commonly brought on board because often neither origins nor destinations are near train stations. The number of bikes brought on board has reached more than 10 percent of boardings (6,207 bicycles in 2015).[15]

Caltrain's limited off-peak service makes transit less usable.

Caltrain operates far fewer trains outside of peak hours, leading to long waits. For example, at Palo Alto Station, service drops from four trains per hour between 7 a.m. and 9 a.m. to only one train per hour between 11 a.m. and 3 p.m.

During both peak and off-peak hours, it's possible that the constrained service schedule keeps stations with low service levels from growing to the same boarding levels as larger stations. The attractiveness of Baby Bullet service at stations such as Redwood City and Hillsdale draws riders who may actually live or work closer to Caltrain stations not served by Baby Bullets.

There are a number of reasons why there are not more trains and why service can be unreliable, which we discuss in Chapter 4.

Users of Highway 101 face growing delays due to traffic and inefficiencies.

Motorists using Highway 101 increasingly face delays and unpredictable travel times. To avoid sitting in traffic, drivers are leaving their homes earlier or later, causing the morning rush hour to get longer and longer. Stop-and-go conditions on Peninsula freeways now routinely start as early as 7 a.m. on weekdays, with traffic remaining heavy on some segments of Highway 101 until nearly 11 a.m. The evening commute is no better, with delays starting as early as 2:30 p.m. and routinely running until 7 p.m. These trip delays and the lengthening of the peak period wreak havoc on trip planning, making even routine trips extremely unpredictable.

FIGURE 2

Caltrain Ridership Is Outpacing Growth in Service

Since the state and then the PCJPB took over passenger services, in 1980 and 1991 respectively, Caltrain service and ridership have grown. Recently, ridership has grown much faster than new service has been provided, creating crowded conditions, as shown by this comparison of Caltrain's annual ridership and number of trains per day since 1941.

Source: Data compiled from *Accommodating Long-Term Growth on North America's Commuter Railroads*, John G. Allen, 2013; *The Peninsula Commute Story*, Steve Miller, 1987; *The San Francisco Peninsula Railroad Passenger Service; Past, Present, and Future*, Mark Duncan, 2005; *Caltrain and the Peninsula Commute Service*, Janet McGovern, 2001.

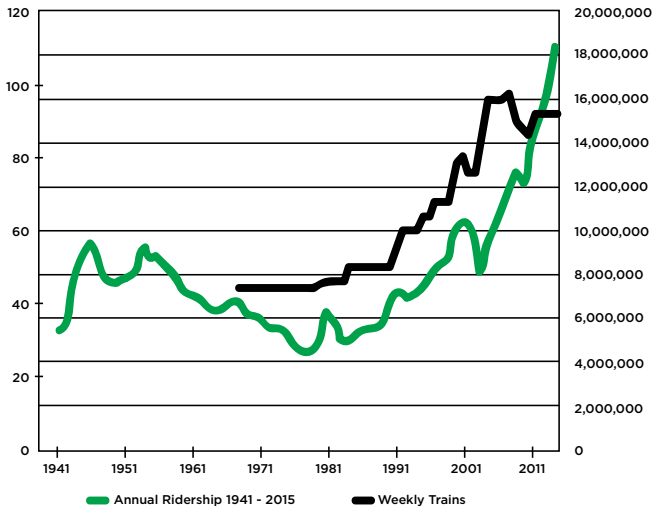


FIGURE 3

Caltrain Ridership vs. Capacity During Peak Hours

During peak hours, the average number of passengers exceeds the seat capacity on Baby Bullet and limited trains, meaning some passengers must stand.

Source: Caltrain 2016 Annual Passenger Counts

Service Type	Average Passengers per Train	Seated Capacity	Percent of Seating Capacity Used
Baby Bullet	870	762	114%
Limited	754	650	116%
Local	415	650	64%

For example, for the 9.4-mile trip from Redwood City Transit Center to downtown Burlingame, riding the bus on El Camino Real would take more than one hour during the morning peak. Driving would take approximately 20 to 45 minutes via El Camino Real and 16 to 28 minutes via Highway 101. The El Camino Real bus runs every 15 minutes at its peak, and while this is frequent for the Bay Area, it adds waiting time to the length of the trip.

Since reaching a peak in 2001, overall bus ridership across the Caltrain Corridor counties has declined for all three public agencies: VTA, SamTrans and the San Francisco Municipal Transportation Agency (SFMTA). Providing reliable bus service that riders will choose over driving requires rethinking bus routes and getting buses out of traffic through dedicated bus lanes and other improvements.

Few people use carpools or buses on 101.

Together, Muni, SamTrans, AC Transit, Dumbarton Express and VTA offer 11 public bus routes that serve portions of the 101 corridor. While buses are full overall, few people use these services to travel on Highway 101. Single-passenger cars are the prevailing users of Highway 101, comprising approximately 75 percent of vehicles on 101 despite carrying only 52 percent of passengers. Buses make up less than 1 percent of vehicles yet carry 15 percent of passengers. (See Figure 5 on page 12.)[16] Private transit buses, particularly those provided by employers, are a growing mode of transportation on Highway 101 — but those buses are also stuck in traffic.[17]

With an average of 1.5 people per vehicle, including buses, limited freeway capacity is being consumed inefficiently. The actual number of people moved can be increased either with more buses or with a greater number of people occupying each car. This requires a change in how the highway is managed. With no road pricing (charging a user fee to people who drive, especially at peak hours) and limited high-occupancy vehicle lanes (which allow carpools to drive faster), solo drivers have little incentive to economize, exacerbating the heavily congested conditions. An additional unfortunate consequence of heavy car use on 101 is safety: Cars are much more likely than buses to be in collisions.[18]

Local buses don't compete well with driving.

Today it is possible to make trips between neighborhoods located on El Camino Real using local bus services, and many do use the bus. But few people who have the option to drive choose the bus over their cars, because transit is not time-competitive with driving.

Caltrain serves a narrow market.

Caltrain riders today are almost entirely between the ages of 18 and 64 and nearly three-quarters of riders report incomes above $60,000 per year.[19] The majority of riders are making work trips during traditional peak hours; 75 percent of them use the system three or more days per week.

Although fares are not necessarily high for the quality of service, they may be too high for some people, especially when the cost of connecting services is included. Fares range from $3.20 to $13.75 one way; the average fare across all categories is about $4.50 for a 20-mile trip.[20] Caltrain does offer a variety of discounts through the GoPass (highly discounted passes that large businesses can purchase for their employees), monthly passes (unlimited rides between designated zones) and other programs (such as half-price fares for seniors, youth and disabled passengers). Today 41 percent of riders use a monthly pass and 18 percent use GoPasses.[21] In addition, many travelers must pay for connecting bus or taxi service to get to the train station, often on both ends of the trip. Caltrain riders receive a 50-cent discount when transferring to Muni. (However, there is no discount for Muni riders transferring to Caltrain). Caltrain's monthly pass includes bus transfers to VTA and SamTrans transit, but non-pass holders have no transfer discount.

Another challenge is Americans with Disabilities Act (ADA) accessibility: Currently, every Caltrain has at least one car designated as ADA accessible with the use of a wheelchair lift. In total, a Caltrain train can accommodate between three and 10 wheelchairs, depending on the train type. Boarding assistance is available from conductors for those in wheelchairs or who have difficulty with stairs. Six Caltrain stations are currently not wheelchair accessible.[22]

FIGURE 4

2016 Weekday Service Levels and Boardings at Caltrain Stations

Caltrain stations have varying levels of service and large differences in ridership. The highest-ridership stations are those with the most Baby Bullet trains and the most nearby destinations.

Source: Caltrain 2016 Annual Passenger Counts

Station	Average weekday boardings	Number of trains (weekday, per direction)			
		Local	Limited-stop	Baby Bullet	Total number of trains
San Francisco	14,769	14	21	11	46
Palo Alto	7,424	14	18	11	43
Diridon	4,712	14	21	11	46
Mountain View	4,659	14	18	8	40
Redwood City	3,814	14	16	6	36
Millbrae	3,606	14	16	11	41
Sunnyvale	3,190	14	14	3	31
Hillsdale	2,958	14	18	5	37
San Mateo	2,179	14	18	3	35
Menlo Park	1,796	14	16	3	33
22nd	1,715	14	13	5	32
Cal Avenue	1,628	14	12	0	26
San Carlos	1,475	14	18	0	32
Santa Clara	1,093	14	15	0	29
Burlingame	1,054	14	15	0	29
San Antonio	942	14	9	0	23
Lawrence	901	14	14	0	28
San Bruno	717	14	14	0	28
Belmont	664	14	9	0	23
South San Francisco	471	14	9	0	23
Hayward Park	427	14	6	0	20
Bayshore	253	14	5	0	19

As the Region Grows, We'll Need to Move More People

The Bay Area is growing rapidly. From 2010 to 2015, the three counties of the Caltrain Corridor added 388,600 workers — 18 percent growth — surpassing the 1997–2000 dot-com boom. The number of people who live in the Caltrain Corridor counties also grew significantly, with 242,630 residents added over this five-year period. Housing growth, though substantial at 45,775 new homes, has not kept pace with employment growth. This means that an increasing number of workers in the corridor are commuting from more affordable housing elsewhere in the Bay Area and, increasingly, the Central Valley and Monterey and San Benito counties.[23] Consequently, the region's housing shortage is aggravating its transportation problems.

Plan Bay Area 2040, the region's plan for growth, projects that employment will increase by 51 percent in San Francisco County, 37 percent in San Mateo County and 42 percent in Santa Clara County. That's 802,000 new jobs between 2010 and 2040. The number of households in the three counties is projected to increase by 40 percent, 23 percent and 42 percent, respectively.[24]

A further indication of the potential for new jobs and expanded travel demand is the amount of new and proposed office and commercial development. Many cities are planning growth near Caltrain stations; cities with transit-oriented development plans in the works include San Jose (the Diridon and Tamien station areas), Santa Clara, Sunnyvale, Mountain View, Palo Alto (California Avenue), San Mateo (Hillsdale and Bay Meadows), Millbrae, South San Francisco and San Francisco (the Transbay Transit Center and Central SoMa districts and development projects near 22nd Street Station, such as Pier 70). Almost 5 million square feet of new office/commercial/industrial space are planned for the Diridon Station area in San Jose, 6.4 million square feet are planned in Mountain View's North Bayshore and 6 million square feet are expected in the Transbay Transit Center District in San Francisco.[25] Furthermore, the Grand Boulevard Initiative, a reimagining of El Camino Real, envisions bus and rail transit playing a key role in how people get around.

Companies farther away from Caltrain stations, at places such as Stanford Research Park in Palo Alto, North Bayshore in Mountain View

Like many cities with Caltrain stations, Redwood City is putting new housing and jobs near Caltrain, giving people the option of commuting and running errands by rail. This choice links land use policy with efficient use of the existing transportation system.

or Santana Row in San Jose, are increasingly planning their growth with Caltrain in mind, with the expectation that connections will be facilitated by shuttle buses, light rail, bicycles and walking. Some growing cities, such as Mountain View, have begun to consider new rail connections that would meet the Caltrain line.[26]

Growth in the Caltrain Corridor Is Becoming Transit-Oriented

New growth in the Caltrain Corridor, both near and far from train stations, is taking place in the form of densification. Formerly single-use or low-density office spaces are being redeveloped into high-density or mixed-use developments. The Bayshore Precise Plan, the Moffett Park Specific Plan and the Santa Clara Square development project are all examples of densification. Densification can solve some transportation challenges by putting stores and housing within reach of jobs. However, densification also requires rethinking how to get people in and out of a particular location.

Many places in this corridor were built as automobile-dependent developments. These types of places have received very little attention in urban and regional transportation plans and have little public transit infrastructure, making it difficult to reduce car use and organize transportation solutions. Densification of these places will require changes to transportation infrastructure and services, such as new bicycle lanes and shuttle buses, and new travel behaviors, such as staggering work hours in order to avoid gridlock.[27]

Demand for train travel is likely to keep growing because of increased congestion on Highway 101, easier ways to reach rail stations (such as ride sharing and shuttles) and growth near rail stations. New transit connections will also add riders to the Caltrain line. In the near term, San Francisco's Central Subway, opening in 2019, and increased BART frequencies will add demand. In the medium term (mid-2020s), major transit connections such as BART Silicon Valley and the extension of Caltrain to the Transbay Transit Center will connect today's Caltrain to entirely new transit markets and thousands of new riders each day. Special events, especially baseball games at AT&T Park and football games at Levi's Stadium, bring another type and level of crowding — which will grow with the opening of the Warriors' arena (Chase Center) in San Francisco in 2019. Both San Francisco International Airport and Mineta San Jose International Airport, already major generators of trips in the corridor, will handle larger volumes of air travelers in the future.[28]

In the longer run, new Caltrain and bus riders would come from regional growth, new transportation connections and changes in land use and public policy (such as the price of parking).

FIGURE 5

Buses on 101 Carry More People in Less Space

Vehicles containing only one person make up approximately 75 percent of vehicles on 101, despite carrying only 52 percent of passengers. Buses make up less than 1 percent of vehicles yet carry 15 percent of passengers.

Source: Produced for SPUR by Arup based on observation data from San Mateo County, Metropolitan Transportation Commission 2015, http://www.transformca.org/sites/default/files/Optimized%20HOT%20SMC%20101%20Factsheet%20Final.pdf

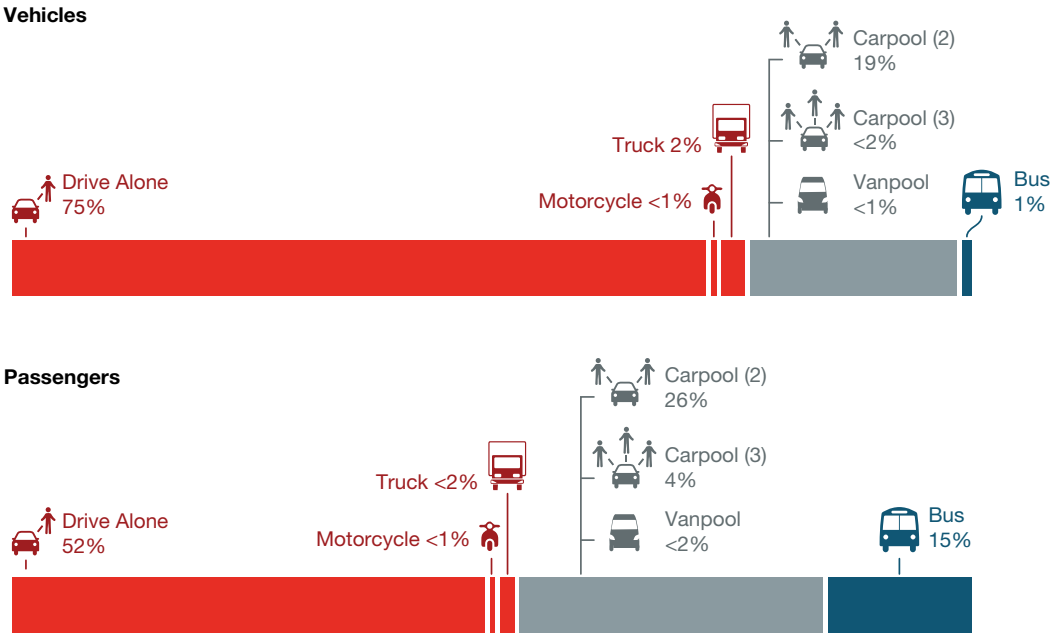
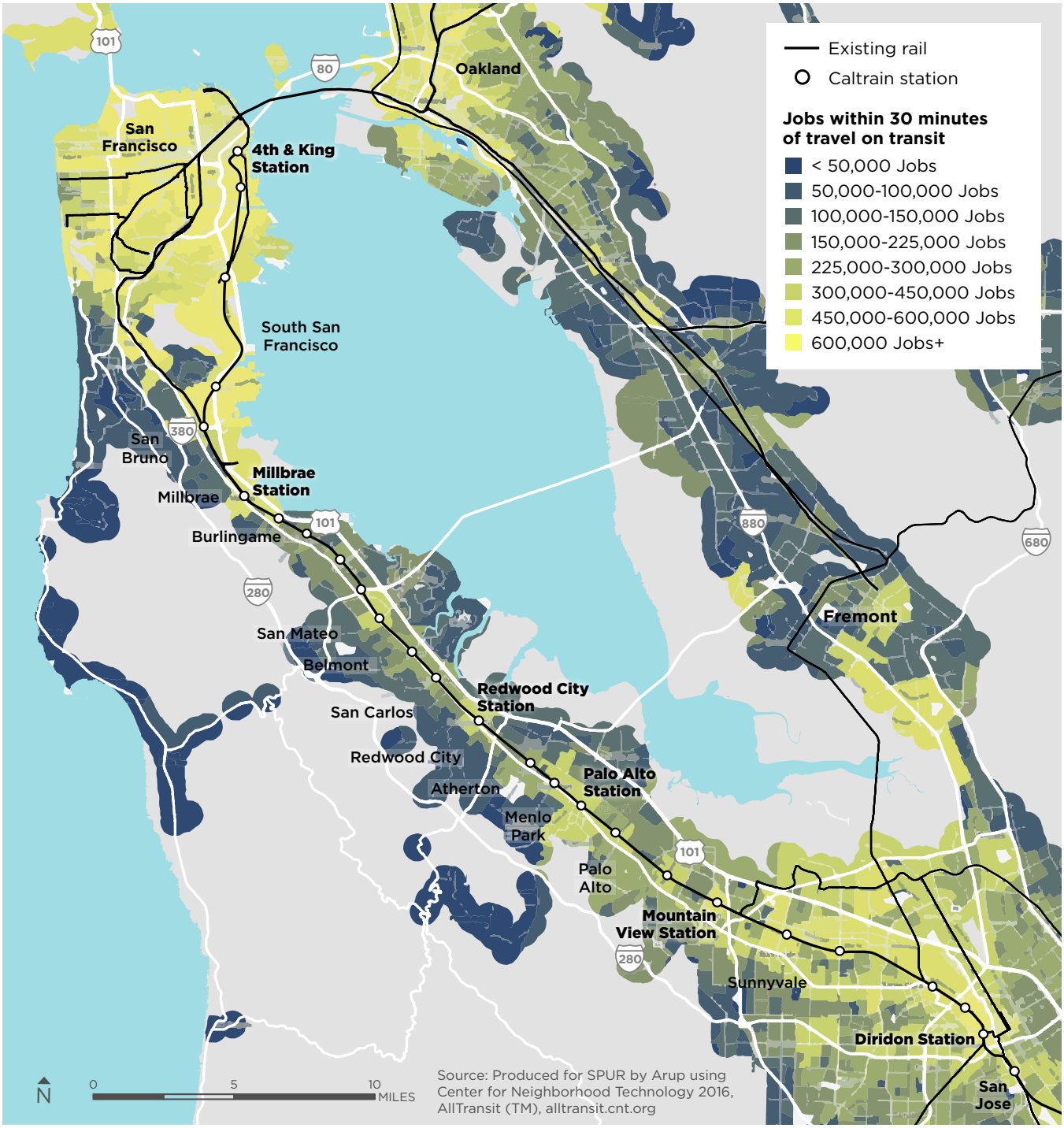


FIGURE 6

Number of Jobs Accessible by a 30-Minute or Less Transit Ride

The density of jobs and availability of efficient transit varies dramatically in the Caltrain Corridor, which affects workers' ability to access jobs. Improved transit services, as well as building more housing near jobs, would give more people access to work opportunities and a higher quality of life.



Source: Produced for SPUR by Arup using Center for Neighborhood Technology 2016, AllTransit (TM), alltransit.cnt.org

CHAPTER 2

Our Vision for the Caltrain Corridor

Convenience, Connectivity, Capacity, Community and Climate Protection

In the future, the way we use transit in the Caltrain Corridor may be vastly different than it is today. Our vision for the Caltrain Corridor centers on a modern and attractive rail system, catalyzed by the electrification of rail in the corridor and the arrival of high-speed rail service, both expected by 2025. Rail can and should be the backbone of Peninsula transportation: It can be fast and frequent, it can shape compact city growth and it's a low-carbon, low-pollution form of transportation.

In this vision, the Caltrain Corridor evolves in five ways:

Convenience

The corridor's robust transit system is useful for many kinds of trips that once took place with a car, or else didn't take place at all:

- Daily trips to work for all types of workers, during both crowded peak commute hours and off-peak hours
- Long-distance trips, such as from San Francisco to San Jose and beyond
- Trips to and from the San Francisco and San Jose airports
- Off-peak work trips or trips to school, such as from San Mateo to Stanford at midday or at night
- Leisure trips for social visits, shopping, entertainment, sporting and cultural events

Frequent Caltrain and other transit services are available throughout the day, allowing more noncommuter trips and freeing people from planning their trips around transit schedules. Trains reliably arrive and depart at the same time each hour on a predictable, frequent and regular schedule. With waits of 10 minutes or less most of the day, frequency is similar to BART service — and average train speed increases, with local, express and eventually high-speed trains.

All transit services — rail, buses and shared mobility — use the same fare structure, easy-to-understand branding and shared information tools, making the system more legible and attractive for users. Transportation services in the corridor are available and affordable to as many people as possible because fare subsidies and policies increase access and help match travelers with empty seats.

Connectivity

The corridor is seamlessly connected with the rest of the region and the state — not just on paper but in the passenger experience. Major rail transfer facilities like the Transbay Transit Center, Millbrae Station and San Jose Diridon Station offer timed connections between services, such as when switching from a high-speed rail train to an express Caltrain. When the Caltrain from San Francisco arrives at Diridon Station, a VTA light rail train waits for Caltrain passengers. Because trains arrive and depart predictably, it is easy to schedule reliable bus connections to and from the corridor's rail stations. Local rail stations are easy to get to and depart from; new types of transit and personal mobility innovations such as e-bikes grow station access.

The ultimate build-out of Caltrain connects to the Transbay Transit Center and then continues under the Bay to Oakland and then all the way to Sacramento (the Capitol Corridor alignment, as envisioned in the Capitol Corridor Vision Plan). In other words, improvements to Caltrain are planned with much more than just the Bay Area, or even high-speed rail to Los Angeles, in mind; this segment is the crux of a San Diego–to–Sacramento high-speed rail corridor that propels California into a sustainable era of mobility and greatly improved quality of life as envisioned in the 2040 California Transportation Plan.[29] Local rail services connect seamlessly to statewide rail services through the Transbay Corridor, the Altamont Corridor, the Dumbarton Corridor, the Capitol Corridor and the Gilroy Corridor. The seamless connections between local, state and regional rail make it logical to use rail instead of driving or flying for longer trips.

Capacity

The transit system moves far more people than it once did. There are more trains operating all day long. Publicly and privately operated regional buses complement rail and provide feeder services to deliver passengers. Buses use a new managed lane on Highway 101 that operates from San Francisco to San Jose. Revenues from dynamic pricing will help subsidize new public transit options along the same corridor, especially for lower income people. Carpools also use this managed lane and enjoy faster trip times. Pricing the lane helps prevent congestion, offering significant time savings for buses and carpools. Ferry service creates a new and expanded option to reach the Peninsula from other parts of the Bay in a shorter amount of time.

The system's expanded capacity has also added resiliency and support for disaster recovery. New transportation modes and transit links help people keep moving in the event of hazards both major and minor. Long-term planning for earthquakes and sea level rise has also prepared the network to handle day-to-day disruptions such as traffic incidents and construction projects.

Community

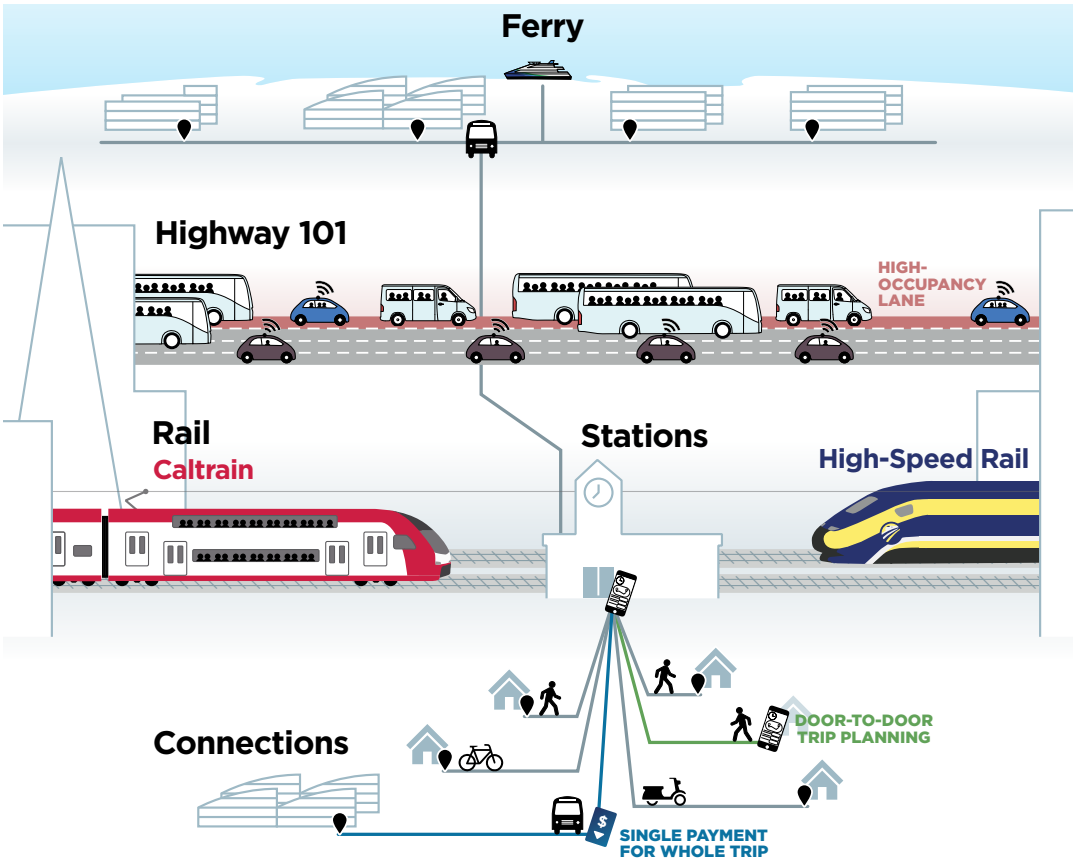
Rail is viewed and used as an asset in local communities. Stations are points of civic pride; architecture and urban design function to make the station both a place to spend time and a gateway to the community. Well-designed and cared for, rail stations signal that they are the heart of the transportation system and a part of the community identity. Stations are integrated with surrounding streets and land uses, which attracts new riders and encourages transit-oriented land use. Local negative impacts from transit — noise, pollution, safety — are reduced or eliminated. Cities are partners in helping transit succeed.

FIGURE 7

How the Corridor Transportation System Would Work

Our vision for transportation in the Caltrain Corridor is a convenient transit system with ample capacity to meet the corridor's needs. Travelers who use transit would have easy trip planning and payment options and a choice of travel modes throughout the day. This approach also supports the development of compact and walkable communities, particularly around rail stations.

Source: Produced for SPUR by Arup



Climate Protection

In this vision of the future, addressing passenger transportation in the corridor has helped California reach its climate goals, such as reducing greenhouse gas emissions to 40 percent below 1990 levels by 2030. Automobiles, the Bay Area's largest single source of climate pollution, are no longer the primary way to travel in the corridor. Walking, biking and public transit make up a much larger percentage of trips than they once did, and the electrification of Caltrain has further reduced emissions. With fewer greenhouse gas emissions, air pollution is down and public health is better. Residents are breathing cleaner air and are at less risk for developing asthma or allergies. The region has saved millions of dollars in avoided hospitalizations and sick days.[30] Meanwhile, cars and their infrastructure no longer interfere with the use of low- or no-carbon modes of transportation. For example, large roadways and fast-moving vehicles are no longer barriers to walking and biking in most of the corridor. People walk to and from stations and around station areas, and walking is prioritized as a means of transportation. Walkers and cyclists of all ages and abilities feel safe due to careful street design.

State, regional and local policies have successfully moved toward a zero-carbon transportation system in the Bay Area. The performance targets in Plan Bay Area, which guides investments and policy decisions for transportation funding, are met and exceeded: We have reduced per capita greenhouse gas emissions from cars and trucks and increased the percentage of trips made by modes other than cars.[31]

FIGURE 8

Upgrading the Capacity to Move People in the Caltrain Corridor

Adding capacity is a key part of the vision plan. As the region grows, highways, rail and ferries should move more people each day.

*Does not include new capacity added by high-speed rail service.

Source: SPUR analysis

	People moved during peak hour today (each direction)	People moved during peak hour under the vision plan (each direction)
Caltrain	3,250	10,800*
Highway 101 (one lane, converted to high occupancy)	1,780	5,680
Ferry	0	1,400

CHAPTER 3

Opportunities and Challenges

Achieving this vision for a great corridor will not be easy. We will need to overcome many long-standing challenges. At the same time, there are opportunities unique to this moment that we can leverage to create a new kind of transportation system. The following opportunities and challenges drive the recommendations in this vision plan.

Opportunity: Electrification and high-speed rail can dramatically improve rail capacity, comfort and reliability.

The next major, long-awaited improvement to rail service on the Peninsula is electrification of the railroad — that is, converting the train fleet from diesel to electric. This project includes electrifying Caltrain tracks between 4th and King Station in San Francisco and Tamien Station in San Jose, together with installing a new train control system and replacing today's diesel locomotives with electric ones. The result will be trains that can run closer together (allowing greater frequency), safer train operations, less pollution, less noise and — importantly — the ability for high-speed rail trains to use the same tracks. Together, these projects are known as the Caltrain Modernization Program (CalMod). The first electric train service is anticipated in 2021.[32]

However, the CalMod project on its own may not increase capacity enough to meet possible future growth in demand. (See page 21 for more discussion.)

The Role of High-Speed Rail

As soon as 2025, high-speed rail will begin operating in the Caltrain Corridor with plans to serve three stations: San Francisco's Transbay Transit Center, Millbrae Station and San Jose's Diridon Station. A fourth station in the Caltrain Corridor, most likely between Millbrae and Diridon, is still under consideration. Seats on high-speed rail trains may be available for local trips (between San Jose and Millbrae, for example), but this will depend on availability, given that many seats will be filled with passengers who started their trip in Fresno or Los Angeles. It will also depend on the price of high-speed rail seats. Pricing policies for high-speed rail will be determined by the concessionaire who operates the service in the future. Nonetheless, high-speed rail seats do contribute new capacity in the corridor as high-speed rail passengers are making trips that would otherwise use Caltrain or Highway 101.

The California High-Speed Rail Authority and Caltrain were part of a nine-party agreement, in 2012, to develop a blended system in which the two services will share tracks and stations, thus avoiding expanding rail to four tracks throughout the corridor. Sharing infrastructure, a practice used in France and Germany,[33] minimizes the cost and impacts on communities and maximizes the benefits from investments in new infrastructure. It can better serve passengers by making stations more compact and transfers between trains easier. This creates an entirely new role for Caltrain as a high-speed rail connector service. (However, as discussed in Chapter 4, high-speed rail service will have to be carefully integrated with local trains.)

High-speed rail trains will use electric multiple units — train cars that receive power from overhead wires. Each car receives its own power, rather than having a single engine at the front or back of the trains.

The rail authority's business plan proposes to deliver the project and begin service in phases.[34] As the size of the high-speed rail network and demand for it grow, the number of trains per hour will increase from two during peak hours and one during off-peak hours to four trains per hour all day.[35] Completion of these phases will depend on funding availability:

Phase 1: Service Between San Francisco and Anaheim

- Silicon Valley (San Jose) to Central Valley (Bakersfield) service begins in 2025. If funding becomes available and the Caltrain Corridor is ready, the northern terminus of this service could be San Francisco and the southern terminus could be Bakersfield. As of publication, this project segment is under construction.
- San Francisco to Los Angeles/Anaheim service would begin in 2029 if funding becomes available.

Phase 2: Service Extended to Sacramento and San Diego

- Service is extended south from Los Angeles/Anaheim to San Diego.
- Service is extended north from Merced to Sacramento.

FIGURE 9

The Future Statewide Rail Network

The ultimate build-out of Caltrain would reach the Transbay Transit Center and then continue under the Bay to connect with a new, electrified and straightened Capitol Corridor alignment (per the Capitol Corridor Vision Plan). In other words, the Caltrain upgrade project is about much more than just the Bay Area or even high-speed rail to Los Angeles and San Diego; this segment is the crux of the San Diego–to–Sacramento high-speed rail corridor that can propel California into a sustainable era of mobility and greatly improved quality of life.

*BART includes VTA's BART Silicon Valley project.

Source: Produced for SPUR by Arup

The Caltrain Corridor will become part of an improved statewide rail network.

High-speed rail and many other statewide rail modernization projects will connect this corridor with other California cities via Amtrak and local services that have timed connections with high-speed rail at transfer points across the state. Regional rail projects will also connect the Caltrain Corridor to the rest of the region and state: BART Silicon Valley (under construction, needs funding), rail service on Dumbarton Rail Bridge (under study, needs funding) and a second transbay crossing (under study, needs funding) could connect the Caltrain Corridor with the Capitol Corridor, reaching Sacramento and beyond.

Opportunity: Electrification can transform the economics of the railroad.

Electrification gives us the chance to create an attractive train schedule with frequent service between the places people want to go while also operating more cost-efficiently. The new electric trains will be electric multiple units: Each rail car has its own propulsion, so cars can be added to make longer trains without losing performance. One of the primary reasons why electrification allows for more efficient service, where trains can run closer together, is that electric trains accelerate much faster than diesel trains. Faster acceleration is important because it reduces the time penalty for making a stop. This makes it more cost-efficient to add new trains to the schedule. The result could be that adding trains to the schedule actually brings in revenue rather than requiring more subsidy. This is especially true in the Caltrain Corridor: Caltrain is almost unique in the world as a single-line commuter rail with bidirectional demand, which makes it possible to fill seats in both directions all day long.

Opportunity: Public-private partnerships and policies can make transit work better.

Private organizations in the Caltrain Corridor are leaders in shifting people away from driving and toward more sustainable travel modes. Tools for reducing solo driving — collectively known as transportation demand management — include charging for previously free parking (with discounts for carpoolers), offering transit passes, and improving infrastructure and facilities for bicyclists and pedestrians. In addition, many large employers run employee shuttle services directly to their campuses from neighborhoods around the region. These shuttles provide employees with an alternative to driving alone and allow workers to begin their workdays while commuting.[36]

Some of this innovation is driven by public policy, such as the trip cap goal that Santa Clara County and Stanford University agreed upon when the county granted a permit for campus expansion.[37] The cap set a limit on the number of vehicles that are allowed onto campus during certain hours of the day. From 2002 to 2015, Stanford University reduced employee single-occupancy vehicle trips from 72 percent to 50 percent by using these strategies and offering services such as the popular Marguerite Shuttle bus system, which is open to the public. Trip caps increase demand for transit services and other more sustainable transportation solutions.[38]

Transportation management associations (TMAs) are another emerging public-private partnership to solve transportation problems for particular communities. TMAs help people shift from driving alone to other travel modes by offering or facilitating carpools, offering transit subsidies and passes, running buses and shuttles for groups of companies, operating "guaranteed ride home" programs, and coordinating parking pricing and other policies. Many of these associations serve downtowns and include smaller business, not just office parks with a few big companies.

One such example is the Downtown Palo Alto Transportation Management Association, which was created to help achieve the city's goal of a 30 percent drive-alone rate.[39] These associations enable employment-rich areas to pool funds to coordinate express buses and carpool/vanpool services for companies too small to run their own. (Technology companies that can afford to operate private shuttles represent a minority of all the employment in the corridor.) Another example of a TMA is Commute.org, a nonprofit governed by 17 cities and San Mateo County. It runs shuttles to multi-tenant office parks, such as a route between Oyster Point and the South San Francisco BART station.

Private employers and institutions are also working proactively to increase bicycling by partnering with cities to build new bike trails and coordinate their plans. For example, the Google Bike Vision Plan, an evaluation of the greater Mountain View area bike network, has proposed changes to make biking safer and more comfortable for a greater segment of the population.

Opportunity: The digital age of transportation portends safe, efficient, convenient passenger transportation.

The digital age of transportation — heralded by the emergence of technology based on apps, sensors and communications — is being invented in the Caltrain Corridor. This creates a multitude of opportunities for new partnerships, pilot projects and testing. Some of these technologies include:

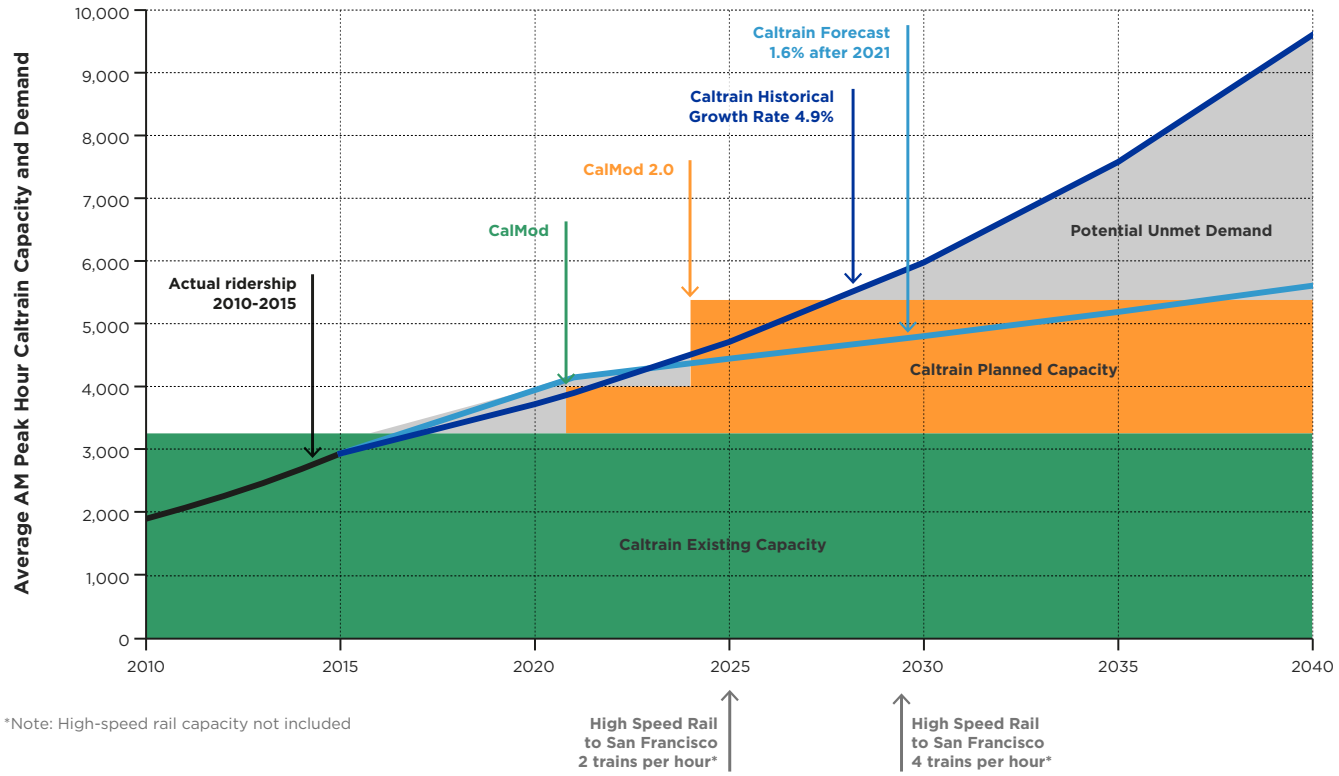
- **Personal mobility options.** Traditional bikes and bike sharing are already common options for personal mobility. Emerging tools include tricycles, cargo bikes, e-bikes, e-scooters and e-skateboards.
- **New delivery options.** Increasingly, people are using delivery services to receive goods rather than making a trip. These services, and perhaps someday automated delivery vehicles (both wheeled and flying), could further transform how people acquire goods.
- **New ways to form carpools.** Alternatives to driving alone have focused on ride-sharing services such as carpools and vanpools. New services are emerging that use internet features and mobile applications to provide on-demand carpooling.
- **On-demand rides.** Transportation network companies, such as Uber and Lyft, provide on-demand rides hailed through a smartphone app (also known as ride hailing). Major growth and change are expected in this sector in the coming years, especially as auto manufacturers and other companies launch ride-hailing services. The ease of ride-hailing may actually increase single-occupant (excluding the driver) auto trips, which works against transportation goals. Ride-hailing could also make high-occupancy carpool lanes overfull with cars with only one passenger (and one driver). A remedy for this is to require three-person carpools in high-occupancy lanes.
- **Mobility as a service.** Mobility as a service refers to the idea that a traveler can get around by comparing mobility services — such as train, taxi, bike sharing or bus — and purchasing services all on one platform. The Moovel smartphone app is an example of this, and a pilot has started in the greater Palo Alto area.[40] Having a single platform enables the public sector or businesses to offer mobility subsidies or discounts to employees, and it also enables data collection.
- **Widespread real-time information.** Continually updated information on conditions and prices for transit and roads — provided through smartphones, electronic signs and other applications — increasingly shapes where, when and how people travel. For example, telling travelers how much parking is available or how long driving would take at a particular time can lead them to choose a different transportation mode. Informing transit passengers when the next train will be arriving both increases comfort and allows passengers to make better use of their waiting time, which can help avoid crowded platforms.

FIGURE 10

More Can Be Done to Meet Possible Demand

Growth in demand could exceed the amount of transit service Caltrain has planned for in the CalMod and CalMod 2.0 projects. (Read more about CalMod 2.0 on page 27.) Transportation solutions for a high-growth scenario need to be developed for rail service.

Source: SPUR analysis of data from the Caltrain Modernization Program



*Note: High-speed rail capacity not included

- **Pricing, payment and traveler information.** Technological advances make trips using multiple services much easier and more seamless, whether travelers are getting from the transit station to their final destination or making connections to the regional and statewide rail network. Technology is also making it easier to get real-time information on what is happening on the ground at any given time. This helps agencies that operate highway or transit facilities to estimate the correct price to shift behavior and get that price information out to users, who can then use it to choose and purchase their mobility. Pricing is one of our strongest tools to balance supply and demand, shape travel choices and help achieve our sustainability goals. At a simpler level, technology is making it easier to offer multiple prices for transportation, such as off-peak transit fares or passes.
- **Autonomous and connected vehicles.** Autonomous or driverless vehicles could lead to a transformation in mobility and how roads are used. One possible impact is that autonomous vehicles may result in reduced car ownership. In cities, fleets of autonomous taxi services available at any time or location could create an affordable alternative to owning a car.[41] Such services are beginning to be tested in U.S. cities. Eventually, existing road lanes could accommodate significantly more vehicles: If cars can sense one another, they can safely travel more closely together. This increase in vehicle flow could be dramatic — equivalent to adding new road lanes.[42] However, the promise that wide deployment of autonomous vehicles will reduce congestion or the need for roads and parking spaces will not come to pass without other public policy interventions, such as pricing of road use and parking and the addition of buses and carpools, which would help avoid a scenario of autonomous car gridlock. This is because the increased efficiencies of vehicles carrying a few people are not enough to overcome the vastly higher efficiencies that are offered by buses and rail.

There are many scenarios for how these technologies might change urban and regional transportation in the Bay Area. Rather than making rail and transit less relevant, these technologies could usher in a new era of rail-oriented urban growth, where land previously used for traffic and parking is used for housing, jobs and public space, allowing transit to operate more efficiently. However, this future can only happen if we choose the right policies and investments today.

CASE STUDY

Switzerland's Taktfahrplan and Bahn-2000

Passengers on the concourse at the Zurich Hauptbahnhof train station, the largest railway station in Switzerland. The Bahn-2000 has been an unprecedented success.

Taktfahrplan: The "Pulse" Plan

Switzerland's highly praised railway system operates based on a *Taktfahrplan*, a public transport schedule that is organized around a repeating beat or pulse (*Takt*). Public transport vehicles arrive at a station at about the same time, passengers transfer between vehicles and the vehicles leave. The pattern repeats on a fixed interval, for example, every half-hour, all day long.

For passengers, a Taktfahrplan schedule is easy to remember and the system provides access to many more places than direct trains; short connection times and reliable service keep transfers from being a burden. For operators, a Taktfahrplan leads to more efficient service by using vehicles and infrastructure more intensively.

When Swiss National Railways began comprehensively implementing the Taktfahrplan in the mid-1980s, the idea was not new. Similar schedules were being operated in the Netherlands and other countries, and the approach of creating pulsed public transport systems had also been used for buses (timed transfers) and even airplanes (hub-and-spoke). The innovation was to implement the Taktfahrplan consistently on long-distance, regional and local trains throughout the country.

Switzerland's approach was very successful. Since 1970, the annual number of passenger-kilometers traveled has increased by 113 percent, compared to only 30 percent in the European Union as a whole. In Zurich, the Taktfahrplan schedule is partly responsible for an increase in ridership on the S-Bahn (similar to Caltrain or BART) by more than 160 percent since 1990.

Bahn-2000

In the 1970s Switzerland voted against building a national high-speed rail system between Zurich and Geneva. Voters opposed it because it would have only served a few cities and because it was already possible to travel the 171 miles between the two cities in about three hours.

Instead of the high-speed line, Swiss railway planners decided to create a supercharged Taktfahrplan with faster speeds on some lines and more connections at hubs. The goal became not to travel as fast as possible but rather as fast as necessary to make the Taktfahrplan work in the entire country. This would make it faster and easier to travel between all destinations in the country, rather than just between the cities on the high-speed rail line.

Applying the Taktfahrplan approach to Switzerland's vast railway network was complex. The main problems were station capacity (tracks for trains and space for people to transfer) and speed on specific line segments. (Some high-speed segments were needed to achieve the required less-than-one-hour travel times, for example, on the line between Zurich and Bern.)

The Bahn-2000 program was designed to build the new infrastructure needed to support the nationwide Taktfahrplan schedule. The program was completed in 2004 and has been an unprecedented success. Rail patronage has risen substantially, and revenues have increased.[49]

However, Switzerland's success is not without drawbacks. Today many parts of the network are overcrowded and capacity is strained. This is also true for other railways that have adopted Taktfahrplan approaches. Consequently, European railways are turning to new methods of strategic planning using information and communications technologies to help them solve the unintended challenges of their success.

Challenge: Caltrain is financially unstable, making it difficult to plan for the future.

While a large sum of funding has been assembled for the CalMod project, the ongoing funding for rail operations and system maintenance continues to be unstable because Caltrain, unlike all other major Bay Area transit agencies, lacks a dedicated source of funding, such as a dedicated parcel tax, sales tax or general fund transfer.

Today, outside of fare revenue (which accounts for nearly 71 percent of operating costs) and grant sources, Caltrain is largely funded through contributions from its joint powers board members (San Francisco, San Mateo and Santa Clara counties), each of which can elect to reduce or withdraw funding at any time — and when one county reduces its contribution, the other counties may also reduce their contributions.[43] This situation not only constrains planning but can also cause a funding crisis at any time, forcing immediate service cuts or project postponement.[44] As discussed above, electrification could change the economics and enable the railroad to have more revenue, but there would still be a need for significant funding to develop the projects outlined in this vision plan.

The lack of an ongoing revenue stream for Caltrain makes it difficult to plan for improved services, a new fleet and new capital projects. Despite clamors for more service today — and despite being located in one of the wealthiest corridors in the nation — Caltrain has not increased off-peak services and only plans for a small service increase with electrification, because the agency does not foresee having the funding to increase train operations. Caltrain's Strategic Plan calls for creating a more frequent, all-day train service that grows to meet demand.[45] However, Caltrain's Short Range Transit Plan, which is constrained by anticipated funding, only expects to increase daily service from 92 trains today to 114 trains a day in 2021, with no increases to follow.[46] (In comparison, currently 285 BART trains per day stop at the Embarcadero station, and BART plans to operate 30 trains each hour through the Transbay Tube in 2021.)[47]

Challenge: Transportation planning is done locally, for one mode at a time, instead of through an integrated, corridor-wide approach.

The sheer number of transportation planning and operating agencies serving this corridor, each with a different focus and geography, makes it hard to plan and implement solutions. Fragmentation in this transportation corridor is worse than in many others: The 47 miles of Caltrain between San Francisco and San Jose traverse 17 cities and involve 10 public transit operators (and a growing number of quasi-public shuttle operators), three county congestion management agencies, regional agencies and state agencies. All of these entities own transportation facilities, operate transportation services or have jurisdiction over transportation decisions.

Making matters worse, transportation jurisdictions typically follow county or city boundaries, but those boundaries don't correspond to how people live their lives. Because city, county and transit agencies all report to their own local boards, the needs of the corridor as a whole are not prioritized, and it can be unclear how corridor-wide projects fit with local plans. While reducing the number of agencies is one strategy to reduce fragmentation, there is also the opportunity for more corridor-scale collaboration on policymaking and infrastructure planning.

Challenge: Neighborhood impacts and policies make it harder to grow rail service.

The railroad has both positive and negative impacts for cities in the corridor — not unlike highways and roads. On the one hand, it provides a transportation service with many social, environmental and economic benefits. On the other hand, trains and related facilities have negative impacts on the surrounding land. As a result, the ability to add service can be hampered by the impacts of the service and infrastructure on neighboring communities. One major concern is safety and traffic around at-grade crossings, the places where the railroad crosses local roads. There are 42 such crossings in the corridor today, and they can affect motorists, pedestrians and cyclists who have to wait until a train has passed. For the past 20 years there has been an average of 13 deaths a year on the Caltrain right-of-way, the majority of which were caused by suicide.[48]

Other major neighborhood concerns are the noise, vibration and pollution from diesel engines. This was an impetus for the electrification project, which will reduce these effects (although locomotive horn noise will not be affected).

Despite these challenges, we can move forward in a unified direction to achieve our vision for the Caltrain Corridor. The next five chapters explain the policy choices, projects and programs that should be pursued across five aspects of transportation: rail, rail stations and connections, Highway 101, ferries and the transit passenger experience. Chapters 9 and 10 explain what the vision plan will cost and how we can fund it.

CHAPTER 4

Rail

Goal: Develop reliable, frequent all-day rail service between San Jose and downtown San Francisco, with enough capacity to meet demand.

Of the many transportation modes in the corridor, Caltrain presents the most exciting opportunities to move more people without more traffic and pollution. We recommend that Caltrain plan to grow its ridership to nearly four times what it is today by making the best possible use of the rail corridor, offering attractive local, express and high-speed rail trains, and extending the rail corridor to reach downtown San Francisco's large transit market.

RECOMMENDATION 1.

Adopt an integrated rail schedule that adds frequency all day at regular intervals, increases capacity to meet demand and attracts new riders.

Who: Peninsula Corridor Joint Powers Board (PCJPB), California High-Speed Rail Authority (CAHSRA), ACE, Capitol Corridor, Amtrak

Rail service in the corridor should have two main service goals:

- **Ensure access.** Provide a predictable minimum level of service at all stations that reliably connects with higher-speed (express) services and the rest of the system.
- **Ensure quality.** Offer travel times that are competitive with driving, especially for longer-distance trips where rail can average higher speeds.

The primary tension with developing a rail schedule is offering service at as many stations as possible (often described as "access" or "coverage" services) while also providing fast travel times. To a limited extent, both goals can be satisfied by providing some "slow" trains that offer more stops and some "fast" trains with fewer stops. For example, electrical multiple unit trains that serve all stops can traverse the corridor in approximately 75 minutes, whereas high-speed rail trains plan to traverse the corridor in 40 minutes, with just one stop in Millbrae. However, above certain service levels, slow and fast trains cannot coexist on the same corridor because fast trains catch up with the slow trains in front of them. For these higher levels of service, passing tracks, which allow fast trains to overtake slow trains, are necessary. An added scheduling challenge is to make sure that trains arrive and depart stations at regular intervals, such as every 10 minutes.

In the future, there will likely be more local trains, more express trains and also high-speed rail trains on the Caltrain tracks. This discussion builds upon the prototypical schedules explored in the 2012 Caltrain/HSR Blended Operations Analysis.[50] It focuses on blending Caltrain's local and express services with high-speed rail, although there are other train operators whose services should be integrated between Santa Clara and Diridon Station and points south.

Service South of Diridon

This vision plan covers the Caltrain Corridor between the future Transbay Transit Center in San Francisco and Diridon Station in San Jose because this is Caltrain's mainline system and is what the current service schedule is built around. However, Caltrain's service south of Diridon — to Tamien, Gilroy and Morgan Hill stations — also needs increased service. These stations currently have three northbound departures each morning and three southbound arrivals each evening. While the CalMod project will extend to Tamien Station, thanks to Caltrain ownership of the right-of-way, Union Pacific Railway owns the segment of rail south of Tamien that extends to Morgan Hill and Gilroy. The future Caltrain service structure will likely retain its focus on service between Diridon and San Francisco, with peak period service to Gilroy, but this has not yet been determined. Service between Tamien and Gilroy will be provided with a diesel shuttle train service. Further research should be done to evaluate options for increasing service south of Diridon.

RECOMMENDATION 2.

Adopt service planning guidelines to correlate future service levels with actual ridership and with ongoing local support for station-area development.

Who: PCJPB, Metropolitan Transportation Commission (MTC), cities along the corridor

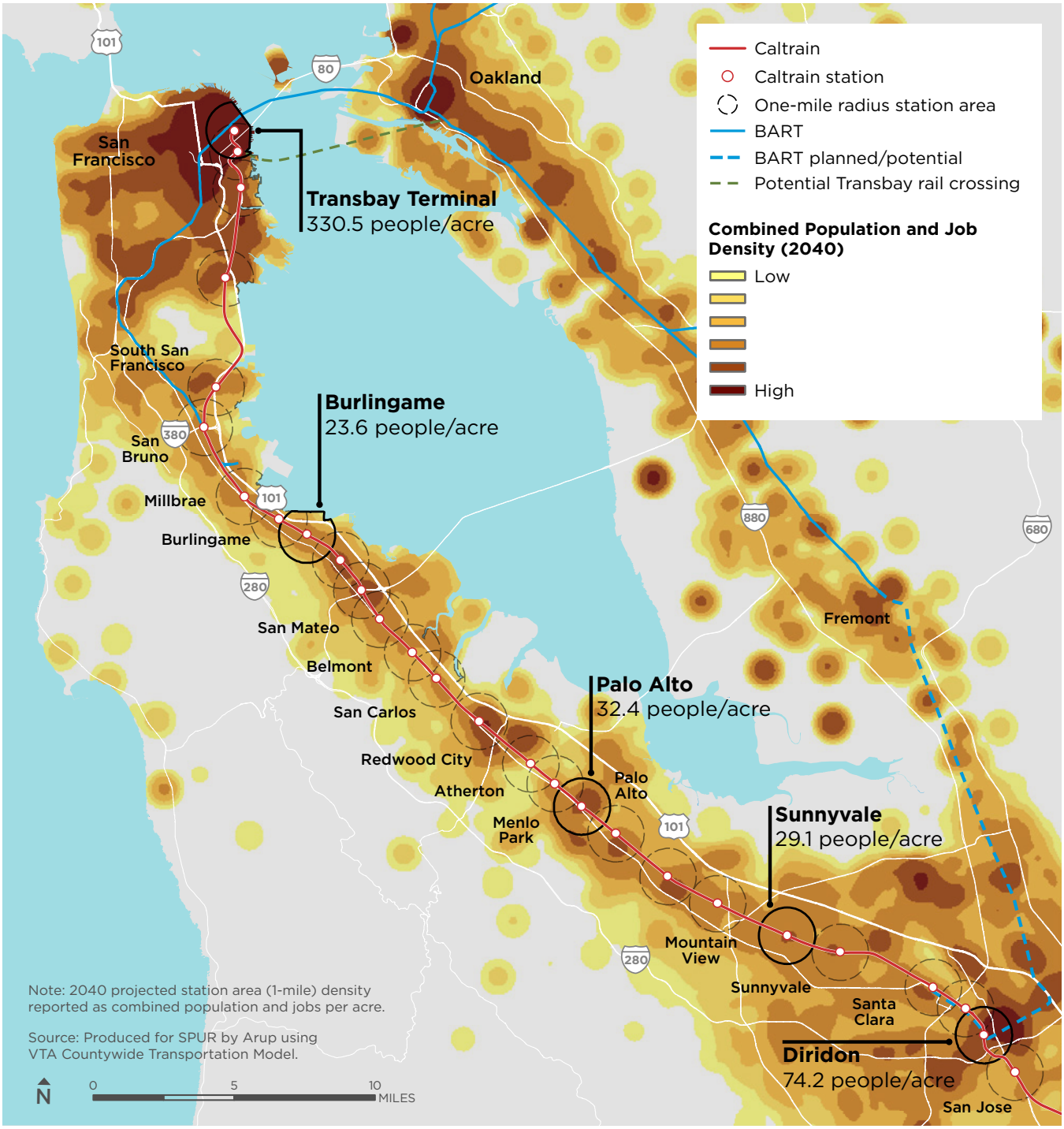
In practice, several factors must be considered when allocating transit service and developing a timetable within a certain operating budget: Which stations should get more express service? Which stations should be ensured a minimum amount of service?

One approach, increasingly used for bus services, is to use a portion of funds for "ridership" services (service where there are the most riders) and a portion of funds for "coverage" services (service at more stops, even when there is little demand), for example, 80 percent for ridership and 20 percent for coverage.[51] Actual land use and actual demand should be a primary consideration for ridership-based services. For example, Lawrence Station in Sunnyvale has historically been a low-density station area but is now being zoned for higher-density jobs and housing and therefore merits higher Caltrain service levels.[52] Stanford Research Park, near California Station, is a similar example.

FIGURE 11

Growing Station Areas Will Need More Caltrain Service

Plan Bay Area 2040 projects that between 2010 and 2040, employment will increase by 51 percent in San Francisco County, 37 percent in San Mateo County and 42 percent in Santa Clara County. The number of households in the three counties is projected to increase by 40 percent, 23 percent and 42 percent, respectively. A large part of this growth is expected within a mile of Caltrain stations (shown as circles).



How to Grow Rail Service in the Caltrain Corridor

In addition to Caltrain's planned increases in service, the vision plan includes three additional stages of increasing Caltrain service. We call them Rail Modernization 3.0, Rail Modernization 4.0 and Rail Modernization 5.0. Here we highlight the investments that will be needed at each phase in order to keep growing capacity and offering an attractive train schedule. High-speed rail capacity is described in the figure at right, however it is unknown at this time if seats on those trains will be available to meet demand for local trips between San Francisco and San Jose. See Appendix A for more detail. (Available at spur.org/caltraincorridor.)

Existing Plans

- **Today: 60,000 seats/day.** Caltrain currently operates 92 trains per day, with local, limited and Baby Bullet trains. There are approximately 5 miles of existing passing tracks.
- **Electrified Opening Day: 94,000 seats/day.** Electrification includes the train control system upgrade, installing catenary wires and buying 96 electric railcars. On opening day, electrified service can provide a daily line capacity of approximately 84,000 daily passengers. (This assumes a peak period schedule of six trains per hour composed of Baby Bullet and skip-stop trains.[61])
- **CalMod 2.0: 125,000 seats/day.** CalMod 2.0 can provide a daily line capacity of 110,000 passengers by lengthening platforms at 17 stations, operating eight-car trains and purchasing an additional 96 electric cars. Critical grade separations would likely need to be completed before increasing train frequency beyond this level.

Vision Plan

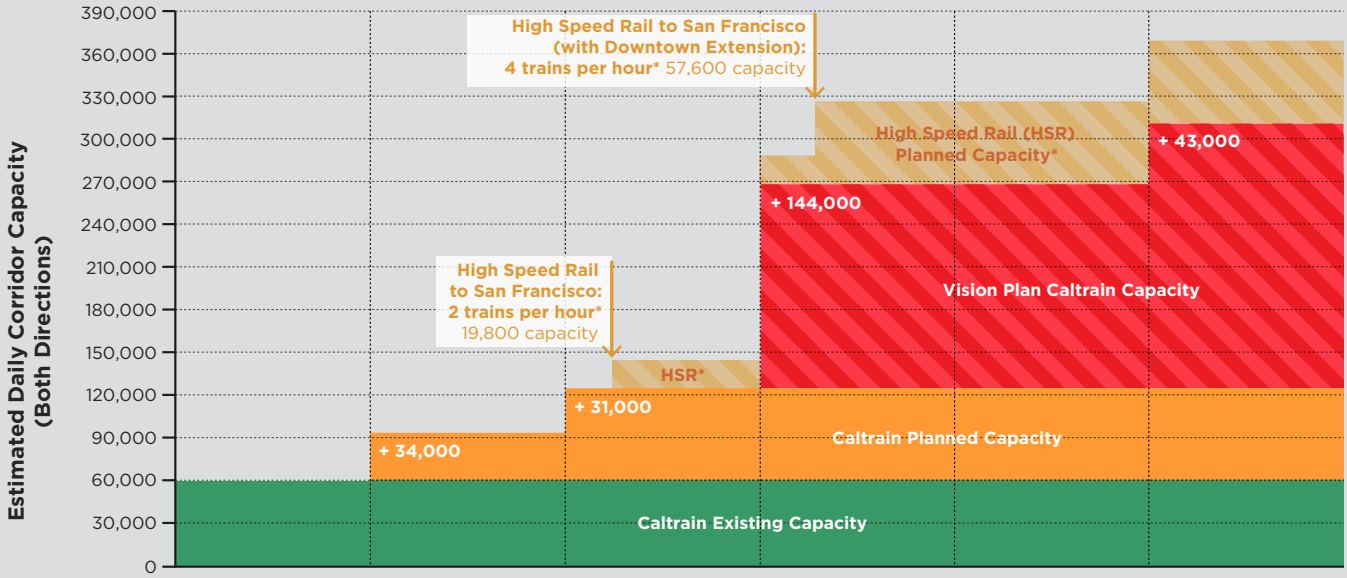
- **Rail Modernization 3.0: 269,000 seats/day.** Phase 3.0 is marked by the introduction of high-speed rail (four trains per hour, serving San Jose Diridon, Millbrae and San Francisco 4th and King). Caltrain can provide a daily line capacity of approximately 269,000 daily passengers at this point by increasing peak period service to eight trains per hour and operating on a skip-stop service pattern. This will require approximately 10 new miles of passing track and 65 additional electric railcars. Without the new passing track, high-speed rail trains would have significant impacts on Caltrain's schedule. Approximately five stations will need to be reconstructed. Critical grade separations need to be completed before increasing train frequency further.
- **Rail Modernization 4.0: 269,000 seats/day.** Phase 4.0 is marked by the opening of the Caltrain and high-speed rail extension to San Francisco's Transbay Transit Center. It also includes the construction of approximately 10 new miles of passing tracks. This new passing track will reduce the travel time of every Caltrain train (by approximately four minutes each between San Francisco and San Jose) by enabling high-speed rail to overtake Caltrain trains without delays, which is not possible under Rail Modernization 3.0. Approximately seven stations will need to be reconstructed during this phase. New capacity on Caltrain will be needed to accommodate the new riders that come with the opening of the extension to the Transbay Transit Center in 2025 (discussed in Recommendation 6).[62]
- **Rail Modernization 5.0: 312,000 seats/day.** At phase 5.0, there are two choices for increasing ridership and train frequency; both would require major policy changes. One is to completely separate the high-speed rail and Baby Bullet trains from slower trains and operate them on a new, separate pair of tracks. This requires four tracks for the length of the corridor — an additional 20 miles more than Rail Modernization 4.0. However, due to community concerns, legislation that has enabled implementation of the blended system currently precludes a four-track solution. (See further discussion in "Barriers to a Four-Track System" on page 28.) An alternate choice is to further optimize the use of the existing rail infrastructure, changing the operating conditions for local, express and high-speed services such that high-speed trains operate at the same speed as Baby Bullet trains. Potentially, high-speed trains could operate on a Baby Bullet-like schedule in the corridor. In either case, there are opportunities to increase ridership and service in the corridor, but the options will require addressing legislative and governance barriers to implementation as well as community and environmental concerns.

FIGURE 12

Keep Growing Rail Service in the Caltrain Corridor

The opportunity to offer attractive and coordinated local, express and high-speed rail service in the Caltrain Corridor depends on what investments and policy decisions are made. The addition of train cars, passing tracks and station modifications all support service growth.

Source: SPUR analysis.



Caltrain Service by Phase

	Existing	CalMod	CalMod 2.0	Rail Modernization 3.0	Rail Modernization 4.0	Rail Modernization 5.0
Estimated timeframe	-	2021	2024	~2025	~2030	~2035
Estimated daily capacity	60,000	94,000	125,000	269,000	269,000	312,000
Peak-hour capacity per direction	3,250**	4,000	5,400	7,200	7,200	10,800
Off-peak capacity per direction	650-1,300	1,300	1,800	5,400	5,400	5,400
Trains per peak hour	5	6	6	8	8	12
Peak-hour station train frequency	12-36 minutes	10-30 minutes	10-30 minutes	7.5-15 minutes	7.5-15 minutes	5-15 minutes
Services patterns	Baby Bullet + Limited	Baby Bullet + Limited	Baby Bullet + Limited	A-B Skip-Stop	A-B Skip-Stop	Baby Bullet + A-B Skip-Stop
Vehicles	+ 16 diesel cars	+ 96 new electric cars	+ 96 new electric cars	+ 65 new electric cars	-	+ 80 new electric cars
Infrastructure	-	Train control, signal system	Longer platforms for 8-car trains	+10 mi passing tracks/stations grade separations	+10 mi passing tracks/stations grade separations	+20 mi passing tracks/stations grade separations

*Actual capacity for local trips on high-speed rail will likely be significantly less than total capacity due to long-haul riders.

** Does not include capacity gained by increasing from 5-car to 6-car trains. 6-car trains will have a 3,900-person capacity per hour per direction.

Note: New track mileage is four-track corridor mileage. Assumptions were made about off-peak service levels to arrive at daily capacity estimates. Ridership can exceed capacity because a single seat can serve multiple riders along the line.

Sources: Caltrain Modernization Program, California High-Speed Rail Authority Buisness Plan, May 2016, SPUR analysis

Sergio Ruiz

One way to ensure ridership and local support is for Caltrain to adopt service planning guidelines that suggest what levels of service to offer at what types of stations and also help guide the location of new stations or the decision to close stations. The policy would encourage local jurisdictions to include complementary transit-oriented development policies such as minimum densities, parking maximums, requiring transportation demand management or anti-displacement policies. The policy could also provide a way to factor in the availability of shuttles and other "first and last mile" connections to get travelers to and from transit stations. Other Bay Area transit operators have similar policies, such as VTA's Service Design Guidelines.[53] Caltrain can encourage station-area development that supports transit ridership by adopting transit-oriented development policies for Caltrain's properties and by participating in local station-area planning efforts.[54]

RECOMMENDATION 3.

Add system upgrades, infrastructure and new train cars strategically to increase frequency, add capacity, increase reliability and reduce travel times.

Who: PCJPB, CAHSRA, Transbay Joint Powers Authority, cities along the corridor

Specific system improvements will be needed to improve the operational flexibility and performance of the overall corridor. Figure 12 on page 25 explains how they can be used together to grow capacity over time. We recommend the following types of infrastructure and system upgrades:

Passing Tracks (Third and Fourth Tracks)

Most of the Caltrain Corridor still has only two tracks, with few opportunities for trains to overtake one another. The lack of passing tracks, where an additional track allows a faster train to pass a slower train, limits the flexibility of the train schedule. Installing passing tracks at the Bayshore and Lawrence stations allowed Caltrain to create the Baby Bullet service. There are two main types of passing tracks. One is rolling overtake tracks, which allow moving trains to overtake other moving trains. These are used today for the Baby Bullet service. The other is passing tracks at stations, which enable trains to pass stopped trains. Other types of tracks are pocket tracks (where a train pulls over and can be passed) and crossing tracks (where trains can switch between tracks).

On a two-track rail corridor, the service goals of speed, coverage and capacity are at cross-purposes; only two of these goals can be completely optimized in a given service pattern. Today, nearly all northbound trains use one track, and southbound trains use the other. In the peak period, to accommodate a mix of fast and slow trains (i.e., Baby Bullet and limited-stop trains), extra tracks are used at specific locations to allow fast trains to pass slower trains. Increasing the length of these existing passing tracks can improve schedule reliability.

Especially when high-speed rail operates on the Caltrain Corridor, having many opportunities for faster trains to pass slower trains will be critical to having an attractive train schedule.[55] The 2013 Caltrain/High-Speed Rail Blended Service Plan Operations Considerations Analysis investigates different passing track options for when high-speed rail and Caltrain operate together.[56]

New Train Cars and Configurations

The size of the fleet limits the amount of train service that can be operated, particularly in the peak hour. Additional train cars will allow more trains to be offered in the schedule. The configuration of seats and other facilities in train cars determines how many seated and standing passengers, as well as bicycles, can fit. As of 2016, the PCJPB has made policy decisions for the new electric train cars to have a seat-to-bike-space ratio of 8-to-1 (versus today's 9-to-1) and to have one restroom per six-car train set. Removing seats could further increase capacity, although some people may not be willing to stand on the train and will choose not to use the service.[57] Removing space for bikes would allow room for more passengers. Caltrain's short-range plan calls for new train cars, though funding needs to be identified. The next generation of train cars should be articulated cars, which add capacity and comfort.

Longer Platforms

Increasing train length is a cost-efficient way to add rail capacity. However, of the 27 stations that will get electrified service along the corridor, 18 are designed for today's six-car trains; the platforms are not long enough to accommodate longer trains. Some stations (such as California Avenue) have ample space to lengthen platforms while others (such as Mountain View) do not. An intermediate operational solution is to instruct passengers getting off at particular stations to move to a certain train car in order to disembark.

Upgraded Signaling System

Signal systems manage train movement. Sophisticated signal systems can help ensure safer train operations while shortening the required time between trains. This in turn makes it easier to schedule more trains per hour, increasing overall corridor capacity. Installing a new signaling system is part of the CalMod project. The Communication-Based Overlay Signal System Positive Train Control system, to be implemented by the end of 2017, brings federally mandated safety improvement to the corridor. The signal system will be overlaid on the existing train control system and will enable crossing gates to be down for shorter times, optimize train speeds and create safety improvements.

Further upgrades to the signal system may be warranted in order to operate trains more efficiently and could be a cost-effective investment, especially compared to new infrastructure. It's not uncommon to have train spacing of 90 seconds on rail systems in other regions; today Caltrain operates with five or more minutes between trains.

Maintenance, Support Facilities and State of Good Repair

As the size of the fleet increases, new maintenance facilities will be needed to store and repair trains, though their locations have yet to be determined.[58] As structures, facilities and vehicles progress through and exceed their useful lives, they require rehabilitation and replacement. State-of-good-repair investments and specific rehabilitation and maintenance activities are required to maintain Caltrain's existing and planned structures, facilities and train cars. Track rehabilitation, bridge replacement, station rehabilitation and diesel train rehabilitation are all examples of state-of-good-repair projects needed to keep growing rail capacity. Two related projects are improvements to North Terminal (4th and King rail yards) to improve operations and South Terminal (Gilroy) to increase operational flexibility.[59]

Level Boarding and ADA Access

Today Caltrain riders must use interior steps to board trains rather than stepping directly from the platform onto the train floor, known as level boarding. Level boarding makes it faster to board large numbers of people and offers easy boarding for people using wheelchairs (who have a very painstaking boarding process today). Faster boarding makes station stop times shorter and more predictable, which can shave several minutes off running times and help trains run closer together. Level boarding will be essential to achieving the high level of service that we envision for the corridor.

A related issue is platform sharing for high-speed rail and Caltrain, which would enable the two services to share tracks. This would make it easier for passengers to navigate the station and transfer between trains; it also makes more efficient station design possible. High-speed rail requires one platform height across the state, so Caltrain would have to use two different door heights on each train car until all 27 Caltrain stations are reconstructed with 50-inch-high platforms, the same as high-speed rail. During this transition time, passengers with disabilities and those with bikes would need time to move to different areas of cars, which they would not need to do with level boarding. Level boarding is also a solution for ADA access. The ADA goal is unassisted boarding for disabled passengers for any train. This can best be accomplished through level boarding with gap filling.[60] Otherwise, disabled passengers will continue to need crew assistance to board or alight.

Accelerating Rail Investments

Some projects can be accelerated and begin to offer benefits without requiring other projects to be completed. These include adding electric multiple unit railcars, grade separating tracks from roads, lengthening platforms, and modifying platforms to provide level boarding and reduce time stopped at stations. Many of these are planned as part of the CalMod 2.0 project, the next series of system investments planned after the initial modernization program. CalMod 2.0 elements include: acquiring electric train cars to allow the entire fleet operating between Tamien and San Francisco to be converted from diesel to electric (as planned, approximately 75 percent of the service operated by Caltrain would become electric on opening day of electrified service); expanding all electric multiple unit trains from six- to eight-car trains; implementing level boarding; and reconstructing platforms to accommodate eight-car trains. Seated, peak-hour capacity would increase 32 percent with CalMod 2.0; with electrification there will be a significant increase in comfortable standing room (approximately 40 percent in the peak hour) as the gallery cars are replaced with electric multiple units.

Station reconstruction does requires a comprehensive passing track strategy to understand which stations will require reconstruction and when. Locating new passing tracks will dictate which stations are reconstructed and when.

Barriers to a Four-Track System

As discussed on page 24, four-track segments would help run a higher-capacity and more reliable rail service in this corridor. Four-track segments would become especially important when high-speed rail and Caltrain operate together. Much of the Caltrain Corridor that is owned by the PCJPB is wide enough for four tracks of rail. (Seventy-five feet is the approximate width required for four tracks that include high-speed rail operations.[63]) To bring the entire corridor to a width appropriate for four tracks would require acquiring several hundred acres of land, many in places with structures or buildings that would need to be removed, such as buildings in downtown San Mateo and downtown Redwood City and tunnels in San Francisco. Unfortunately, these barriers exist in some of the locations that would be the most useful for passing tracks, such as the Palo Alto area.[64]

A *full* four-track rail system along the entire corridor would offer a high level of flexibility and reliability, such as the New York City subway system has. But this option is not under consideration for the Caltrain Corridor due to the agreements reached for the blended system in 2013. In 2009, the California High-Speed Rail Authority proposed a four-track system for the Caltrain Corridor. It would have been on grade-separated track, with portions on a viaduct, but this faced opposition due to visual impacts, plans to extend beyond the existing Caltrain right-of-way and an overall lack of investment in Caltrain. Ultimately, leaders agreed on the blended system project, which would remain substantially within the Caltrain right-of-way and be primarily a two-track system.

Each of the following policies would have to be revisited in order to develop beyond a primarily two-track system:

- **HSR Prop. 1A Legislation.** The legislation funding high-speed rail sets the maximum travel time between Los Angeles and San Francisco, and therefore establishes the average travel speed for the project. If high-speed trains are slowed in the Caltrain Corridor by not having enough dedicated tracks, the overall travel time between San Francisco and Los Angeles would be affected.
- **SB 1029.** This state bill, which provides $705 million of Prop. 1A bonds for Caltrain modernization, made it state law that Prop. 1A bond funding could not be used for a four-track system. SB 1029 states that "Any funds appropriated in this item for projects in the San Francisco to San Jose corridor consistent with the blended system strategy identified in the April 2012 California High-Speed Rail Program Revised 2012 Business Plan, shall not be used to expand the blended system to a dedicated four-track system."
- **2012 Nine-Party Memorandum of Understanding.** The 2012 nine-party MOU states that high-speed rail will operate primarily on a two-track system.

RECOMMENDATION 4.

Improve Caltrain service in the short term, before electrification.

Who: PCJPB

Caltrain faces funding constraints for both capital and operating costs. Funding available today is being used appropriately to support the delivery of Caltrain electrification. However, if those short-term funding constraints could be unlocked (see ideas in Chapter 9, "What the Vision Costs"), there is the potential to increase capacity and meet some long-term service goals earlier. Capacity improvements that could be made before electrification include:

Improvements that would not likely require additional funding:

- Add another train in the shoulder of the morning and evening peak hours (that is, the hour before and after the current peaks, for example, 9 a.m. to 10 a.m.).
- Introduce short-run trains (for example, shuttle service between San Francisco and mid-Peninsula stations).

Improvements that would require additional capital and operating funds:

- Purchase additional railcars. This would have the potential of adding capacity in the short term by making all trains longer (increasing from five to six cars) and by providing the flexibility to add more trains in the peak periods.
- Purchase or lease new diesel locomotives. One of the short-term constraints on Caltrain's current fleet is the age of the existing locomotives. Having additional locomotives would provide the flexibility to add additional trains during peak hours and throughout the day. While Caltrain is focusing on changing the fleet from diesel to electric, diesel locomotives will still be needed for the Gilroy service, so the investment would have a long-term return.

The period before electrified service is also a good time to experiment with fare policies and other strategies to manage demand and attract riders. Insights gained from these experiments can help design the best electrified service plan possible.

In broad terms, if capital and operating funding could be identified for short-term improvements, there is the opportunity to increase peak hour capacity by 20 percent before electrification and by 37 percent after electrification. Other opportunities exist to increase off-peak service, although construction of the electrification project will limit those opportunities and they will not be fully realized until the electrification project is complete.

In Berlin, rail grade separations are integrated with neighborhoods.

RECOMMENDATION 5.

Use a corridor-wide strategy to address the impact of at-grade rail crossings.

Who: PCJPB, CAHSRA, MTC, cities along corridor

Between San Francisco and San Jose, there are 42 at-grade crossings where the rail tracks cross a local road and traffic typically has to stop in order for a train to pass. (Grade-separated crossings, by contrast, put the road in a tunnel or the tracks on a viaduct.) Some of these crossings are adjacent to stations and some are between stations. We need a unified corridor-wide strategy that ensures the most critical crossings are addressed and funded first. The current practice is that municipalities initiate and fund grade-separation efforts. Consequently, grade separations take place where funding is available, not necessarily where they are most needed.

With a corridor-wide strategy, design, engineering and construction best practices can be shared; construction timing can be coordinated together with railroad projects; and grade crossings can be coordinated with station-area development.[65] Also, in places where a four-track grade separation will be needed in the long run, this could be considered early in the design process, together with the overall corridor service plan.

Grade separations are not required by law for any of the service scenarios proposed on pages 24–25.[66] However, higher train frequencies could impact local street circulation by requiring crossing gates to be down more often or for longer periods.[67] There are two primary solutions for eliminating at-grade crossings, both of which should be considered when looking to do what is most cost-effective and what does the most to improve the neighborhoods near stations:

- **Grade separation** is a physical separation of the rail from the local road, usually by raising the rail above the road or lowering the road beneath the rail. Grade separations involve the construction of bridges and/or tunnels and are therefore costly.
- **Closing the road to autos** avoids large grade separation projects and in some cases reduces the traffic on a road. The City of Mountain View has suggested closing Castro Street where it crosses the Caltrain tracks. Access for cyclists and pedestrians could be maintained with a tunnel or a bridge.

Freight Policies

Caltrain's agreement with Union Pacific Railroad gives Union Pacific the authority to operate freight trains on its tracks north of Tamien Station. South of Tamien Station, Union Pacific owns the tracks, and the PCJPB negotiates rights for Caltrain to use them.[68] Freight trains use capacity that could otherwise be available for passenger service, and their facility requirements differ from passenger trains, which affects grade separations. For example, freight trains are limited to about 1 percent grades while commuter trains and high-speed passenger trains can climb grades of 3 percent. Any rail grade separation that must accommodate freight trains' gradual grade requires longer retaining walls and approach ramps. And since freight trains are three feet taller than passenger trains, they also require a deeper trench.

The tradeoffs to passenger service, and to the areas around grade separations, should be considered when determining what type of freight trains use the corridor. Freight is an active piece of the local economy. In the very long run, if land use in the corridor continues to move away from manufacturing, it may be worth revisiting the role of freight on Peninsula rail.

The Transbay Transit Center in downtown San Francisco will connect Caltrain and high-speed rail with BART, SFMTA light rail and numerous bus lines.

RECOMMENDATION 6.

Connect Caltrain and high-speed rail to downtown San Francisco at the Transbay Transit Center.

Who: PCJPB, Transbay Joint Powers Authority, MTC, City and County of San Francisco, CAHSRA, San Francisco County Transportation Authority (SFCTA)

Extending Caltrain service to downtown San Francisco at the Transbay Transit Center has been a goal for decades. (Caltrain currently ends at San Francisco's 4th and King Station, one mile away from Market Street and the Financial District.) Bringing high-speed rail to the transit center is part of the Proposition 1A funding program for the high-speed rail project. When rail runs directly from downtown San Francisco through Silicon Valley cities to San Jose, the corridor can function as one economic cluster connected by rail. The area around the Transbay Transit Center will be the densest cluster of employment in the Bay Area, with 176,000 jobs within a half-mile walking radius.[69]

The Downtown Extension Project (DTX), an approved but unfunded project, would construct a 1.3-mile tunnel from 4th and King Station to the new Transbay Transit Center. At the transit center, rail would connect with BART and SFMTA light rail (via an underground pedestrian walkway), as well as a bus terminal that can serve 300 buses per hour — the equivalent passenger capacity of a BART station.[70]

We have learned from the BART system experience that reaching new markets through extensions requires a commensurate investment to increase capacity and frequency in the core part of the system: Today's crowded conditions in BART's Transbay Corridor are a case in point. In the case of the DTX, this means investment in Caltrain's main line.

The actual number of non-high-speed trains per hour that the DTX and Transbay Transit Center will accommodate has not been finalized and will depend on the design of the extension as well as how long trains will be stationed in the transit center for turnaround processes (cleaning trains, train startup, etc.). The shorter the turnaround times, the more trains can come in and out of the station. Many components of the DTX can still be revised to optimize overall operations: the number of Transbay Transit Center platforms and tracks assigned to Caltrain and high-speed rail; the layout of interlocking trackwork; the track layout where DTX interfaces with the existing approach to 4th and King Station; and the number and configuration of tracks between the existing 4th and King approach and the Transbay Transit Center. San Francisco is studying alternative alignments for the DTX project through the Railyard Alternatives and I-280 Boulevard Feasibility Study.

A business plan for Caltrain would identify ways to maximize service quality and ridership while also maximizing revenue. One aspect would be an examination of all possible revenue sources, including real estate, parking, concessions and railroad tenants.

RECOMMENDATION 7.

Develop a business plan for Caltrain.

Who: PCJPB, CAHSRA

Public transit is a business that provides a public service. There are sources of revenue and there are costs, and in order to best serve the public and sustain transit for the long run, it's important to approach the operation of the railroad with a business plan.

One aspect of the business plan should be a business case analysis, a tool to compare the benefits of different types of investments. Investment options can be compared across a spectrum, such as costs to benefits; value for public investment; environmental, economic and social benefits; impacts on communities and alignment with social goals.

Business planning should be an ongoing practice. There are many ways to improve rail capacity, including changing the train schedule, adding new rail cars, upgrading systems and adding new infrastructure. In practice, funding arrives incrementally so there are many opportunities to reprioritize. All rail investments should be compared against one another at each point in time: There may be more than one way to decrease travel times or better ensure that trains meet at transfer points at the correct time — all at very different costs. (For example, shortening stopping times at stations may be as effective as buying new train cars.) Similarly, it might be more cost-efficient to attract new riders with investments in the railroad instead of funding more first- and last-mile solutions (or vice versa).

Another aspect of the business plan is an examination of all possible revenue sources, including real estate, parking, concessions and railroad tenants. Finally, a business plan enables us to benchmark the Caltrain system against other comparable rail systems.

New Rail Services: Concepts for the Future

The projects in the vision plan are not the full extent of what will be needed in the future: We should continue to grow the rail network as population grows. This means looking at adding local routes that connect with Caltrain (possibly types of transit other than rail), creating major transit corridors that connect with Caltrain and considering entirely new alignments within the Caltrain Corridor.

Local Connections

Some places are growing dense enough that a new transit line might be the best first- and last-mile solution. For example, the Mountain View Shoreline Boulevard Study is contemplating various technologies and pathways to connect the Mountain View Transit Center Caltrain station with the North Bayshore neighborhood.[71] Another example is an automated train (people mover) connection between San Francisco International Airport and the San Bruno BART station (similar to the existing automated train at SFO) or between Mineta San Jose International Airport and Santa Clara or Diridon stations. Similarly, bus rapid transit routes to Bayshore Station and the Transbay Transit Center are also being studied. While these projects are not included in this vision plan, they are a key part of the transportation network that must be considered for the future.

Major Connecting Corridors

During the vision plan timeline, the Caltrain Corridor should become well connected with the rest of the regional and statewide rail network. (See Figure 9 on page 17.) The following three rail corridors are complements to the vision plan, and those responsible for rail in the Caltrain Corridor should treat them as extensions of their own work and goals.

Transit in the Dumbarton Rail Corridor. SamTrans purchased the old Dumbarton freight rail bridge and corridor (which runs from Menlo Park to Redwood City) in 1994. There have been several studies of how to turn this into a bus or rail corridor, and it is included in the Regional Rail Plan.[72] However, regional funding for this project has been used for other purposes, and today there is a peak-hour bus service (Dumbarton Express) on the Dumbarton roadway bridge (Highway 84). An efficient transit service — one that is separated from traffic to offer travel-time savings and well connected with destinations on both sides of the Bay — could move many people who would otherwise need to drive on the crowded Dumbarton and San Mateo bridges. The system could be designed so that trains that operate on the Dumbarton freight rail bridge could share tracks with Caltrain. A study of transit options will be completed in 2017. Decisions for this corridor are made by a consortium of transportation agencies called the Dumbarton Rail Policy Advisory Committee.

BART Silicon Valley connection to Caltrain. The extension of BART from the East Bay to Silicon Valley is a project of VTA. Phase I of the project, which extends BART from Fremont to stations at Milpitas and Berryessa in San Jose, is scheduled to be completed in 2018. Phase II will continue BART from Berryessa Station and connect it with Caltrain and high-speed rail at Diridon Station using a 5-mile tunnel under downtown San Jose. Until Phase II is completed (funding and environmental review are nearly completed), there is no all-day rail connection between Silicon Valley/San Jose and the East Bay.[73]

A second transbay rail crossing. The existing Transbay Tube, which carries BART under the Bay between San Francisco and Oakland, is not well connected with Caltrain or the Peninsula. Additionally, it's operating at capacity and is in need of major rehabilitation. A second transbay crossing has been contemplated for decades and would provide significant opportunities for the Caltrain Corridor. The foremost opportunity may be the chance to have tracks that would accommodate conventional rail trains, such as Caltrain and high-speed rail, rather than just BART trains. Even rubber-tired vehicles and light-rail vehicles are under consideration.

Rail service across the Bay could connect people directly to the Caltrain main line (rather than requiring a transfer between the BART and Caltrain systems) through a connection at the Transbay Transit Center or in the Mission Bay area. A rail connection across the Bay also creates the opportunity to move rail maintenance or storage facilities to other parts of the region. Furthermore, it could also increase the capacity on the main Caltrain line by allow trains at the Transbay Transit Center to continue across the Bay rather than making the transit center into a terminal where trains must turn around. A second transbay crossing is under consideration as part of local planning in San Francisco and Oakland, in the MTC Core Capacity Transit Study, and is part of the 2018 Statewide Rail Plan.[74]

New Alignments in the Caltrain Corridor

If growth continues in this corridor, it's worth thinking innovatively about how to keep people moving by adding new rail alignments. Given the potential for growth at locations east of Highway 101 that are not near existing rail stations, one possibility is a new rail branch through this area. This rail line could branch off from the Caltrain Corridor between Redwood City and Santa Clara, serving new potential markets in the cities of East Palo Alto, Mountain View, Sunnyvale and Santa Clara. Representative new stations on a new Bayshore branch alignment could include Bayfront/Menlo Park, East Palo Alto, North Bayshore, Moffett, Great America Parkway and Levi's Stadium.

Although the estimated costs of a new rail alignment are very high — between $8 billion and $13 billion — the benefits could be great: increasing rail service, bringing high-speed and local train service closer to growing destinations and opening up capacity on the main line for local trains.[75] The infrastructure could even double as sea level rise or bayshore protection. A significant amount of growth would be required in this corridor, particularly at station areas, in order to justify such an investment.

If high-speed rail proves popular enough to justify its own right-of-way, another very long-term idea worthy of consideration is to create a high-speed rail structure in the middle of Highway 101.

CHAPTER 5

Rail Stations and Last-Mile Connections

Goal: Offer quick and intuitive connections at modern, high-amenity stations.

Historic Palo Alto Station is one of Caltrain's highest-ridership stations thanks to a multitude of ways to get to and from the station.

Growing Caltrain to accommodate increased demand for transit along the Peninsula requires the stations to grow along with the service. Stations are the portals where people begin and end their trips. Well-designed stations help people understand the transportation system and make it easier to use. Improving Caltrain for the future means not just improving and expanding the physical spaces but also enhancing the passenger experience of the station.

The trip to or from a station is known as the "first mile" or "last mile" of a passenger's trip, although actual distances vary greatly. Passengers may use a variety of modes to complete their trip, including bike, car, scooter, bus, train, their own feet or a combination of these. Most trips extend beyond the jurisdiction of Caltrain or high-speed rail: Surrounding streets are usually operated by cities, and shuttles or local transit are usually run by a different transit agency. But to make Caltrain a more attractive choice — one that carries far more people than it does today — decision makers need to consider a rail passenger's entire trip.[76]

RECOMMENDATION 8.

Upgrade stations to attract and accommodate more riders.

Who: PCJPB, CAHSRA, cities along the corridor, VTA, SMCTD, San Mateo County Transportation Authority (SMCTA), SFMTA, SFCTA

Because stations are the physical gateway to transit, the way people experience them can greatly affect whether they choose transit over other transportation options. No two stations are the same, and the unique characteristics of the community each station sits within play a role in how it functions. Local Caltrain stations like Bayshore receive fewer trains per hour during the morning peak hour than larger stations such as Palo Alto. Consequently, station services should be scaled differently to reflect passenger demand.

Caltrain stations are generally open structures with no walls or ticket gates. They typically have amenities such as ticket vending machines, system maps, public telephones, benches, electronic panels with real-time information and portable lifters for wheelchairs, since platforms are not at the same level as train floors. Some station buildings have historical significance and are protected.

Caltrain stations currently accommodate a mix of first- and last-mile modes, though not always with an organizing principle. Stations

typically have bicycle parking options (racks and lockers), bus and/or shuttle stops (which may include benches and shelters) and parking lots or garage buildings for vehicles. Drop-off areas and taxi stops are located close to the platform area. In some cases, parking areas and bus stops have larger structures to accommodate the integration of multiple kinds of buses and shuttles.

We recommend the creation of a Station Modernization and Access Program, a pot of funds to modernize Caltrain stations. The following upgrades would make stations more convenient and more comfortable:

- A staffed concierge area to provide information and security. Besides providing typical transit information and services, this area can also be a gathering place for information and/or other services from the surrounding community.
- A mobile app that integrates fare collection, real-time travel information, parking availability and trip-making information.
- Charging stations for electric vehicles, bicycles, scooters, etc.
- Sufficient and comfortable waiting areas and platform spaces; improved lighting and wayfinding signage.

RECOMMENDATION 9.

Improve station access for sustainable and space-efficient modes of travel.

Who: PCJPB, CAHSRA, cities along the corridor, VTA, SMCTD, SFMTA

Today, 50 percent of Caltrain riders get to stations by means other than driving. That's a good start, given that the majority of stations sit within suburban environments, but there's room for improvement. (By way of comparison, less than 15 percent of LA Metro's riders use cars to access rail and bus rapid transit stations.)[77] The challenge for growing ridership in the future will be to move an even higher percentage of arriving passengers away from driving. This means providing sufficient services and access conditions for other travel modes.

The principal modes of access to Caltrain stations are:

- **Walking.** The most important factor for encouraging walking is the neighborhood context where the station is located, including the types of land uses (industrial, commercial, residential), the population density, safety (in terms of both injuries/collisions and crime) and the connectivity of the street network within a quarter mile of the station. Stations located in industrial areas with poor connections to the surrounding neighborhood or in unsafe circumstances are less attractive for pedestrians.
- **Bicycling.** The decision to bike requires conditions similar to walking but on a larger scale. Elements such as bicycle lanes and protected bikeways improve safety and make biking a more attractive alternative. The availability of bicycle parking and bike-sharing services also increases the percentage of passengers arriving by bike. All Caltrain stations except College Park, Atherton and San Martin provide bicycle parking. Across the stations that do provide parking, a total of 655 bicycle parking spots are available; the Palo Alto station provides the most bicycle parking with 178 spaces.[78] Because they often live and/or work far from train stations, many Caltrain passengers bring their bikes on board; Caltrain was one of the first train lines in the United States to allow bicycles on trains, beginning in 1992. Over the years, Caltrain cars have been retrofitted to accommodate more bikes, making it one of the most bike-accessible rail systems in the country. Bike space has in turn become a constraint to adding passenger capacity.
- **Transit.** Whether train passengers arrive by transit depends on the reliability and frequency of transit service, the length of travel time and where the routes go. Because buses and light rail can bring passengers from a much larger area than walking or biking, providing good transit service to stations is essential to reducing the percentage of passengers who drive. VTA, SamTrans and SFMTA all have routes that serve Caltrain stations. Caltrain offers connecting shuttles, and Commute.org operates shuttles to and from BART and Caltrain stations. Many private employers and office parks offer shuttle connections to stations. Cities are also growing their connections: Palo Alto and San Jose both operate local circulator buses in their downtowns. In the future, we anticipate many more private transit services, some of which are very small and offered on-demand, also known as microtransit. Eventually, we expect autonomous or driverless buses.

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The challenge for growing Caltrain ridership will be to move more passengers away from driving as their primary way to get to train stations.

FIGURE 13

How Riders Get to and From Caltrain Stations Today

Stations sit within communities that run the gamut from dense urban environments to low-density suburban areas. To expand access, each station type will require different solutions.

*Includes carpool, motorcycle, etc.

Source: Caltrain, based on 2014 MTC On-Board Survey. Includes trips to and from each station.

Station	Park and Ride	Drop Off / Pick Up	Taxi	Bike	Transit	Walk	Other*
4th and King	0%	7%	13%	14%	29%	36%	0%
22nd Street	18%	8%	4%	22%	12%	35%	2%
Bayshore	27%	11%	0%	15%	31%	16%	0%
South San Francisco	9%	19%	2%	24%	4%	42%	1%
San Bruno	14%	26%	7%	13%	7%	32%	0%
Millbrae	10%	11%	3%	4%	59%	12%	0%
Burlingame	2%	13%	1%	17%	7%	60%	0%
San Mateo	7%	15%	2%	17%	4%	54%	1%
Hayward Park	4%	6%	1%	30%	1%	51%	7%
Hillsdale	18%	15%	2%	15%	8%	41%	1%
Belmont	10%	15%	4%	15%	7%	49%	0%
San Carlos	14%	19%	1%	15%	6%	46%	0%
Redwood City	8%	20%	2%	18%	10%	43%	0%
Menlo Park	4%	20%	3%	21%	11%	39%	1%
Palo Alto	4%	15%	2%	20%	23%	36%	0%
California Ave	7%	16%	3%	22%	3%	45%	3%
San Antonio	11%	17%	2%	17%	2%	51%	1%
Mountain View	14%	21%	5%	17%	16%	27%	1%
Sunnyvale	26%	21%	3%	14%	6%	27%	2%
Lawrence	23%	24%	1%	15%	5%	32%	0%
Santa Clara	18%	24%	9%	13%	11%	25%	1%
College Park	0%	0%	6%	5%	10%	80%	0%
San Jose Diridon	14%	26%	4%	10%	28%	15%	2%
Tamien	54%	11%	0%	10%	15%	10%	0%
Capitol	58%	0%	0%	42%	0%	0%	0%
Blossom Hill	34%	36%	0%	9%	0%	21%	0%
Morgan Hill	51%	19%	0%	9%	0%	21%	0%
San Martin	79%	16%	0%	0%	0%	4%	0%
Gilroy	79%	6%	0%	14%	0%	0%	0%
Systemwide	**10%**	**15%**	**6%**	**15%**	**21%**	**33%**	**1%**

- **Driving.** Getting to the train station by car is typically a choice for passengers who don't live within walking distance (or in walkable areas), don't have a good transit option for getting to the station and/or don't have the benefit of free or low-cost parking at their final destination. All Caltrain stations except for San Francisco, 22nd Street and College Park stations offer parking. A total of 7,597 parking spots are available across Caltrain stations; Diridon offers the most parking (581 spots) and Bayshore the least (38 spots).[79] Driving may also become the first choice in cases when transit service is available but is not a reliable option. Driving also includes passenger drop-off, which is growing in popularity with the availability of ride-hailing services such as Lyft and Uber.

In the future, getting to and from a Caltrain station should be easier than it is today, and we should prioritize sustainable travel modes that support station-area growth. This implies a strategy of not expanding existing parking, leveraging new technology to augment traditional first- and last-mile services (such as shuttles) and promoting the use of personal mobility options such as electric bicycles, scooters, skates and tricycles. Accomplishing this will require the right street, parking and pricing policies — especially as on-demand car services and autonomous vehicles become a greater part of the picture. To discourage single-occupancy autonomous vehicles in cities, pricing will be an important way to ensure that priority is given to either higher-occupancy vehicles — buses, shuttles and lower-impact vehicles — or traditional and electric bikes. Street design improvements will need to extend well beyond the station to at least a half-mile distance for those who walk and even farther for those using other modes.

A technology-driven transportation paradigm shift is underway (see page 18), and while it's still in its infancy, the impact on station access could be big. To date, alternatives to driving alone have focused on ride-sharing services such as carpools and vanpools. Technology, together with the right policies, could enable a dramatic reduction in the need to own a private car, resulting in considerably lower demand for parking spaces and more choices for first- and last-mile connections, such as bike-share systems, electric bicycles and autonomous vehicles.

In the future, we expect that the main modes for accessing stations will be transit — including fixed-route buses, shuttles, carpooling, ride hailing and microtransit — together with bicycles (both pedal and electric), scooters and other portable transportation devices. To accommodate these modes, the Station Modernization and Access Program could fund station improvements such as safety and surveillance systems, wi-fi, wayfinding signage, passenger drop-off areas and bicycle parking. A new First- and Last-Mile Program could fund buses, shuttles and other transit services. In practice, station access improvements and first- and last-mile services should be integrated with the surrounding land uses and transit-oriented development plans around stations. The First- and Last-Mile Program could provide resources to increase access services by supporting the best local solutions for each station, leaving flexibility with respect to the operator and business model.


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RECOMMENDATION 10.

Proactively manage station access and first- and last-mile connections at each rail station.

Who: PCJPB, CAHSRA, VTA, SMCTA, SFCTA, SMCTD, SFMTA, cities along the corridor

Today, first- and last-mile connections at rail stations are haphazard: Sometimes they're easy to find and use, sometimes they're not, depending on the station and available services. This patchwork of responsibility will not be sufficient to grow Caltrain ridership to two, three or four times today's level.

One way to resolve this is to designate a responsible party to actively manage access at each station. A single party should be responsible for making sure that station access options are sufficient, easy to understand and well run. Active management could focus on a performance goal. For example, travelers should be able to make first- and last-mile connections in five minutes or less during peak hours.

The responsible party could be Caltrain, other transportation agencies or third-party organizations, perhaps acting on Caltrain's behalf. Each station or group of stations in the corridor would be assigned to a party that would actively manage all the different options for station access. This party would also coordinate with local jurisdictions on access projects such as bike lanes, transit lanes or pedestrian paths.

In the future, if rail runs on a predictable clock-face schedule it would be possible to time first- and last-mile connections more easily — especially services that are not operated by Caltrain.

Rotterdam Centraal Station in the Netherlands is accessible by multiple modes. The station is surrounded by commercial buildings and welcoming public spaces.

RECOMMENDATION 11.

Build stations with seamless connections between Caltrain and high-speed rail.

Who: PCJPB, CAHSRA, MTC, City of San Jose, City of Millbrae, City and County of San Francisco, California State Transportation Agency (CalSTA), BART, TJPA, VTA, SMCTA, SFCTA

This vision plan does not detail the impacts that the arrival of high-speed rail may have on the corridor and the stations. The potential implications for stations include significantly larger passenger facilities for ticketing and baggage claim; access amenities such as bus bays, pick-up/drop-off curbs or rental car facilities; and food and drink concessions.

Eventually, high-speed rail will stop at four stations in the Caltrain Corridor. Each of these stations requires special attention both to ensure efficient train operations and to prioritize the passenger experience:

- **Diridon Station** will be a rail transfer point for Northern California with more than 1,500 trains and buses serving the station on an average weekday. The Diridon Station Area Plan envisions dense land uses, and the City of San Jose is planning a connection to Mineta San Jose International Airport so that airport passengers will have direct access to the statewide rail network.
- **Millbrae Station** will be the connection to SFO and BART. If the station and its amenities are designed correctly, a traveler could land at SFO and access the statewide rail network. It could even be possible to check luggage through from a high-speed rail station to one's final destination, a service available in other countries.
- **4th and King Station** may be used as a temporary high-speed rail terminal until the extension to the Transbay Transit Center is completed. Some additional investments will be needed to make that station ready for high-speed rail. Station access is particularly constrained at this station, with a chaotic and crowded mix of those walking, bicycling, riding transit and driving.
- **Transbay Transit Center** is largely constructed, and the bus terminal will open in 2018. The rail connection from 4th and King Station to the transit center is planned for completion in 2025, in time to receive high-speed rail service. (See Recommendation 6.)

We recommend that these Caltrain/high-speed rail stations be carefully planned based on global best practices for high-speed rail and that new governing and operating structures be developed to ensure the best possible passenger experience and transportation operations. Ownership of the station should resolved. For example, the historic Diridon Station in San Jose is owned by PCJPB, but it is not clear who would own and operate a new expanded station including more operators (BART and high-speed rail), expanded passenger facilities and retail.

CHAPTER 6

Highway 101

Goal: Move more people on Highway 101, with less delay.

Highway 101 is known for its recurring congestion, which affects both motorists and people taking transit. Traditional approaches to reducing highway congestion focus on building additional lanes, which temporarily reduces congestion but also induces more auto travel — eventually leading to even greater congestion.[80] Rethinking how we use highways isn't only about congestion — it's also critical to reducing the impact of driving on climate change and to reducing traffic on local streets and in neighborhoods.

Newer models for freeway use are emerging all over the country: Highways can be "priced" to reduce demand at peak hours. Charging a toll manages the demand on a highway by encouraging people to switch to a different mode of transportation or travel at a different time of day. Toll payers reduce congestion in mixed flow lanes as they shift over to toll lanes. Raising passenger occupancy requirements in carpool lanes improves performance but could add to congestion in other lanes unless other strategies are used (see the high occupancy/toll lane description below).

Highways can also be places that support transit and not just private cars, particularly when the highway is parallel to a transit line, as Highway 101 is.[81] New approaches actively encourage the use of highway lanes by vehicles that carry more people in less space, such as buses, shuttles, carpools and other forms of microtransit. A notable new opportunity is the explosion of ways to create carpools or use buses, including private employer shuttles, privately operated transit (Bridj, RidePal), carpooling platforms (Scoop, Waze Carpool) and ride hailing (Uber, Lyft). Policies and information are also supporting carpools and bus use. These include real-time information on highways, smartphone apps, parking pricing and variable tolls to shift how and when people travel. Filling or eliminating empty seats (both on transit and in private cars) is the most cost-effective way to address congestion while moving more people, shifting the focus to the throughput of people rather than the throughput of vehicles.

In the past, transit lines have competed directly with freeways for long-haul corridor trips and have served mainly to relieve highway congestion. But in the new landscape of distinct, separated and optimized travel markets for each mode, Highway 101 and rail can work together in the Caltrain Corridor in a way that better matches transportation options in the cities where travelers begin and end their trips.

There are three main strategies for managing a highway lane:[82]

- **Pricing:** Charging a toll to use the lane. On many highways, including the westbound direction on the Bay Bridge, all lanes are tolled, which makes it possible to shape how many vehicles (and what types) are on the highway at one time.
- **Vehicle eligibility:** Allowing or restricting certain vehicles. Minimum passenger occupancy is an example of an eligibility restriction. In California, vehicles with "Clean Air Vehicle" decals are eligible to use most carpool lanes.
- **Access control:** Allowing access to the lane in limited locations. For example, the Highway 237 Express Lane in Santa Clara County can only be accessed at specific places.

"Managed lanes" describes a more sophisticated approach that allows the flexibility to combine or change strategies in response to changing highway conditions or to support policy goals such as regulating demand, separating traffic streams or using available capacity. Ideally, all lanes on a highway are managed to move more people with less delay. The proposal here focuses on first managing one lane and then expanding to more lanes.

Within the existing Highway 101 right-of-way, there are three primary lane management approaches that are applicable:[83]

Adding new highway lanes typically results in more traffic — which also leads to more traffic on local streets.

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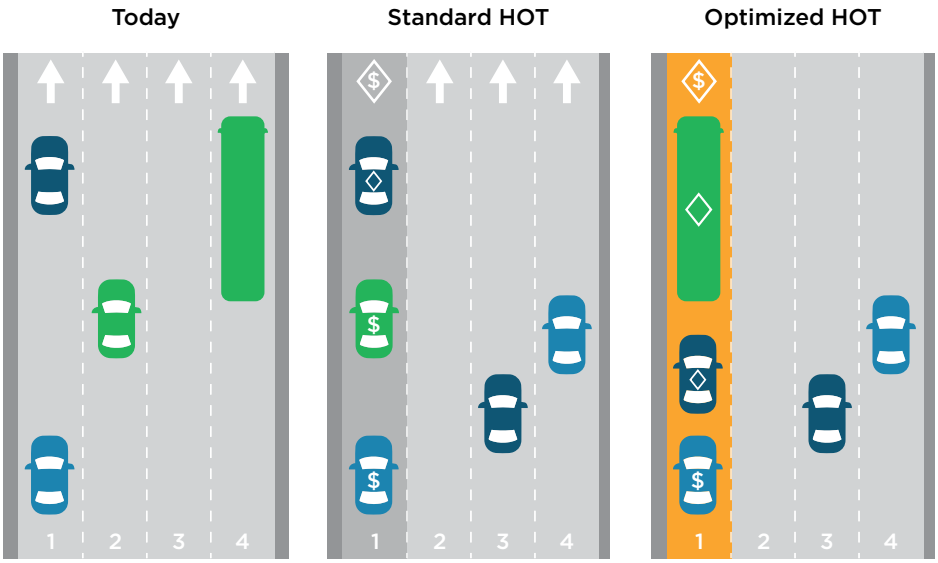
FIGURE 14

How Managed Lanes Work

Changing how lanes are used can move more people. An optimized high-occupancy toll lane designates one lane to be free for carpools and buses and usable by others for a fee. The price is set to keep the lane moving at 45 mph, and revenue can be used to subsidize increased public transit, which can take advantage of the lane.

Source: Produced for SPUR by Arup



- **High-occupancy vehicle (HOV) lanes:** This approach restricts one or more lanes of traffic during peak hours. The vehicles that are allowed to travel in HOV lanes vary by corridor. Most HOV lanes in the Bay Area allow carpools with two or more people (HOV-2) to use the lane, along with buses, shuttles, motorcycles and clean air vehicles. In some highly congested corridors, such as the Bay Bridge, only vehicles with three or more people (HOV-3) are allowed. On Highway 101, modeling by MTC has demonstrated that an HOV-2 lane would be congested as soon as it opened and therefore is not a feasible option. On the other hand, the possibility of an HOV-3 lane raises concerns that, at least initially, there would be insufficient carpools, shuttles and buses to fill the lane. This would result in unused capacity in the carpool lane while congestion in the other lanes continued to increase. Low- or zero-emission vehicles, currently allowed to use HOV lanes, could also fill this space in lieu of high-occupancy vehicles (which suggests a state policy change to not allow that to happen).
- **High-occupancy/toll (HOT) lanes:** This variation of the HOV lane concept allows solo drivers to travel in the carpool lane if they pay a toll. For example, a HOT-3+ lane would allow buses, shuttles and cars with three or more occupants to use the HOT lane for free and charge a price to vehicles with one or two occupants. HOT lanes allow excess capacity in the carpool lane to be used during peak congested periods. The lane is managed to keep traffic at free-flowing speeds at all times, usually by charging increasingly higher tolls as more people begin to use the lane, so that it does not become congested. (This tool, known as dynamic pricing, allows prices to be updated as often as every few minutes.) Tolled lanes have been proven to be effective at changing travel behavior. Solo drivers who do not wish to pay the toll seek other travel choices or choose to travel at other times. This minimizes pressure on the road network and enables a more reliable journey for those who pay the toll. HOT lanes are generally developed in one of two ways: an existing carpool lane is converted to a HOT lane by adding tolling infrastructure; or an entirely new lane is planned, designed and built. HOV-to-HOT conversions are generally far less expensive and can be built more quickly than a new lane. Also, because toll revenues are often used to pay off construction loans, the lower price tag of HOV-to-HOT conversions frees up more toll revenues for other purposes, such as transit, more quickly. However, HOV-to-HOT conversions are only possible where there is an existing carpool lane. There are carpool lanes on 101 in Santa Clara County (from Palo Alto to San Jose) that could be converted to HOT; however, there are no carpool lanes in the northern half of the corridor, from the Whipple Avenue exit in Redwood City to San Francisco.
- **Optimized HOT lanes:** An optimized HOT lane is a HOT lane with heavy investment in transit and carpooling incentives to minimize added congestion in the remaining general-purpose lanes.[84] For Highway 101, a preliminary analysis by MTC showed that such an approach would be possible and would require using several strategies in synergy: reinstating and expanding regional express bus service; expanding private shuttle bus services; increasing carpools; and providing more park-and-ride and first- and last-mile services.[85]

Estimating the Benefit of a Continuous HOT Lane

A HOT lane on Highway 101 could move more people with more reliable travel times and fewer delays due to congestion. Figure 15 on page 40 compares three scenarios for how designating a lane for high-occupancy vehicles can move more people, assuming sufficient transit riders are using the lane. This is a sketch analysis; more detailed modeling would be required to validate these results and to help optimize policy choices.

A recent analysis of the optimized HOT model found that the number of people moved in a single lane could triple from 1,780 people per hour to as many as 5,680 people per hour.[86]

FIGURE 15

Scenarios for Moving More People in a Managed Lane

Lane management can shift an existing highway lane from moving 1,780 people per hour to as many as 5,680 people per hour. This assumes heavy use of the lane by buses (both publicly and privately operated), vanpools and carpools.
Source: *TransForm Innovation Required*, 2014, http://www.transformca.org/sites/default/files/final_hot_101_paper.12.16.2013-1_revised_acknowledgement_0.pdf

Lane Management Scenario	Number of vehicles per hour	Number of people moved per hour
Existing Conditions	1,370	1,780
Planned HOV[87]	700	3,200
HOT without added transit/carpools	1,410	4,040
Optimized HOT with added transit/carpools	1,320	5,680

RECOMMENDATION 12.

Manage a lane of Highway 101 as a high-occupancy toll lane along the entire corridor.

Who: VTA, San Mateo City/County Association of Governments (C/CAG), SFCTA, Caltrans, MTC, CalSTA

Bay Area transportation agencies are planning a 550-mile network of managed lanes, the majority of which are HOT "express" lanes, that will be completed in 2035. Express lanes are already open on Highway 580 in the Tri-Valley area and on Highway 680 from Pleasanton to Milpitas, as well as on State Route 237 between Milpitas and San Jose.[88] Highway 101 should also become a part of the region's managed lane network. Each of the three counties in the Caltrain Corridor (San Francisco, San Mateo and Santa Clara) is developing a strategy to manage its section of 101. In each case, the solution is being driven by local policy goals and working with existing opportunities and constraints. VTA has approved two side-by-side Highway 101 express lanes that begin in Morgan Hill and reach Palo Alto. San Mateo County and San Francisco County are each now studying options for managed lanes on Highway 101 through those two counties.

We recommend using one policy framework for Highway 101 lane management across the corridor, and across county lines, so that congestion can be solved more systematically and the highway can operate with one set of goals. Specifically, we recommend that the three counties work together to create a continuous HOT lane, with dynamic pricing, on Highway 101 between the Central Freeway/Interstate 80 in San Francisco and Interstate 880 in San Jose. A continuous HOT-3+ lane running the length of Highway 101 would support the creation of a regional express bus network serving job centers up and down the Peninsula from San Francisco to San Jose. It would also offer significant time savings to transit and carpools, as well as solo drivers who are able and willing to pay the toll when there is capacity to sell.[89]

It is also important that buses and high-occupancy vehicles using the highway be given priority on streets and roads that connect with the highway, to give them a travel-time advantage over private vehicles. This is a way to connect highway management with local goals to reduce solo driving. For example the Mountain View Shoreline Boulevard Corridor Study is proposing a transit lane at the 101 interchange, and San Francisco is currently exploring converting street lanes into carpool lanes during peak hours.

Preferred Option: Using an Existing Lane

Converting an existing lane to a HOT lane is the less expensive and faster way to add a managed lane through the corridor.[90] Where present, existing HOV lanes along Highway 101 could be converted to HOT lanes. Elsewhere, one general-purpose lane in each direction could be converted to a HOT lane. Converting an existing lane has benefits over new construction as it would cost far less and could be completed more quickly. It would require less environmental review and less traffic disruption. Lane conversion would also avoid physically widening Highway 101, which would be extremely expensive and would impact adjacent private property, surface roads and habitats. Particularly in the section of 101 nearest to San Francisco, widening the highway would be costly and difficult because many stretches are narrow, elevated and/or tightly abutted by retaining walls, piers or sensitive bay and marsh habitat.

Converting a lane to HOT-3+ and filling the lane with high-occupancy vehicles instead of single-occupancy vehicles would increase the overall passenger throughput of the freeway corridor, moving more people in the same amount of space. This is consistent with California's and the Bay Area's goals to reduce per-capita emissions and the number of vehicle miles traveled. It will further reduce vehicle miles and improve social equity by generating future toll revenues that can be invested in transit in the corridor. This approach would require state and federal legislation to allow the conversion of a general-purpose lane to a HOT lane.[91]

An immediate option is simply to convert the left-most lane to an HOV-3 carpool lane as a pilot project, which could be done with inexpensive new signage and striping on the highway. An HOV-3 lane could quickly incentivize the use of casual carpool (similar to the successful East Bay/Bay Bridge casual carpool), thereby moving far more people in that lane, particularly during peak periods. This would also allow the usage of casual carpool apps (both where passengers pay and where they don't), which have yet to succeed on the Peninsula because carpooling does not save enough time to attract participants. If, during this experiment, the lane is saturated (and there are no time savings), this would be evidence that a HOT-3+ lane could succeed. If the lane isn't full, the pilot could be ended.

Alternate Option: Adding a Lane

An alternative to using an existing lane is to connect auxiliary lanes into one continuous new lane. (An auxiliary lane is an extra highway lane that connects interchanges, giving drivers more time to merge in or out.) There are currently 14 miles of auxiliary lanes on 101. However, turning an auxiliary lane into a general-purpose lane is a major capital project that could degrade the remaining lanes as merging becomes more difficult. In some cases, this would also require the renovation of bridges and overpasses that are not currently wide enough to

accommodate an additional lane. In areas without auxiliary lanes, such as San Francisco and northern San Mateo County, existing general-purpose lanes would need to be converted. In these areas, lane conversion would require roadway restriping, installing tolling equipment and adding new signage.

RECOMMENDATION 13.

Adopt equity policies and programs for HOT lanes.

Who: MTC, SFCTA, SMCTA, VTA, C/CAG, Caltrans

HOT lanes increase the price of travel for solo drivers who choose to use the managed lanes. This raises concerns about equity and fairness, because not everyone can afford to pay tolls — especially during times of day when demand for the managed lane is greatest and therefore the tolls are highest. Managed-lane policies should evaluate the equity impacts of each alternative, consider the local context and identify strategies to ensure that HOT lanes are a net benefit to low-income travelers.

Several studies have evaluated the impact of HOT lanes on low-income commuters. A study of Highway 85 HOT lanes in Atlanta looked at license plate data from more than 17,000 HOT users and found that, on average, about 50 percent more high-income drivers than low-income drivers use the HOT lanes. In contrast, the study found roughly equal numbers of high- and low-income drivers in the general-purpose lanes.[92] A study of State Route 91 HOT lanes in Orange County found similar results.[93]

Both studies also found that low-income and very-low income groups do use the HOT lanes, albeit less frequently, concluding that the lanes do provide value to low-income drivers. Indeed, blue-collar and service workers often have less flexible schedules than white-collar professionals, and they are more likely to lose their job if they are late to work. Because HOT lanes allow for a faster and more predictable travel time than congested general-purpose lanes, their value to low-income commuters may be quite high, even if low-income commuters don't use them as often as high-income commuters do.

Strategies to make HOT lanes accessible to those who may not otherwise be able to afford them include:

- Offer prodigious public transit services, which can use the lane for free.
- Set aside a portion of toll revenues for providing quality transit options along the corridor, such as express buses that use the HOT lanes and serve low-income neighborhoods.
- Provide discounts to low-income drivers. Both this and the strategy above to set aside toll revenues are used on express lanes on Highway 110 and Highway 10 in Los Angeles. (See "Los Angeles Express Lanes" case study on page 43.)
- Integrate tolls with transit policy by giving toll credits to transit passengers once they've taken a certain number of rides on transit (for example, 10 bus rides). This recognizes that not everyone needs to make the same trip in the same way each day and rewards those who choose to travel on transit regularly but occasionally need to drive.
- Cap the HOT toll amount charged per car. If the toll reaches a specified level, the lane reverts back to an HOV lane.

Further coordination and planning would be required to extend and connect HOT lanes on 101 to those on other corridors such as Highways 880 and 680. Drivers could connect with other HOV/HOT facilities using existing general-purpose ramps or future direct HOT connector ramps — ramps whose sole purpose is to connect two HOT lanes on different highways, such as those on Highways 680 and 237 in the East Bay.[94]

Addressing Congestion in Managed Lanes

On heavily traveled corridors like 101, it is easy to imagine a time when the demand for a HOT lane would exceed the supply, leading to congestion and delays in the HOT lane itself. Other HOT lane managers across the Bay Area and the country are now developing strategies to manage growing congestion in HOT lanes. Excess demand for a Highway 101 HOT lane should be managed in several ways:

- **Increasing enforcement.** Solo drivers illegally using the managed lanes can be a problem. Greater enforcement, including video surveillance and restricting the ability of drivers to weave in and out of the HOT lane, can help reduce toll violators and decrease congestion.
- **Increasing tolls and expanding transit.** Adjusting toll prices in response to congestion can help keep speeds moving. In Miami, toll managers have responded to increased demand by raising tolls and reinvesting the additional revenue in express buses.[95]
- **Restricting solo drivers.** When speeds drop too low on a HOT lane, the number of solo drivers that are allowed to use the lanes is restricted. In California, when HOT lane speeds fall below 45 mph, single-occupancy vehicles are not authorized to use a HOT lane until speeds increase. HOVs and buses can continue to use the lane freely during these congested periods.
- **Managing clean air vehicles.** California's clean air vehicle program gives stickers to qualifying vehicles (such as hybrid or electric cars) that allow them to use HOT and HOV lanes for free, even as solo drivers. As these vehicles gain in popularity, they make up an increasingly large share of managed-lane users. For example, VTA estimates that clean air vehicles account for 31 to 38 percent of users of State Route 237 HOT lanes during peak hours. California policymakers may need to further reduce the use of clean air vehicle stickers in managed lanes whose purpose is to reduce car use.
- **Adding more HOT lanes.** As managed lanes grow in popularity, a second managed lane can be added or converted, if feasible. This can either be a second HOT lane or, to further increase efficiency, a bus-only lane. The effect on the remaining general-purpose lanes should be considered and mitigated with added transit and carpool choices.

Interstate 280

Interstate 280 also plays a role in moving vehicles up and down the Caltrain Corridor, but it is not close to most cities and major destinations. Nonetheless, it can be a conduit for more transit vehicles and could also be a good facility for piloting autonomous vehicles in the future, due to the lower levels of traffic and lower number of entrances and exits. Lanes on Interstate 280 can be managed in order to create a delay-free lane for transit and high-occupancy vehicles. San Francisco is evaluating the potential for managed lanes on 280 in the city as part of its Freeway Corridor Management Study. In particular, the segment of 280 from downtown San Francisco to the 101 interchange may be an especially good candidate for express lanes because it could provide a continuous managed lane from downtown San Francisco to 101.

Local Streets

When planning improvements to the highway, it's important to do so within the context of local streets and roads, which may not have the capacity to absorb increased traffic volumes. New intelligent transportation system tools such as adaptive ramp metering and signal timing can recognize changing traffic conditions and adapt in real time. Such tools not only benefit freeway users but can also improve traffic conditions on local streets adjacent to 101.

RECOMMENDATION 14.

Use revenue from pricing Highway 101 to add more public transit service.

Who: VTA, SMCTA, C/CAG, SFCTA, MTC, Caltrans

Revenue collected from pricing a lane is typically used to pay off construction and management costs for the lane. Once these costs are paid, there may be a revenue stream that can be used to advance the goal of moving more people in the corridor if policies are adopted to enable this. While this revenue stream is not the primary objective of road pricing, it's an added benefit. The funding is not meant to replace other revenue streams but instead add to them. An added benefit of converting an existing lane rather than building a new lane is that more toll revenue can be used for transit in the near term because conversion is far less expensive than highway widening.

A regional toll policy for the three counties in the Caltrain Corridor, or for the Bay Area as a whole, would be another way to connect the region's express lanes and help them function as one system.

An analysis of eight HOT lane facilities in the western United States found that, on average, they generated between $110,000 and $800,000 per lane-mile per year in toll revenue (an average of $290,000). However, revenue varies widely by region depending on population, employment and congestion. Assuming the average revenue rate observed from precedent projects described in Figure 16, the preferred concept for the Highway 101 freeway corridor could generate approximately $29 million in annual toll revenues. This figure is a conservative estimate because 101 is a more economically important and congested corridor than most.

FIGURE 16

Revenues and Operating Costs of High-Occupancy/Toll Lanes

On average, HOT lanes generate between $80,000 and $800,000 per lane-mile per year in toll revenue.

* Figures not publicly available at time of analysis.

Source: Produced for SPUR by Arup

Project	Lane-Miles	Annual Revenue ($M)	Annual Operating Costs ($M)	Annual Revenue per Lane-Mile ($)
Los Angeles Express Lanes	78	$ 62.2	$ 42.2	$ 800,000
I-405 Express Toll Lanes (Washington State)	50	$18.4	$ 3.0	$ 370,000
I-25 HOV Express Lanes (Denver)	14	$ 3.6	*	$ 250,000
I-680 Express Lanes (Alameda County)	14	$ 1.9	*	$ 140,000
SR-237 Express Lanes Phase I (Santa Clara County)	11	$ 1.2	$ 0.9	$ 110,000
I-15 Express Lanes (San Diego)	80	$ 6.0	$ 5.2	$ 80,000
AVERAGE				$ 290,000

RECOMMENDATION 15.

Grow regional express bus services.

Who: VTA, C/CAG, SFCTA, Caltrans, MTC, SMCTD, SFMTA

Improvements to Highway 101 present an opportunity to fully implement the express bus transit service concept in a corridor where it can succeed. Express bus service uses the freeway or highway network to provide longer-distance trips, extending transit past the end of a rail line, supplementing or linking rail lines and serving markets far from rail. A benefit of buses is their scalability: Service can be decreased or increased as needed (although it needs to conform with restrictions on funding — public bus services receiving federal funding must meet equity standards). New bus routes can also be implemented as pilots.

Unlike in San Francisco and the East Bay, land use in the Peninsula and South Bay is characterized by relatively low residential densities and dispersed campus-style job centers that are connected by wide arterial roads, expressways and freeways. This type of land use is well served by express buses when those buses are able to bypass traffic through dedicated lanes, such as those proposed on 101.

Markets for Express Buses

The following characteristics distinguish express bus service from local or limited bus service:

- Longer total route length, often with end points in both urban and suburban areas
- Greater spacing between stops, at least along trunkline segments
- Significantly higher frequency at peak times, or operating only at peak times
- Fixed schedules to serve more uniform demand from routine commuters
- Portions of routes on freeways or other limited-access highways
- Different vehicle configurations, often with more seating and only one door
- Higher fares from local and limited tickets or passes
- Certain stops designated as only for receiving or discharging passengers
- Permission to travel in freeway carpool lanes, on designated access ramps or on shoulders
- Connections available to local and limited bus lines at certain key stops

Examples of express bus services in the Bay Area include Dumbarton Express and SamTrans Route KX, which supplement or link one or more rail lines; WestCAT Express Routes and VTA Route 181, which extend a rail line; and Golden Gate Transit, WestCAT LYNX and AC Transit transbay buses, which serve markets far from rail. SamTrans cut express bus service beginning in 2010 and again in 2014, leading to a drop in express bus ridership from more than 6,000 boardings per day to fewer than 1,000 boardings per day.[96]

In the Caltrain Corridor, markets for express buses include:

- **Employment centers not near Caltrain.** Today, the employer shuttles that connect San Francisco and Oakland with the campuses of Google, Facebook, Apple and other tech firms are growing, but they face an uncertain future due to increasing regulation and high costs. These markets may be a match for public express buses serving similar destinations, if funding can be made available. Replacing or supplementing certain private commuter shuttles with public express buses could also present a longer-term opportunity for public-private partnership. Smaller employers, office parks and transportation management associations could use express buses to move workers along Highway 101. Express bus services could also run from the Peninsula to San Francisco making one or more stops, most likely terminating at the Transbay Transit Center.

CASE STUDY

Los Angeles Express Lanes

In 2012, the Los Angeles County Metropolitan Transportation Authority (Metro) opened express lanes on the 110 and 10 freeways — important commute corridors connecting downtown and the harbor area to surrounding cities — by converting previous carpool lanes. Metro's innovative approach to these lanes, which integrate express bus service, carpool incentives and discounts for low-income drivers, has won accolades nationwide.

As part of the express lanes project, Metro upgraded existing bus services that use the carpool lanes, increasing service frequency, installing signals that offer priority to buses at key intersections, improving lighting and security, and renovating bus stations and platforms. The service, now called the Silver Line, runs every four minutes at peak hours. Toll revenues from the HOT lanes subsidize the Silver Line, and HOT drivers can earn free toll credits by riding the bus. As a result of these investments, ridership on the Silver Line has steadily grown from 7,300 weekday riders in 2010 to an estimated 16,500 weekday riders in 2016, even as system-wide transit ridership has decreased.

LA's express lanes also provide important incentives for carpooling. Studies have found that when a carpool lane is converted to a HOT lane, carpooling declines by an average of 30 percent.[97] In order to keep carpools going, LA's express lanes provide financial incentives for carpooling. Not only do carpool drivers continue to use the lanes for free, they also receive gift cards and win prizes. Other metro areas, such as Atlanta, pay new carpoolers $1 per day to encourage them to carpool.

Metro considered the needs of low-income commuters in planning the express lanes. In addition to considerably improving peak-hour bus service along the corridor, the agency uses toll revenues to provide weekend and late-night bus service. Low-income drivers are also eligible to waive registration and equipment fees. For those who lack credit cards and internet access, Metro offers cash payments and pay-as-you-go memberships for tolls.

- **Weekend service from Caltrain stations.** Since 2005, weekday trains have bypassed both the Broadway and Atherton stations in order to allow through passage of Baby Bullet express service. The five-minute-long Broadway–Millbrae shuttle ride, with 10 weekday morning departures, offers passengers timed transfers to nine northbound trains. A similar shuttle connected Atherton passengers to the Redwood City station but closed in 2007 due to low ridership, perhaps related to the inconvenience of transfers. Weekday express bus routes could revive direct San Francisco service at these and other stations with low service levels.
- **The Fremont ACE station.** Although one AC Transit line (the U) connects this station to Stanford University, an express bus that crossed the Dumbarton Bridge and continued into San Francisco could significantly reduce travel times for ACE passengers bound for San Francisco from the Central Valley. Currently, they must transfer to Caltrain at San Jose (another 37 minutes south of Fremont) and backtrack up the Peninsula. While AC Transit's U line does connect the Fremont BART and ACE stations, non-transbay riders may not board it (to reserve capacity for the longer transbay trips).[98]
- **Mineta San Jose International Airport.** While the local VTA 10 bus makes a circular route between airport terminals, Caltrain and VTA light rail, an express bus could serve airport passengers bound either for downtown San Francisco or connecting to flights at SFO.

Express bus services in this corridor require coordinated and regional service planning; no one existing transit agency has the ability to serve all of these markets, and the use of buses can be optimized only if there is a shared approach to the service. Three ways to deliver regional bus services include: growing the role of existing regional agencies to deliver cross-county services; developing new consortiums to run regional services (for example, the Dumbarton Express bus is operated by AC Transit and funded by SamTrans and VTA together with regional toll revenue); and changing state legislation or memorandums of understanding so that the rules don't limit services from crossing county lines. This would enable local operators to respond to cross-county demand instead of ending service at transit transfer facilities on the county line and forcing riders to transfer. Any new regional bus service should aim to make more efficient use of the region's existing bus fleet, maintenance yards and other facilities.

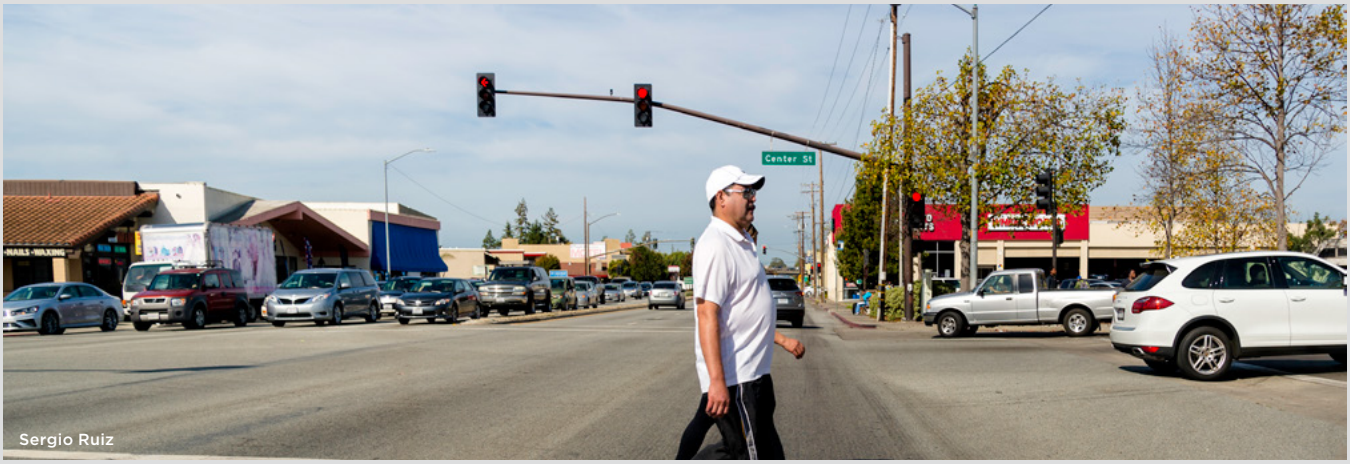
Before launching any express bus service in the Caltrain Corridor, one question to ask is whether it's serving places or markets that Caltrain is unable to serve and what a Caltrain- or rail-focused alternative could be. This would ensure investment in the best long-distance solutions. Another decision is whether a premium bus service (coaches, wi-fi, etc.) is needed to serve the market.

Reducing Demand for Driving

The projects and programs proposed for Highway 101 are major investments. If we do not also properly manage parallel and connecting roads, the investment in 101 will be underutilized. If the costs of driving and polluting continue to be low (compared to other places and compared to the societal costs), we will continue to experience overuse of our roads and limited demand for transit.[99] If parking at final destinations is still free, we will have to use further subsidies and incentives to move people onto transit.[100] And if all connecting highways do not have managed lanes, the managed lane on Highway 101 may go underutilized.

Transportation demand management policies and programs can support the formation of carpools and private transit. Park-and-ride locations, casual carpool pickup and drop-off locations, support for apps and shuttle bus stops, and employer transportation demand management programs will all help facilitate the full use of a HOT lane by high-occupancy vehicles. While not the focus of this study, addressing demand through data-driven and research-based strategies is a critical part of keeping the Caltrain Corridor moving.

El Camino Real: Re-Thinking the Caltrain Corridor's Main Street



El Camino Real is a critical artery and place. As the corridor grows, improving transit here will be necessary.

While El Camino Real is not a focus of this vision plan, as a route that connects the Caltrain Corridor it needs to be rethought. For much of the road's 52 miles between San Jose and San Francisco, Caltrain runs directly adjacent, and Highways 101 and 280 parallel it on either side, between one and four miles away.

El Camino Real's current roadway width ranges from two to three lanes in each direction, and most of the corridor also contains on-street parking. Five transit agencies (excluding first- and last-mile shuttles) serve the El Camino Real corridor: BART, Caltrain, SamTrans, VTA and SFMTA. Since 2013, SamTrans has offered one main bus service, Route ECR, which merged and replaced the corridor's former Routes 390 and 391. Route ECR runs from the Daly City BART station to the Palo Alto Transit Center every 15 minutes on weekdays and every 20 minutes on weekends, stopping at four BART stations and six Caltrain stations in between. From the Palo Alto Transit Center, riders may continue southbound on VTA; Lines 22 and 522 both run from there to the Eastridge Transit Center in eastern San Jose. Route 522 currently operates as a limited-stop bus with two or more buses per hour, while Route 22 serves all local stops along the same path with at least one bus per hour. While multiple transit lines operate within the corridor, 70 percent of workers along El Camino Real still access their jobs by driving alone.

Grand Boulevard Initiative

In response to new development and densification along El Camino Real, 19 cities, counties and public agencies jointly introduced the Grand Boulevard Initiative, a collaboration of stakeholders dedicated to making the outdated El Camino Real corridor from Daly City to San Jose safer, more pleasant and more efficient. A Grand Boulevard Task Force, currently numbering 41 members and two chairs from public and private institutions, is evaluating opportunities for housing and urban development along El Camino Real that could accommodate an appropriate mix of cars, pedestrians, bicycles and transit. Specifically, the Grand Boulevard Initiative guiding principles include fewer cars on the road, less congestion, and cleaner air based on the underlying premise that public transportation will become faster and more convenient.[101]

Bus Rapid Transit

Faced with increasing congestion and population, both VTA and SamTrans are concurrently but independently planning upgrades to portions of the El Camino Real corridor; the two agencies have proposed converting Routes 522 and ECR into bus rapid transit (BRT), a rapid bus system whose frequency, speed and comfort can be compared to a modern light rail system. These two bus services would still meet and terminate at the Palo Alto Transit Center but would arrive there on dedicated lanes, likely in the median of El Camino Real. BRT would be a locally focused service along this parallel corridor with greater speed and efficiency than a standard local bus route.

Without accounting for annual operations and maintenance expenses, VTA's BRT line is estimated to cost up to $233 million, while the SamTrans BRT capital cost estimate is $177 million. Both studies favored BRT operations along the center of El Camino Real; for most of its length, a landscaped or painted median currently separates bidirectional traffic. Repurposing El Camino Real's innermost two travel lanes to contain a BRT right-of-way for either VTA or SamTrans would, combined with the existing median width, afford enough space for BRT stations. The VTA BRT project schedule indicates completion in 2020. However, a few of the cities in the corridor have not yet voted to support the project, mostly due to concerns about what would happen to travel time for cars. SamTrans also evaluated a range of less expensive and more immediately implementable service concepts. The SamTrans proposal is awaiting funding to move forward.

Ideas for the Future

One possibility to advance the idea of BRT is to enable private buses or even carpools to use the BRT lanes, which increases their use while moving more people. This kind of integration would require technology and policy innovations. In the long term, the BRT lane could also be a guide way for autonomous (driverless) buses, which would run more frequently through the corridor and be synchronized with traffic signals.

CHAPTER 7

Ferries

Goal: Establish public ferry service for Peninsula travelers.


U.S. Army Corp of Engineers

Before the advent of railroads and bridges, ferries were commonly used to move people around the Bay, particularly between San Francisco and Oakland. Today, ferries play a very small role in the region's transit system, comprising only 16,000 out of 1.7 million daily transit trips in 2015.

In order to be a reliable transit option, ferries would need to run more frequently and offer more routes. But adding public ferry service raises concerns about pollution, high fares, the availability of appropriate terminal locations and the challenge of first- and last-mile connections, among other issues.

Technology could change these dynamics. The new plug-in technologies that ports are using for freight and cruise ships could eliminate emissions while ferries idle at dock. Advances are also being made in solar- and battery-powered ferries. Operating subsidies can enable services to be incubated while ridership grows.[102] One advantage of ferries over rail or highways is that for the most part, capital costs are relatively small: All that's needed is a terminal and boats.

RECOMMENDATION 16.

Create a ferry terminal at the Port of Redwood City.

Who: Water Emergency Transportation Authority (WETA), MTC, Port of Redwood City, Redwood City, SMCTA

Ferries can add valuable redundancy to the transportation system in the Caltrain Corridor, offering another option when highways or rail are not available, perhaps due to a collision or earthquake.[103] Ferries can also provide a way to serve markets that are difficult to reach with rail, such as the North Bay or East Bay. For these reasons, the state envisioned a ferry facility at the Port of Redwood City when it created the Water Emergency Transportation Authority (WETA) in 2007.[104] WETA has included Redwood City in its 20-year strategic plan, and $15 million was allocated to Redwood City for ferry terminal development in 2004's San Mateo County Measure A.[105] This ferry terminal would consist of several elements: terminal buildings to accommodate passengers and staff (indoor or outdoor waiting areas, ticketing area, restrooms and other amenities); enclosed and climate-controlled support structures to house electrical, IT, security and other maintenance equipment; parking and drop-off spaces for buses, cars, bicycles and other modes; and signage and wayfinding for passengers.

Funding is a key reason that this project has not been built. Costs to complete the project are included in the cost estimates for the vision (see Chapter 9). Following through on this planned project is a necessary first step toward better using water transit in the Caltrain Corridor.

RECOMMENDATION 17.

Expand ferry services to include Peninsula stops.

Who: WETA, Port of Redwood City, MTC

Both public and private operators can provide ferry transit services. WETA and the Golden Gate Bridge Highway and Transportation District are the main public ferry operators today in the Bay Area. Private ferry operators already offer service on small boats to the South San Francisco and Redwood City terminals. Some private operators are looking to provide public services where anyone could pay to ride a privately operated ferry.

WETA will require operating subsidies in order to begin service to a future terminal at the Port of Redwood City or to grow service to the South San Francisco terminal.[106] Most ferry terminals on the Bay begin as origin points for trips to downtown San Francisco due to the great number of jobs near the San Francisco ferry terminal. It is plausible that Peninsula service could be more of a two-way service, just as Caltrain has a bidirectional ridership, between the Peninsula and San Francisco. It could also include two-way service between the Peninsula and the East Bay or, possibly, a ring around the Bay that could serve different types of riders than just commuters.

However, a significant challenge facing ferry riders to the Port of Redwood City is the availability of connections to and from the ferry. (Few Bay Area ferry terminals are surrounded by communities, and half of their surroundings are water.) The Redwood City terminal is located on Seaport Boulevard, almost two miles from Highway 101 and even farther from most nearby job centers and commercial areas. This can be overcome with a combination of private shuttles, on-demand services like ride sharing and bike sharing, or — where there is enough demand — a public shuttle bus. The First- and Last-Mile Program proposed in Recommendation 10 can be expanded to include ferry terminals.[107] There is also the possibility of transit-oriented development around terminals.[108]

Assuming that each new WETA ferry boat would carry about 400 passengers, adding two public boats per hour adds 800 new seats. At a level of four private ferry boats per hour, another 1,000 passengers could use the new ferry terminal.

CHAPTER 8

A Seamless Transit Experience

Goal: Create a coordinated and convenient transportation network.

To unify the transit experience for passengers, Caltrain, BART and high-speed rail can coordinate their schedules and present unified maps, information and payment systems.

Growing transit use means making the transit experience convenient and attractive. With so many different transit services and agencies in one corridor, special attention must be paid to coordinating them all to function together as one network. SPUR's 2015 report *Seamless Transit* identified five types of transit coordination needs: information, fares, payment, service planning and capital planning. The following three recommendations encompass these categories.

RECOMMENDATION 18.

Integrate information and payment across mobility services.

Who: PCJPB, CAHSRA, MTC, VTA, SMCTD, SFMTA, transit operators, Clipper 2.0 Board, BART, CalSTA

Unlike driving, many transit trips can require a variety of connecting services to get from one place to another. Door-to-door information on when and where services run and the ability to pay for your whole trip at once are essential. In other parts of the world, transit riders can use smartphones and other mobile devices to plan, book and manage their trips — and to pay fares and obtain real-time travel information en route in order to make more productive use of their time. Clipper, the region's transit fare payment system, should offer the same kind of functionality. Silicon Valley has created the tools and standards that we need to make this all happen; now Clipper should put them into practice.

An advanced example of seamless payment is Germany's Deutsche Bahn Touch&Travel system, which uses electronic travel cards that work on both high-speed and local rail. The Touch&Travel system uses GPS to automatically charge a fare when a passenger walks through the fare gates, much like FasTrak charges vehicles as they pass through toll booths. Travelers using Switzerland's SwissPass can use a single card to pay for rail as well as car sharing, bike sharing, a mobile phone service, ferries, streetcars and services to recreational areas.

In tandem with planning for high-speed rail and the 2018 Statewide Rail Plan, California is developing a network integration program whose philosophy is that all types of rail in California should have integrated schedules and fare payment, leading to a more efficient use of resources and a more convenient passenger experience.

Highway 101 and Caltrain should also be integrated to manage demand and improve the customer experience. Because Caltrain faces crowded conditions — which may continue even after electrification due to expected increases in demand — Caltrain and its corridor partners (SMCTA, C/CAG, SFCTA and VTA) could monitor Caltrain together with transit on Highway 101 and balance ridership across the two modes using incentives such as fare and toll pricing.

RECOMMENDATION 19

Operate BART, Caltrain and high-speed rail as one system from the rider's perspective.

Who: BART, PCJPB, CAHSRA, MTC, Clipper 2.0 Board

BART is the region's largest rail system, both in miles and riders. Today BART connects with Caltrain at Millbrae Station; in the future, the two services will also connect at San Jose's Diridon Station, Santa Clara Station and the Transbay Transit Center in downtown San Francisco. High-speed rail will connect with Caltrain and BART at Diridon Station, Millbrae Station and the Transbay Transit Center (and possibly one other station in the corridor).

Today, the BART–Caltrain connection is not timed, is physically inconvenient and requires passengers to pay a separate fare. The same could be true of high-speed rail when it opens. In order to achieve the ring around the Bay that transportation planners have aspired to for decades, a few steps will need to be taken. The first is to time transfers between Caltrain and BART so that passengers don't have long waits for connecting services. The same care should be taken with planning high-speed rail schedules. Each station where the three services meet should be considered a major transfer point, and each system's train schedule should be designed to make that transfer happen within just a few minutes (like the Swiss "pulse" system, described in the sidebar on page 20). Higher-frequency service can also help make connections seamless for the rider. One way to increase BART's frequency to Millbrae is to introduce an additional express BART service between Millbrae/SFO and Daly City, as described in BART's Metro Study.[109]

A fare payment system and fare structure that works across all three services (plus others), as well as shared maps and information, will make our transportation network truly feel like rail that rings the Bay. BART's distance-based fares and Caltrain's zone-based fares should be harmonized into one fare scheme that is seamless for riders. Maps and rider tools such as smartphone apps are another area where BART and Caltrain should collaborate to unify the rider experience. Because this corridor will be part of California's high-speed rail network, there is also a statewide need to integrate the passenger experience across rail operators.

RECOMMENDATION 20.

Use fare subsidies and fare policies to improve transit affordability and make transit work for more people.

Who: MTC, PCJPB, SFCTA, SMCTA, VTA, transit operators, Clipper 2.0 Board

There are many reasons to change transit fare policies. Foremost, improved fare policies can eliminate unintended penalties for simply transferring between vehicles, transportation modes or providers. When set appropriately, fare policies can also encourage people to choose transit more often. And they provide a way to help distribute transit demand better across times of day and service types.

We recommend keeping transit fares at a level that the market will support while also providing effective discounts and means-based programs. At Caltrain and other transit agencies, the policy has been to keep fares low so that they're affordable for lower-income passengers, in effect subsidizing both the lower-income and the higher-income passengers. This policy hurts overall system resources, especially when the great majority of Caltrain passengers have the financial capacity to pay more.

There is a tension between fare revenue, equity and increasing the number of people who take transit. A focus on increasing fares without addressing equity issues leaves lower-income travelers unable to use transit. We recommended developing a fare subsidy program that expands access to transit to more of those people for whom cost may be a barrier. This would likely include youth, seniors and lower-income residents and workers. This program should apply to both rail and bus transit and to local and regional trips.[110] Another way to address these issues in a balanced way would be to make discount transit passes (particularly rail passes) available to businesses districts or groups of employers, helping them get into the hands of lower-income workers. In addition to providing discount passes to employers, a more robust discount pass program could be made available through social service agencies, colleges and schools.

International regions offer many examples of universal fare cards and strategic pricing. For example, SwissRail offers a half-price fare card for 120 francs ($122) per month that anyone can use on rail, boats, buses and trams. This type of loyalty pass encourages discretionary use of transit all over the country.[111] On Germany's Touch&Travel system, a local public pass (BahnCard City-Ticket) entitles passengers to free transit to and from the railway station when making a trip of more than 100 kilometers (62 miles).[112]

Research shows that universal passes and monthly passes lead to greater use of transit. Transit passes, particularly when combined with off-peak pricing, help transit agencies fill unused seats. Populations such as students, tourists and seniors can benefit from the lower fare options and more leisurely travel.[113]

RECOMMENDATION 21.

Conduct short-range and long-range transportation planning as a corridor.

Who: CAHSRA, MTC, SFMTA, SMCTD, SFCTA, C/CAG, SMCTA, VTA, Caltrain, BART, Caltrans, WETA, transit operators

A low level of transit coordination in this corridor has led to both delays in addressing transportation needs and inefficient use of assets. Informal coordination among agencies is a powerful tool to address a fragmented user experience and is increasingly how regions plan and operate transportation (as opposed to consolidating transit agencies). The preceding recommendations can only be addressed through formal and informal coordination between transportation agencies, cities, institutions, business and civic leaders, and others in the Caltrain Corridor.[114]

A fully integrated payment system could allow travelers to use a single card to pay for rail, bus, car-sharing, bike-sharing and ferry services.

Where operators share riders or service areas, such as VTA and SamTrans buses, it makes sense to coordinate service planning. The benefits include more rational routes, better use of vehicles and higher ridership. Riders can experience expanded options and more frequent service. The existing Short-Range Transit Planning process, which MTC requires, could expand to integrate individual plans or to focus on county or subregion plans. These short-range transit plans could include performance metrics or targets, institutional goals and timelines. New data sources such as Clipper usage or mobile data can now improve the joint service planning process by providing insights on how people travel and how they respond to service or fare changes.

In particular, regular meetings of transit service planners and long-range transportation planners (at both cities and transportation agencies) must begin. Some areas where coordination is needed are:

- **Bus routes.** Travel paths that cross county lines might benefit from new public transit, but there's no clear way to create those services when many transit operators' coverage areas stop at the county line. (See discussion of express buses on page 43.)
- **Capital projects.** In the Bay Area, local agencies develop regional projects. As a consequence, large capital projects are often not in the places with the most demand, and the places with the most need for new capital projects don't have them. An example of this problem is North Bayshore in Mountain View, which sits at the edge of two counties and draws a growing number of regional trips.
- **Highway management.** As discussed earlier, the three counties that manage Highway 101 have developed their management and investment plans for the highway independently, making it unlikely that the best solution for efficiencies or cost will be implemented. Conducting shared planning, and even shared environmental review, would improve outcomes. The vision plan recommends that road pricing be used across the three counties, which will require a corridor-level body to manage the highway.

CHAPTER 9

What the Vision Costs

The vision plan will cost about $600 million for vehicles, between $9.9 and $14.3 billion for capital projects and between $6.2 billion and $6.8 billion for operations and maintenance. (See Figure 17.)

Cost Methodology, Risks and Considerations for Megaprojects

The following cost estimates are based on existing estimates for projects in the Caltrain Corridor and, where those are not available, on costs of similar projects and programs. These costs focus on increasing capacity and availability of transit on rail, Highway 101 and ferries. We have not researched investments related to protecting the infrastructure from disasters or hazards such as sea level rise. Similarly, costs for local improvements that extend beyond the station area, or for upgrading local transit systems, are not included.

In practice, costs can vary greatly depending on the quality and complexity of project designs, the cost of labor, the availability of needed expertise and construction teams, legal challenges and many other factors. Across the world, there are repeated examples of challenges with delivering "megaprojects," large-scale, complex ventures that typically cost a billion dollars or more, take many years to develop and build, involve multiple public and private stakeholders, are transformational and impact millions of people.[115] The new eastern span of the Bay Bridge is a well-known example of a megaproject that experienced challenges; the Transbay Transit Center and CalMod project are also examples. While not a subject of this research, there are best practices for how megaprojects should be managed in order to avoid major cost overruns. See Appendix C for further details. (Available at spur.org/caltraincorridor.)

The costs outlined here do not include transaction costs such as financing costs, potential lawsuits, environmental mitigation or public outreach. Nor do they include an allowance for unusually complicated components or technology. As a next step, more complete plans and cost estimates should be developed. Similarly, sufficient staffing needs to plan and deliver these projects must be estimated as soon as possible. In addition to a business plan, ongoing risk analysis and independent oversight/peer review should be adopted early on for all major projects. These critical actions often come too late in the process, as they did for the Bay Bridge.

Comparing Costs and Benefits in the Corridor

Our research for the vision plan did not include a cost–benefit comparison for the named projects. Instead, we sought to understand what types of projects and programs would increase transit convenience, connectivity, capacity, community and climate protection.

A cost–benefit analysis or business plan specific to Caltrain would be a logical follow-up to this vision plan. (See Recommendation 7.) For the entire corridor, it will be useful to compare the investments, particularly those needed to add increased capacity only at peak hours, such as an additional ferry boat, train or express bus. The benefits measured should include not only new riders or decreases in travel times but also environmental and social benefits.

Plan Bay Area's performance assessment of transportation projects in the region does compare projects and programs of a minimum size against a wide range of performance targets that have been set by the Metropolitan Transportation Commission and by state laws. While this serves as a screening against less-effective investment, it is not a proactive, iterative tool with which to develop the most beneficial projects in the Caltrain Corridor.

FIGURE 17

Caltrain Corridor Vision Plan Complete Cost Estimate

Totaling the estimates from each section of recommendations, the vision plan will cost between $17 billion and $21 billion. Operating costs are over the life of the vision plan (through 2035). All numbers are in 2016 dollars. See Appendix B for details. (Available at spur.org/caltraincorridor.)
Source: SPUR analysis

	Project or Program	Fleet	Capital	Operations and Maintenace
Rail				
	Caltrain short-term (2017–2021)	n/a	n/a	$600 million*
	Caltrain Modernization (2021–2023)	n/a	n/a	$700 million
	Caltrain Modernization 2.0 (2024)	$400 million	$30 million	$350 million
	Rail Modernization 3.0 (2025–2029)	$36 million	$460 million	$660 million
	Rail Modernization 4.0 (2030–2034)	n/a	$120-$130 million	$1.32 billion
	Rail Modernization 5.0 (2035)	$44 million	$600-$620 million	$1.32 billion
	Rail grade separations	n/a	$2-$6 billion	n/a
	Downtown SF Rail Extension	n/a	$4.5 billion	n/a
	Caltrain maintenace facility	n/a	$164 million	n/a
	Caltrain terminal improvements	n/a	$250 million	n/a
	Caltrain level boarding	n/a	$160 million	n/a
	Rail Total	**$480 million**	**$8.2 - $12.3 billion**	**$4.95 billion**
Stations and Last-Mile Connections				
	Station Modernization and Station Access Program	n/a	$260 - $279 million	$80 million
	First- and Last-Mile Program	n/a	n/a	$610 million
	Diridon Station upgrade	n/a	$820 million	n/a
	Millbrae Station upgrade	n/a	$500 million	n/a
	4th and King Station upgrade	n/a	$100 - $200 million	n/a
	Stations and Last-Mile Connections Total		**$1.7-$1.8 billion**	**$690 million**
Highway 101				
	Highway 101 managed lane	n/a	$20-$150 million	$10-$15 million
	Regional bus service	$40 million	n/a	$200–$720 million
	Highway 101 Total	**$40 million**	**$20-$150 million**	**$210-$735 million**
Ferries				
	New vessels	$80 million	n/a	n/a
	Ferry operations	n/a	n/a	$260 million
	Port of Redwood City ferry landing		$40 million	
	Ferry Total	**$80 million**	**$40 million**	**$260 million**
Seamless Transit Experience				
	Integrated trip planning and payment	n/a	$15 million	$10-$20 million
	Targeted fare subsidies	n/a	n/a	$100 million
	Coordinated long-range planning	n/a	n/a	$30 million
	Coordinated Transit Total		**$15 million**	**$140 - $150 million**
Total		**$600 million**	**$9.9 - $14.3 billion**	**$6.2 - $6.8 billion**

*$600 million is for current levels of service. Increased levels of service prior to Caltrain Modernization would require additional funding.

CHAPTER 10

How Do We Fund the Vision?

What Are the Most Promising Funding Sources?

This level of investment will require many funding sources, developed over time. However, transportation agencies are experiencing growing shortfalls to fund maintenance and expansion, particularly better transit. Despite overall growth in transit investment over the past few decades, current levels of investment are not sufficient to maintain facilities in acceptable condition, sustain current levels of performance, and expand systems and services to serve growing travel demand. To make matters even more challenging, funding transportation expansion has increasingly fallen on local and regional revenue sources rather than federal sources.[116] On the other hand, there are many ways to fund transportation projects and operations, as shown in Figure 18.

Most discretionary revenue sources have already been fully committed to local and regional transportation projects. Moving projects in this vision plan forward will require efforts to elevate each project's priority within existing funding streams, as well as establishing new and innovative revenue sources. Some new sources have not yet been applied to the types of projects in the vision. Others will require legislative and/or voter approval to be implemented. Figure 19 proposes a plan to fund the vision using some existing sources while also creating new sources of revenue. See Appendix B for more details. (Available at spur.org/caltraincorridor.)

FUNDING STRATEGY 1

Advocate for anticipated regional, state and federal revenue: **$3 billion**

Who: PCJPB, CAHSRA, all cities and public agencies in the corridor, MTC, Transbay Joint Powers Authority, Port of Redwood City, WETA, transit operators, civic leaders

Many projects in the vision plan are already identified in the Regional Transportation Plan (RTP). The RTP, developed by MTC in cooperation with local agencies every four years, sets the stage for all major capital and operating programs within the Bay Area. RTP projects are reprioritized every two years during the update process (most recently in 2016). While the funding is largely allocated based on formulas and existing agreements, advocacy on the part of agencies and business and civic leaders could lead projects in the vision plan to be prioritized and funded sooner.

The RTP also assumes that there will be some new regional funding sources that will add new revenue — for example, Regional Measure 3 for bridge tolls, a new regional gas tax and congestion pricing projects (user fees for motorists). For this reason, these are not included as new revenue sources in this proposal. However, the creation of these new funding pots is essential to maximize available RTP funding and therefore maximize vision plan project funding.

FIGURE 18

Types of Transportation Funding

Transportation projects and services are funded in a number of ways. One way to categorize funding types is to look at who the primary payer is: the public or business community (such as a sales tax), users (such as a transit fare), beneficiaries or districts (such as developer impact fees) or the private sector (such as concession contract or grant).

Source: SPUR analysis

General public or business community pays	Sales taxes Parcel taxes Gross receipts taxes Business taxes
User pays	Tolls Road user charges Fares and transit passes Vehicle registration fees Parking taxes
Beneficiary/district pays	Property-based business improvement districts SB 142/public transit assessment districts Business-based business improvement districts Community facilities (Mello-Roos) districts Developer impact fees Enhanced infrastructure finance districts
Private sector pays	Private grants Public-private partnerships

FIGURE 19

Sources of Funding for the Caltrain Corridor Vision

The following combination of sources could fund the proposed fleet, capital and operating expenditures identified in the vision plan over the next 20 years.
Source: SPUR analysis

Funding Source	Anticipated Revenue
Anticipated regional, state and federal revenue	$3 billion
Transit fares and highway tolls	$5 billion
Countywide sales tax	$2 billion
Corridor parcel tax	$2.5 billion
Local property-based and business-based funding	$3 billion
New regional and state funding	$3 billion
Public-private partnerships	TBD
Total	$18.5 billion+

FUNDING STRATEGY 2

Use fares and tolls to cover transit operating costs: **$5 billion**

Who: PCJPB, CAHSRA, SFCTA, SMCTA, VTA, SMCTD, SFMTA, Caltrans, civic leaders

User fees such as transit fares and road tolls are a logical funding source for transportation projects and should play a larger role. The costs to run efficient electric rail systems are low enough that it's common for fares to cover operating costs — and even throw off additional funds that can be reinvested in capital programs.

This assumes today's average fares (approximately $6 per passenger) and enough demand to match the capacity proposed in the vision plan. For example, at the Rail Modernization 3.0 phase, after $6.8 billion of investment (the majority of which is the DTX and grade separations, averaged at $600 million per year), annual fare revenue would be almost $400 million.

FUNDING STRATEGY 3

Dedicate funds from county sales taxes: **$2 billion**

Who: SFCTA, SMCTA, VTA, civic leaders

In California, county sales taxes are commonly used to raise new funds for transportation and are increasingly standing in for federal funding. In the Bay Area, county sales taxes are used for highway projects, transit projects, transit operations, streets, bicycle facilities and many other transportation-related uses (eight out of nine Bay Area counties have transportation sales taxes). Based on previous experience in the Bay Area, it appears feasible to fund $2 billion in projects and programs in the Caltrain Corridor over the next 15 to 20 years, through sales taxes in Santa Clara, San Mateo and San Francisco counties.[117] Sales taxes for general funds require 50 percent plus one votes to pass, while dedicated sales taxes (tied to an expenditure plan) require two-thirds of voter approval to pass.

Santa Clara County's successful 2016 sales tax ball measure included $700 million for grade separations and $300 million for CalMod 2.0 capacity upgrades.

FUNDING STRATEGY 4

Pass a new parcel tax, possibly through a transit district: **$2.5 billion**

Who: PCJPB, SFCTA, SMCTA, VTA, civic leaders

A parcel tax is levied on each parcel (such as by home, by square foot or by acre), rather than on the assessed value of a property. Parcel taxes are commonly used for transit operations (BART and AC Transit have dedicated parcel taxes) and for other public services such as libraries and schools. A parcel tax provides a steady revenue stream that is not tied to a specific expenditure plan. Parcel taxes, because they are special taxes, require two-thirds voter approval to pass and can be applied to both residential and commercial parcels.

Creating a parcel tax offers the opportunity to create a transit district; districts can accept more state and federal funds for transit. In the case of Caltrain, it would mean creating a new district or joining an existing transit district (such as the BART district). One opportunity with a parcel tax is the ability to create taxing district boundaries that correlate with the most significant users or beneficiaries of the investment. A district could be confined to an area that has a direct relationship to Caltrain, such as within a few miles of the rail corridor.

FUNDING STRATEGY 5

Develop local matching funds, especially for stations and grade separations: **$3 billion**

Who: Cities in the corridor, VTA, SMCTA, SFCTA, civic leaders

Local funding is a key piece of the vision plan. It's a logical source for matching funds for grade separations and station improvements and to augment first- and last-mile services because the benefits are accrued locally and because these projects have a close nexus with local land use and transportation goals.

Local funding is often, but not always, property based. Some local funding mechanisms are public transit assessment districts (governed by SB 142, enabling assessments within a half-mile of transit stations), community facilities or Mello-Roos districts (self-imposed taxes on property owners to finance public services and improvements), business-based improvement districts (which levy a tax on participating businesses within a district) and property-based business improvement districts (a self-governed district to augment services). For example, the Transbay Transit Center Program is a Mello-Roos district that is contributing funds for the construction of the Transbay Transit Center.

Developer impact fees can be collected by a city or county to fund capital expenses such as bike and pedestrian projects, traffic signals or transit-related projects. Parking taxes or revenue

can also be used to fund transit-related infrastructure. Cities in the Caltrain Corridor are increasingly looking at business taxes to fund transportation and other infrastructure. Rather than using this tool city by city, a shared business tax scheme, where business across several jurisdictions are taxed as part of one district or assessment area, could be a more efficient solution. Income taxes and payroll taxes are another type of business tax that should be explored, as they can be progressive and raise significant funding.

FUNDING STRATEGY 6

Develop innovative sources for remaining capital need: **$3 billion**

Who: All cities and public agencies in the corridor, MTC, civic leaders, CalSTA

Existing state and federal funding streams combined with local funding will not be sufficient to develop the model corridor that we envision. We propose pursuing entirely new funding streams to grow funding for the Caltrain Corridor. The options are:

1. Pass a new regional transportation revenue measure: $2 billion. This could be based on a tax or fee and could include major regional transportation investments, similar to Los Angeles County Measure M (2016) or Seattle's Sound Transit series of parcel taxes.
2. Expand regional and state proposals to price driving and carbon: $500 million. Key state opportunities are a carbon tax and a vehicle-miles-traveled tax. Adding to the cost of driving has an additional benefit of creating new demand for transit.
3. Work at the state level to create a new or augmented revenue source similar to cap-and-trade: $500 million.

FUNDING STRATEGY 7

Identify elements that would be attractive for private investment: **TBD**

Who: PCJPB, CAHSRA, MTC, all cities and public agencies in the corridor, private sector leaders

This vision will not become a reality with public funding alone. Opportunities for private investment such as concessions and public-private partnerships need to be identified and pursued. Project sponsors such as PCJPB should develop a concerted action plan to identify and carve out portions of the vision plan that could be turned over to the private sector for investment, project delivery, operations or all three.

Selected elements of the vision could be accomplished via a public-private partnership (P3), an agreement between a government agency and a private sector entity that participates in delivering a public sector project. Contrasted with traditional models, the private sector assumes a greater role in the planning, financing, design, construction, operation and maintenance of public facilities. P3s transfer risks to the private sector and can reduce costs, increase certainty of execution, accelerate funding and accelerate project completion. While P3s are still emerging in California and the United States, they are increasingly common around the world. A local example is San Francisco's project to replace Doyle Drive with the Presidio Parkway, where a concessionaire was brought on to design, build, finance, operate and maintain the project for 30 years.

Some P3s could be strictly concessions. For example, WETA could build a series of ferry terminals with public funding and invite the private sector to submit proposals to provide the ferries and operate the service. Other options could include concessions to operate bus lines, shuttles, ferries, rail lines or toll lanes. The possibilities are many and should be explored. This effort would include private sector outreach by agencies and civic leaders to help identify which portions of the vision could be delivered with private participation and investment, as well as the type of arrangement that would be the most appropriate in each case.

Private grants, or cost-sharing agreements, are another way that private funds could help pay for vision plan elements. A potential upside of private funding is that it can be less restrictive than public funding.

CONCLUSION

Next Steps

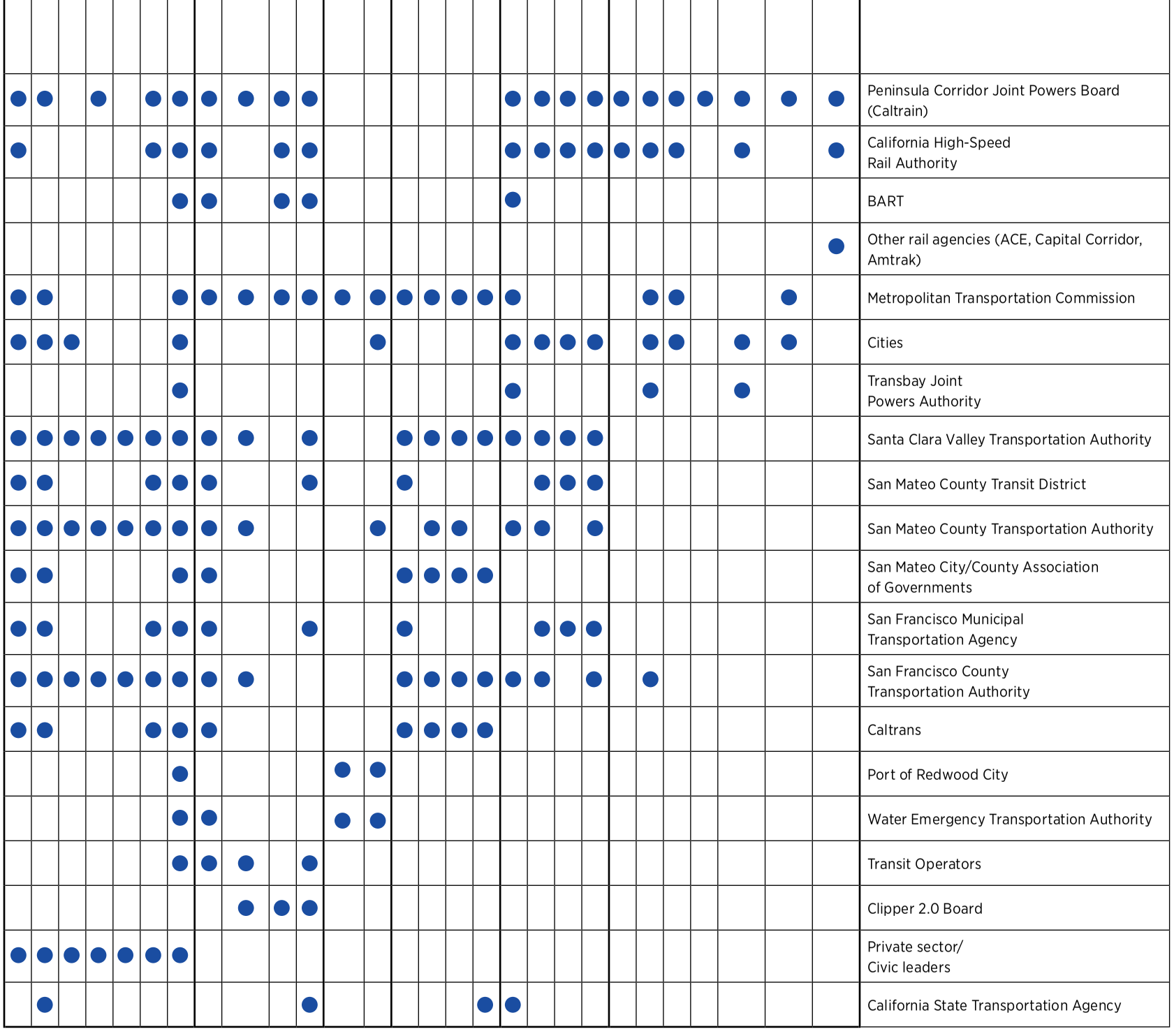
The projects and programs in the vision plan can and should be funded and completed in 20 years or less. Many of them need to be completed before Caltrain's electrified service begins or before high-speed rail service begins. Where moving forward gets complicated, creative problem-solving and learning from international precedents will help us find solutions.

Upcoming policy decisions in the Caltrain Corridor will require close cooperation among multiple agencies that have historically managed and designed their transportation systems independently. Working across the public and private sectors, we can develop both the resources and the leadership needed to work together and make the vision a reality, in a timely manner.

The plan of action that follows summarizes the vision plan recommendations.

Plan of Action

Rail: Develop reliable, frequent all-day rail service with enough capacity to meet demand.	**Recommendation 1:** Adopt an integrated rail schedule that adds frequency all day at regular times, increases capacity to meet demand and attracts new riders.
	Recommendation 2: Adopt service planning guidelines to correlate future service levels with actual ridership and with ongoing local support for station area development.
	Recommendation 3: Add system upgrades, infrastructure and new train cars strategically to increase frequency, add capacity, increase reliability and reduce travel times.
	Recommendation 4: Improve Caltrain service in the short term, before electrification.
	Recommendation 5: Use a corridor-wide strategy to address the impact of at-grade rail crossings.
	Recommendation 6: Connect Caltrain and high-speed rail to downtown San Francisco at the Transbay Transit Center.
	Recommendation 7: Develop a business plan for Caltrain.
Rail Stations and Last-Mile Connections: Offer quick and intuitive connections at modern, high-amenity stations.	**Recommendation 8:** Upgrade stations to attract and accommodate more riders.
	Recommendation 9: Improve station access for sustainable and space-efficient modes of travel.
	Recommendation 10: Proactively manage station access and first- and last-mile connections at each rail station.
	Recommendation 11: Build stations with seamless connections between Caltrain and high-speed rail.
Highway 101: Move more people on Highway 101, with less delay.	**Recommendation 12:** Manage a lane of Highway 101 as a high-occupancy toll lane along the entire corridor.
	Recommendation 13: Adopt equity policies and programs for HOT lanes.
	Recommendation 14: Use revenue from pricing Highway 101 to add more public transit service.
	Recommendation 15: Grow regional express bus services.
Ferries: Establish public ferry service for Peninsula travelers.	**Recommendation 16:** Create a ferry terminal at the Port of Redwood City.
	Recommendation 17: Expand ferry services to include Peninsula stops.
A Seamless Transit Experience: Create a coordinated and convenient transportation network.	**Recommendation 18:** Integrate information and payment across mobility services.
	Recommendation 19: Operate BART, Caltrain and high-speed rail as one system from the rider's perspective.
	Recommendation 20: Use fare subsidies and fare policies to improve transit affordablility and make transit work for more people.
	Recommendation 21: Conduct short-range and long-range transportation planning as a corridor.
Funding the Caltrain Corridor Vision	**Funding Strategy 1:** Advocate for anticipated regional, state and federal revenue.
	Funding Strategy 2: Use fares and tolls to cover transit operating costs.
	Funding Strategy 3: Dedicate funds from county sales taxes.
	Funding Strategy 4: Pass a new parcel tax, possibly through a transit district.
	Funding Strategy 5: Develop local matching funds, especially for stations and grade separations.
	Funding Strategy 6: Develop innovative sources for remaining capital need.
	Funding Strategy 7: Identify elements that would be attractive for private investment.


Peninsula Corridor Joint Powers Board (Caltrain)
California High-Speed Rail Authority
BART
Other rail agencies (ACE, Capital Corridor, Amtrak)
Metropolitan Transportation Commission
Cities
Transbay Joint Powers Authority
Santa Clara Valley Transportation Authority
San Mateo County Transit District
San Mateo County Transportation Authority
San Mateo City/County Association of Governments
San Francisco Municipal Transportation Agency
San Francisco County Transportation Authority
Caltrans
Port of Redwood City
Water Emergency Transportation Authority
Transit Operators
Clipper 2.0 Board
Private sector/ Civic leaders
California State Transportation Agency

Endnotes

[1] Roads and bridges that connect with Highway 101— the San Mateo and Dumbarton bridges, Highway 280, Highway 85, Highway 87 and Highway 237 — all have their own congestion and management needs. Because most destinations are located near Highway 101, and because it parallels Caltrain, Highway 101 is a focus of this vision plan.

[2] Population numbers from Metropolitan Transportation Commission/Association of Bay Area Governments, see: MTC/ABAG, Plan Bay Area, 2013, http://files.mtc.ca.gov.s3.amazonaws.com/pdf/Plan_Bay_Area_FINAL/pbafinal/index.html

[3] Noreen McDonald, "Are Millennials Really the 'Go-Nowhere' Generation," Journal of the American Planning Association, 81, 2015, page 90, http://www.tandfonline.com/doi/full/10.1080/01944363.2015.1057196

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[5] Laura Tam and Sarah Jo Szambelan, Fossil-Free Bay Area, SPUR, 2016, page 8, https://www.spur.org/sites/default/files/publications_pdfs/SPUR_Fossil_Free_Bay_Area.pdf

[6] Janet McGovern, Caltrain and the Peninsula Commute Service, California Arcadia Publishing, 2012.

[7] There were multiple trains to Los Angeles including the Coast Daylight, a daytime train that survived until 1971. At that point Amtrak's Coast Starlight, which travels from Seattle to Los Angeles via Oakland, replaced the Coast Daylight, leaving the commuter service as the only rail service between San Jose and San Francisco.

[8] Steve Miller, The Peninsula Commute Story, 1987.

[9] Louise A. Mozingo, Pastoral Capitalism, MIT Press, 2011.

[10] Chris Brittle et al., Peninsula Mass Transit Study, Metropolitan Transportation Commission, 1985, http://bayrailalliance.org/files/library/Peninsula_mass_transit_study.pdf

[11] Andrew Nash, "Caltrain Rapid Rail Plan," Transportation Research Record 1677, 1999, pages 31-39, https://www.researchgate.net/publication/245558937

[12] Caltrain 2016 Annual Passenger Counts, http://www.caltrain.com/Assets/__Agendas+and+Minutes/JPB/Board+of+Directors/Presentations/2016/2016-05-05+Annual+Counts.pdf

[13] Today, Caltrain operates a weekday schedule with 92 trains per day (46 northbound and 46 southbound). Trains are operated as one of three designated services: local, which makes all station stops; limited-stop, which makes approximately half of the total station stops; and Baby Bullet, which makes at most six of the total station stops.

[14] Seated capacity refers to the total number of seats available per train. To calculate seated capacity per train, the total number of passengers on a train at a given time is divided by the total number of seats available per train.

[15] Caltrain 2015 Caltrain Annual Passenger Count, http://www.caltrain.com/Assets/_Marketing/pdf/2015+Annual+Passenger+Counts.pdf

[16] MTC data collected in San Mateo County in 2015. MTC presentation available at http://www.transformca.org/sites/default/files/062515%20San%20Mateo%20101%20Corridor%20Strategies.pdf

[17] MTC's 2012–2014 Shuttle Census found that at least 765 private buses operated each day in the region in 2014. With 9.6 million annual boardings, the shuttles in aggregate are the equivalent to the region's sixth largest transit operator. The total number of public transit boardings annually in the region was approximately 531 million. Shuttle buses play an outsize role in the Caltrain Corridor, particularly during peak hours, due to the amount of buses provided by employers here. See: http://mtc.ca.gov/sites/default/files/2016%20Bay%20Area%20Shuttle%20Census.pdf and http://mtc.ca.gov/sites/default/files/Statistical_Summary_2015.pdf

[18] Todd Littman, The Hidden Traffic Safety Solution: Public Transportation, American Public Transportation Association, 2016, https://www.apta.com/resources/reportsandpublications/Documents/APTA-Hidden-Traffic-Safety-Solution-Public-Transportation.pdf

[19] Caltrain and MTC, Caltrain 2014 On-Board Transit Survey: Final Report, 2014, http://www.caltrain.com/Assets/_MarketDevelopment/pdf/Caltrain+Origin+$!26+Destination+Survey+2014.pdf

[20] Caltrain, Fares, 2016, http://www.caltrain.com/Fares.html

[21] Ibid.

[22] Caltrain, Using a Wheelchair, http://www.caltrain.com/riderinfo/Accessibility/wheelchair.html

[23] U.S. Census Bureau, 2010 and 2015 population estimates, https://www.census.gov/en.html; State of California Employment Development Department, Labor Market Information, http://www.labormarketinfo.edd.ca.gov/geography/metropolitan-areas.html. The number of people crossing the boundaries of the nine-county Bay Area increased by 78 percent between 1990 and 2013. See: Jeff Bellisario, Micah Weinberg and Camila Mena, The Northern California Megaregion: Innovative, Connected, Growing, Bay Area Council Economic Institute, 2016.

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[25] City of San Jose, Memorandum, 2011, https://www.sanjoseca.gov/DocumentCenter/Home/View/643; Draft Environmental Impact Report: North Bayshore Precise Plan, State Clearinghouse #2013082088, 2014, http://www.mountainview.gov/civicax/filebank/blobdload.aspx?BlobID=13791; Transbay Transit Center, Transbay Neighborhood, http://transbaycenter.org/project/redevelopment-plan

[26] Shoreline Boulevard Corridor Study, City of Mountain View, 2014, http://www.mountainview.gov/civicax/filebank/blobdload.aspx?BlobID=15441

[27] Robert Lang, Edgeless Cities: Exploring the Elusive Metropolis, Brookings Institution Press, 2003. By way of contrast, "edge cities" are more planned, higher-density, more mixed-use places located at the edges of regions.

[28] San José International Airport Master Plan Update Project, January 2011, http://www.flysanjose.com/fl/about/improve/overview/Jan_Add_2011.pdf

[29] California Transportation Plan 2040, http://www.dot.ca.gov/hq/tpp/californiatransportationplan2040/2040.html. These concepts are being further developed through the 2018 California State Rail Plan.

[30] Passenger vehicles are the Bay Area's largest single source of climate pollution, contributing 32 percent of our greenhouse gas emissions. Public transit emits far less greenhouse emissions than autos, and the electrification of Caltrain will further reduce the emissions from that system. Walking or biking emits virtually no greenhouse gases. See: SPUR analysis in Fossil-Free Bay Area, http://www.spur.org/publications/spur-report/2016-09-21/fossil-free-bay-area, with data from Bay Area Air Quality Management District. The estimated reduction from electrified Caltrain service is 176,000 metric tons of CO2 per year (assumes service to Transbay Transit Center, through 2040). See Caltrain Modernization Program, http://www.caltrain.com/projectsplans/CaltrainModernization/Modernization/Caltrain_Modernization_InfoGraphic.html

[31] The draft 2016 plan places all growth in the existing urban footprint of the region. The result is an estimated 18 percent reduction in per capita C02 emissions and a 3 percent increase in non-auto mode share by 2040. Plan Bay Area is the implementation of several policies: The Sustainable Communities and Climate Protection Act of 2008, also known as Senate Bill 375, is a State of California law targeting greenhouse gas emissions from passenger vehicles. The Global Warming Solutions Act of 2006 (AB 32) sets goals for the reduction of statewide greenhouse gas emissions. Passenger vehicles are the single largest source of greenhouse gas emissions statewide, accounting for 30 percent of total emissions. SB 375 therefore provides key support to achieve the goals of AB 32. SB 375 instructs the California Air Resources Board to set regional emissions reduction targets from passenger vehicles. The Metropolitan Planning Organization for each region (in the Bay Area this is the Metropolitan Transportation Commission) must then develop a Sustainable Communities Strategy that integrates transportation, land-use and housing policies to plan for achievement of the emissions target for their region.

[32] The CalMod project has a funding plan and work on the project has commenced. The first part is electrifying the 51.4 miles of track between San Francisco's 4th and King and San Jose's Tamien stations ($704 million) and replacing 75 percent of Caltrain's diesel fleet with electric trains ($618 million). The second piece is a new, $230 million train control system, known as Communications-Based Overlay Signal System Positive Train Control system, which will allow trains to run more precisely and closer together, making increased frequency possible. More important, positive train control increases safety because the system can control train movement in the event of human error.

[33] For a detailed discussion of sharing tracks between different types of rails, see Nash, Andrew, Best Practices in Shared-Use High-Speed Rail Systems, 2003, http://transweb.sjsu.edu/MTIportal/research/publications/documents/02-02.pdf

[34] California High-Speed Rail Authority, Draft 2016 Business Plan, 2016, http://www.hsr.ca.gov/About/Business_Plans/Draft_2016_Business_Plan.html

[35] Ibid.

[36] MTC's 2012-2014 Shuttle Census shows that, together, these shuttles were the region's sixth largest transit operator in FY 2014-15. See: http://mtc.ca.gov/sites/default/files/2016%20Bay%20Area%20Shuttle%20Census.pdf

[37] Stanford University's trip cap was a pioneering public policy/land use regulation approach to managing auto trips in and out of a particular area. See: http://govcr.stanford.edu/wp-content/uploads/2015/10/general-use-permit.pdf

[38] There are many other trip caps in the corridor. Mountain View's North Bayshore Trip Cap requires a 30 to 45 percent single-occupancy vehicle (SOV) mode share target, depending on the density of employment within buildings. See: North Bayshore Transportation Demand Management Plan Guidelines Final, 2015, http://www.mountainview.gov/civicax/filebank/blobdload.aspx?BlobID=15164. Sunnyvale's Central and Wolfe Trip Cap requires about a 50 percent SOV mode share target (a 35 percent reduction from ~76 percent). See: Central & Wolfe TDM Plan, http://bit.ly/1NSV0Vd. Menlo Park's East of 101 Trip Cap requires about ~56 percent SOV (25 percent reduction), with a $50 penalty/trip/day. See: Menlo Park 2013 Facebook West Campus Trip Cap, pages 40-46, http://www.menlopark.org/DocumentCenter/View/2342

[39] Palo Alto TMA, http://www.paloaltotma.org/app_pages/view/19

[40] Joint Venture Silicon Valley, a regional collaborative forum, has been developing the concept of mobility as a service for the Caltrain Corridor by exploring pilot projects in partnership with institutions, cities and other stakeholders aiming for near-term implementation.

[41] Todd Littman, "Autonomous Vehicle Implementation Predictions," Victoria Transport Policy Institute, December 10, 2015, pages 6-7, http://slidepapers.in/wp-content/uploads/2016/03/Autonomous-Predictions-Vehicle-Implementations.pdf

[42] National Association of City Transportation Officials (NACTO), NACTO Policy Statement on Automated Vehicles, 2016, http://nacto.org/wp-content/uploads/2016/06/NACTO-Policy-Automated-Vehicles-201606.pdf

[43] Caltrain's 2016 operating budget anticipates approximately $84 million in fare revenue and $117 million in operating expenses. See: http://www.caltrain.com/Assets/_Finance/BUDGETS/JPB/FY2016+JPB+Adopted+operating+budget.pdf

[44] A budget crisis emerged in late 2010, when San Mateo County experienced a significant budget shortfall and elected to reduce its funding for Caltrain by two-thirds, from $14.7 million to $4.9 million. San Francisco and Santa Clara counties also proposed reducing their contributions. Had this happened, Caltrain's annual operating budget of $100 million would have been suddenly reduced by 24 percent, to $76 million. This would have required drastic cuts in service, including virtually all midday and late-night service, all weekend service and all service to certain stations. While drastic cuts were averted by a one-time transfer from San Mateo County's Measure A Sales Tax Revenue, such a crisis could arise at any time should any of the three member counties again face a budget shortfall.

[45] Caltrain Strategic Plan FY2015-2024, September 2014, http://www.caltrain.com/Assets/Caltrain+Modernization+Program/Documents/Strategic+Plan+Final+Doc.pdf

[46] Caltrain Short Range Transit Plan 2015-2024, October 2015, http://www.caltrain.com/projectsplans/Plans/Short_Range_Transit_Plan.html. The CalMod 2.0 project anticipates operating eight-car trains, rather than today's six-car trains, although the actual operating scheme has not been determined. It may also be beneficial to take advantage of the electric multiple units and operate shorter trains with more frequency or for shorter routes.

[47] Embarcadero Station Schedule http://www.bart.gov/stations/embr/schedule

[48] Caltrain Partners with San Mateo County on Suicide Prevention Forum, 2015, http://www.caltrain.com/about/MediaRelations/news/Caltrain_Partners_with_San_Mateo_County_on_Suicide_Prevention_Forum.html

[49] Swiss Federal Railway, Facts and Figures, http://sbb.ch/zahlen-und-fakten

[50] The 2012 Caltrain/HSR Blended Operations Analysis indicates that Caltrain and high-speed rail can operate together, without substantial additional rail infrastructure, for a combination of up to six Caltrain trains and four high-speed rail trains per hour. While this combination of services is feasible with only a small amount of new rail infrastructure, it would probably force an uneven Caltrain timetable: A group of three Caltrain trains depart from each terminal station within 10 minutes of one another, and then 20 minutes must pass before the next group of Caltrain trains can depart. See: http://www.caltrain.com/projectsplans/CaltrainModernization/BlendedSystem/BlendedSystemPlanningProcess/Caltrain_HSR_Blended_Service_Plan_Operations_Analysis.html

[51] Jarrett Walker, Human Transit, Island Press, 2011, pages 117-34.

[52] For more discussion of station-area development for rail, see: SPUR, Beyond the Tracks: The Potential of High-Speed Rail to Reshape California's Growth, 2011, https://www.spur.org/sites/default/files/publications_pdfs/SPUR_Beyond_the_Tracks.pdf

[53] VTA, Service Design Guidelines, 2007, http://www.vta.org/sfc/servlet.shepherd/version/download/068A0000001Fb8j

[54] For example transit agency transit-oriented development guidelines, see BART's Transit-Oriented Development Policy, https://www.bart.gov/sites/default/files/docs/BART%20Board%20-%20TOD%20Policy%20Draft%206-9-16%20Adopted%20FINAL_0.pdf and Metro's Transit-Oriented Development Program, http://www.oregonmetro.gov/tools-partners/grants-and-resources/transit-oriented-development-program

[55] Passing tracks for the two opposite directions of travel can either be constructed in the same locations on the corridor (resulting in some four-track corridor segments) or in different locations (resulting in, at most, three-track corridor segments). The four-track approach reduces the length of the corridor impacted by new track construction but requires greater width. The three-track approach reduces the maximum corridor cross-section to three tracks but brings construction impacts (including station reconstructions) to a greater length of the corridor.

[56] For more information, see: http://www.caltrain.com/projectsplans/CaltrainModernization/BlendedSystem/BlendedSystemPlanningProcess/Caltrain_HSR_Blended_Service_Plan_Operations_Analysis.html

[57] A bigger move to increase train car capacity is to use articulated trains, or train cars that are open to the next train car. (Articulated buses can be found today in several Bay Area communities.) Articulated trains increase capacity by approximately 10 to 25 percent because they increase the amount of usable space and spread passengers more evenly through a train. Although no U.S. passenger rail operators have chosen articulated rail cars, they are used today in Paris, Shanghai and Munich (a recent survey showed 75 percent of non-U.S. metro systems use articulated trains). Using articulated trains on the Caltrain Corridor would be subject to regulatory approvals and safety laws, retrofitting of maintenance facilities, as well as a train car design that works with the catenary wire system.

[58] CAHSRA is evaluating light maintenance facility locations in Brisbane and Gilroy.

[59] These state of good repair and system enhancement projects are described in the Caltrain Short Range Transit Plan 2015-2024. See: http://www.caltrain.com/projectsplans/Plans/Short_Range_Transit_Plan.html

[60] Because high-speed rail trains move so fast, they need additional clearance between the track and platform. This creates a gap between platforms and trains that is wider than the three-inch ADA maximum for unassisted boarding. To provide unassisted boarding without bridge plates, the gap can be bridged automatically by a moving step that extends from the train. The step is key to unassisted boarding for wheelchair users.

[61] The daily train schedule for the new electrified service has not yet been developed. The expected increase in seated, peak-hour capacity with the CalMod project (2021 service) is approximately 11 percent, although the new train car design is not yet finalized.

[62] An estimated 33,000 Caltrain riders will use the Transbay Transit Center station. See: http://transbaycenter.org/project/faqs

[63] The 2009 environmental impact review (EIR) for California high-speed rail evaluated options for high-speed rail to operate on dedicated tracks through the Peninsula, different from the blended system being developed today. The four-track

project options can be found here in the EIR for the high-speed rail project, see: http://www.hsr.ca.gov/docs/programs/bay_area_eir/BayCValley10_EIR_vol1_complete.pdf. A recent high-level analysis showed that 94 percent of the corridor is 75 feet or wider (the width needed for four tracks with high-speed rail), and 68 percent of the corridor is 100 feet or wider, see: http://www.cahsrblog.com/2013/09/four-track-hsr-on-peninsula-just-got-harder-but-not-impossible/

[64] A detailed analysis of the Joint Powers Board Right of Way can be found in the California High Speed Rail Authority environmental documents of 2009, more easily viewed at: http://caltrain-hsr.blogspot.com/2009/01/caltrain-right-of-way-maps.html.

[65] San Mateo County created a $350 grade separation program through its 2004 Measure A sales tax, most of which has been spent. San Francisco County does not have a grade separation program, and Santa Clara County funded $700 million grade separations in its November 2016 sales tax measure. See: http://www.smcta.com/Assets/SMCTA/Documents/2009-2033+Transportation+Expenditure+Plan.pdf. The California Public Utilities Commission maintains a priority list of highway-rail grade separation projects that may qualify for state and federal funding. See: http://www.cpuc.ca.gov/General.aspx?id=2891

[66] The Federal Railroad Administration's trigger for fully grade separating would be at 125 mph, which is faster than high-speed rail will run on the Caltrain Corridor. New and reconstructed stations identified in the cost estimates in this section are assumed to include grade-separated crossings to/from platforms for passengers.

[67] The Caltrain electrification EIR evaluated grade crossings using a service plan with six Caltrain and four high-speed rail trains per hour, for a total of 10 trains per hour. The scenarios presented in this section further increase trains per hour.

[68] More background on freight operations can be in found in Caltrain electrification EIR. See: http://www.caltrain.com/Assets/Caltrain+Modernization+Program/FEIR/3.14+Transportation.pdf

[69] Today, the Market Street/Financial District area is connected with Caltrain via the BART line to SFO. The BART travel time between Millbrae station and Montgomery station is 30 minutes (not including time to get to Millbrae station and wait for a connecting train) and includes 10 stops and payment of a new fare. When Caltrain is extended to downtown San Francisco, the Caltrain travel time from Millbrae to the Transbay Transit Center will be approximately 20 minutes, depending on the exact stopping pattern of the train between the two stations. See: Peninsula Corridor Electrification Project Environmental Impact Report, Appendix I – Ridership Technical Memorandum, Caltrain, 2014.

[70] The SF Planning Department Railyards and 280 Boulevard Feasibility study is considering how the DTX, high-speed rail and other infrastructure in SoMa, Mission Bay and Showplace Square/Lower Potrero Hill neighborhoods can be organized differently to improve transportation and land use outcomes. Options under consideration include a change in the alignment of the DTX project. See: http://sf-planning.org/railyard-alternatives-and-i-280-boulevard-feasibility-study-rab.

[71] Shoreline Boulevard Corridor Study, 2014, http://www.mountainview.gov/civicax/filebank/blobdload.aspx?BlobID=15441

[72] See: Dumbarton Rail Corridor Alternatives Study, 2011, http://www.smcta.com/Assets/Dumbarton+Rail+Corridor/documentation/Dumbarton_Rail_Corridor_Alternative_Study-2010.pdf A new Dumbarton corridor study is underway. See: http://www.samtrans.com/Planning/Planning_and_Research/DumbartonTransportationCorridorStudy.html

[73] For more information on VTA's BART Silicon Valley Phase II project, see: http://www.vta.org/bart/stations

[74] For further discussion of second transbay crossing, see: SPUR, Designing the Bay Area's Second Transbay Rail Crossing, 2016, http://www.spur.org/sites/default/files/publications_pdfs/SPUR_Designing_the_Bay_Area's_Second_Transbay_Rail_Crossing.pdf

[75] SPUR/Arup analysis. For the purposes of cost estimation, we used a sample alignment that maximizes the use of existing rights-of-way (to minimize construction impacts to communities) and, wherever it would be possible without community impacts, assumes trains would run at grade. Along Highway 101, we considered aerial alignments alongside the freeway to be feasible. Wherever at-grade and aerial alignments were not feasible (e.g., through East Palo Alto), we assumed below-grade/tunneled alignments.

[76] For a robust discussion of the first/last mile to transit and a methodology for improving station access across jurisdictions, see: Los Angeles County Metropolitan Transportation Authority, First Last Mile Strategic Plan and Planning Guidelines, 2014, http://media.metro.net/docs/sustainability_path_design_guidelines.pdf

[77] Ibid.

[78] SRTP, 2015, http://www.caltrain.com/Assets/_Planning/Strategic+Plan/Strategic+Plan+FY2015+-+FY2024/Caltrain+Short+Range+Transit+Plan+-+FY2015-FY2024+-+Final.pdf

[79] Ibid.

[80] Duranton Gilles and Matthew A. Turner, "The Fundamental Law of Road Congestion: Evidence from US Cities," American Economic Review, 101, 2011, pages 2616-52.

[81] Transit Cooperative Research Program, TCRP Report 145: Reinventing the Urban Interstate: A New Paradigm for Multimodal Corridors, 2011, http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_145.pdf

[82] U.S. Department of Transportation Federal Highway Administration, Managed Lanes: A Primer, 2015, http://ops.fhwa.dot.gov/publications/managelanes_primer/

[83] At the time of this study, there is a state-led collaboration across the Highway 101 corridor. The collaboration is working on a shared policy approach for the corridor and a more integrated project development process.

[84] TransForm, Innovation Required, 2014, http://www.transformca.org/sites/default/files/final_hot_101_paper.12.16.2013-1_revised_acknowledgement_0.pdf

[85] MTC presentation available at http://www.transformca.org/sites/default/files/062515%20San%20Mateo%20101%20Corridor%20Strategies.pdf

[86] A disadvantage of any HOT (or HOV) facility on the innermost lanes of a freeway is that cars and buses entering the HOT facility (after entering the freeway from an on-ramp) must cross leftward across several general-purpose lanes. Similarly, cars and buses in the HOT facility must cross rightward across several general-purpose lanes to exit. This action of a traffic stream crossing other traffic streams creates a "weaving conflict." The effect of the weaving conflict is reduced, however, if users of the HOT lane have longer average trip lengths (i.e., large volumes of traffic are not entering or exiting along most of the freeway corridor). In specific cases, direct access ramps (to/from arterials) or direct connector ramps (to/from other HOT/HOV or freeway facilities) may be warranted to mitigate weaving conflicts.

[87] Figures based on the current focus of planning for Highway 101 in San Mateo County, which is to create an HOV lane by widening some portions of the highway and using existing auxiliary lanes in other places. See: http://www.transformca.org/sites/default/files/final_hot_101_paper.12.16.2013-1_revised_acknowledgement_0.pdf

[88] MTC Express Lanes, 2016, http://mtc.ca.gov/our-work/plans-projects/major-regional-projects/mtc-express-lanes

[89] Several studies, by both public agencies and advocacy organizations, have been conducted recently to identify potential improvements for the Highway 101 freeway corridor, see: San Mateo – 101 HOV Lane Feasibility Study; Dowling/Kittelson & Associates, 2012; San Mateo 101, HOV Lane Analysis, Final Mainline Report; Kittelson & Associates, 2012; Staged HOV Lane Analysis (from Whipple Avenue to I-380). See also Kittelson & Associates, 2012; Innovation Required: Moving More People with Less Traffic. TransForm, 2013; Project Study Report: US 101 HOV Project Development Support (PSR-PDS); San Mateo County Transportation Authority (SMCTA), City/County Association of Governments of San Mateo County, California Department of Transportation (Caltrans), 2015; San Mateo 101 Corridor Strategies: An Innovative Partnership in the Making; Metropolitan Transportation Commission, 2015; San Francisco Freeway Corridor Management Study; San Francisco County Transportation Authority, study underway.

[90] TransForm, Innovation Required, 2014, http://www.transformca.org/sites/default/files/final_hot_101_paper.12.16.2013-1_revised_acknowledgement_0.pdf

[91] AB 798, passed in 2009, prohibits converting an existing nontolled general-purpose lane to a tolled lane, although conversions of HOV lanes are allowed. California legislature could allow a limited number of demonstration projects to test the optimized HOT lane scenario; these demonstration projects would be allowed to convert existing nontolled general-purpose lanes to HOT if the project includes a simultaneous increase in transit, vanpools and other transportation choices along the same corridor. These projects should have initial time limitations and require detailed studies before being made permanent. For more information, see: http://www.transformca.org/resource/innovation-required-moving-more-people-less-traffic

[92] Sara Khoeini and Randall Guensler, "Using Vehicle Value as a Proxy for Income: A Case Study on Atlanta's I-85 HOT Lane," Research in Transportation Economics 44, no. 6, 2014, pages 33-42.

[93] Edward Sullivan and Mark Burris, "Benefit-Cost Analysis of Variable Pricing Projects: SR-91 Express Lanes," Journal of Transportation Engineering 132, no. 32006, pages 191-98.

[94] Highway connections to this corridor include the following. State Route 92 to/from the San Mateo–Hayward Bridge: HOV lanes currently exist at the westbound toll plaza east of the bridge in Hayward but not on the bridge itself. State Route 84 to/from the Dumbarton Bridge: HOV lanes currently exist at the westbound toll plaza east of the bridge in Fremont but not on the bridge itself. There is currently no freeway connection from 101 to the west end of the Dumbarton Bridge. State Route 237 (Southbay Freeway): HOV lanes currently exist from 101 to First Street. As part of Phase 2 of the SR-237 express lanes project, these HOV lanes are planned to be converted to HOT lanes by 2018. State Route 87 (Guadalupe Freeway): HOV lanes currently exist from 101 to State Route 85. Several expressways in Santa Clara County (such as the Lawrence Expressway, the Montague Expressway and the San Tomas Expressway) have HOV lanes in effect during peak periods.

[95] For more information see: http://www.miamidade.gov/transit/express-buses.asp

[96] MTC presentation available at http://www.transformca.org/sites/default/files/062515%20San%20Mateo%20101%20Corridor%20Strategies.pdf

[97] Mark Burris et al., "The Impact of HOT Lanes on Carpools," Research in Transportation Economics 4, no. 1, pages 43–51, http://doi.org/10.1016/j.retrec.2014.04.004

[98] Update to the initial Dumbarton Corridor Study being managed by SamTrans. See: http://www.samtrans.com/Planning/Planning_and_Research/DumbartonTransportationCorridorStudy.html

[99] Frontier Group, A New Way Forward: Envisioning a Transportation System Without Carbon Pollution, 2016, http://www.frontiergroup.org/reports/fg/new-way-forward

[100] California Transportation Plan 2040 explains that the pricing of driving is critical to reducing greenhouse gas emissions and increasing usage of transit and other sustainable modes. See: http://www.dot.ca.gov/hq/tpp/californiatransportationplan2040/index.shtml

[101] Grand Boulevard Initiative Vision, October 2006, http://www.grandboulevard.net/images/stories/documents/visionchallengegps.pdf

[102] As an example, Treasure Island Development Authority is planning for ferry service to Treasure Island, anticipating 45 trips per day with service every 15 minutes during peak hours, subsidized by revenue from congestion pricing tolls to get on the island. For more information, see: http://sftreasureisland.org/transportation%20

[103] See: SPUR, On Solid Ground: Rebuilding Our Transportation Infrastructure, 2013, http://www.spur.org/sites/default/files/publications_pdfs/SPUR_Rebuilding_Our_Transportation_Infrastructure.pdf

[104] The San Francisco Bay Area Water Emergency Transportation Authority (WETA) was established by SB 976 and replaced the WTA (Water Transit Authority). The intention of SB 976 is to improve the ability of ferries to respond in an emergency and to consolidate several regional ferry services.

[105] Measure A includes $30 million for "cost-effective ferry service to South San Francisco and Redwood City"; $8 million from this measure was used to develop the South San Francisco ferry service. See: http://www.smcta.com/Assets/SMCTA/Documents/2009-2033+Transportation+Expenditure+Plan.pdf

[106] WETA's System Expansion Policy defines conditions that warrant ferry services and anticipates a 10-year period for ridership to develop, during which operating subsidies should be available. See: http://sanfranciscobayferry.com/sites/default/files/weta/currentprojects/ProposedRoutes/SystemExpansionPolicy.pdf

[107] Development around ferry terminals is also a consideration. MTC's Resolution 3434 TOD expansion policy includes a discussion of ferry-oriented communities. See: http://ctod.org/pdfs/2005MTCTODPolicy.pdf

[108] MTC's Resolution 3434 Transit-Oriented Development policy, which conditions regional funding for transit expansions, includes a ridership threshold for ferries: minimum 750 housing units per ferry terminal station area.

[109] BART Sustainable Communities Operations Analysis, 2013, http://www.bart.gov/sites/default/files/docs/BART%20SCOA%20Final%20Report%20June%202013.pdf. See page 56.

[110] MTC is completing a need-based fare study, whose recommendations may be used to develop a regional need-based fare subsidy/pass program. If this program increases access to rail and bus transit on the Peninsula to those for whom cost is a barrier, that would help move the vision plan forward. For more information, see: http://mtc.ca.gov/our-work/plans-projects/other-plans/means-based-fare-study

[111] SBB Half-Fare Travel card, https://www.sbb.ch/en/travelcards-and-tickets/railpasses/half-fare-travelcard.html?WT.ac=keyvisual-hta-en

[112] Deutsche Bahn, Touch&Travel App, https://www.bahn.com/i/view/USA/en/prices/mobile/touch-and-travel.shtml

[113] See: Jeffrey Brown, Daniel Baldwin Hess and Donald Shoup, "Unlimited Access," Transportation 28, no. 3, 2001, pages 233-67, http://shoup.bol.ucla.edu/UnlimitedAccessUCLA.pdf; Cornelius Nuworsoo, Discounting Transit Passes, Access, 2005, http://www.uctc.net/access/26/Access%2026%20-%2005%20-%20Discounting%20Transit%20Passes.pdf

[114] Donald Chisholm, Coordination Without Hierarchy: Informal Structures in Multiorganizational Systems, University of California Press, 1992; TCRP Report 173: Improving Transit Integration Among Multiple Providers, Volume I: Transit Integration Manual, Transit Cooperative Research Program, 2014, http://www.trb.org/main/Blurbs/171934.aspx

[115] Bent Flyvbjerg, "What You Should Know About Megaprojects and Why: An Overview," Project Management Journal, 2014, pages 6-19, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2424835

[116] Transit Cooperative Research Program, TCRP Report 129: Local and Regional Funding Mechanisms for Public Transportation, 2009, http://www.trb.org/Publications/Blurbs/160356.aspx

[117] There is a state sales tax ceiling that applies to each of these three counties. Through state legislation, San Mateo County (and other counties) has received an exemption from the 2 percent cap on city and county sales taxes; increasing the local ceiling from 2 percent to 3 percent results in a 10.5 percent sales tax ceiling (the state sales tax is 7.5 percent).

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