Bay Area Core Capacity Transit Study

Final Report

METROPOLITAN TRANSPORTATION COMMISSION

SEPTEMBER 2017

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CORE CAPACITY TRANSIT STUDY

Study partners

Alameda-Contra Costa Transit District (AC Transit)
Bay Area Rapid Transit District (BART)
Caltrain
San Francisco Bay Area Water Emergency Transportation Authority (WETA)
San Francisco County Transportation Authority (SFCTA)
San Francisco Municipal Transportation Agency (SFMTA)

Cover photos by Sergio Ruiz

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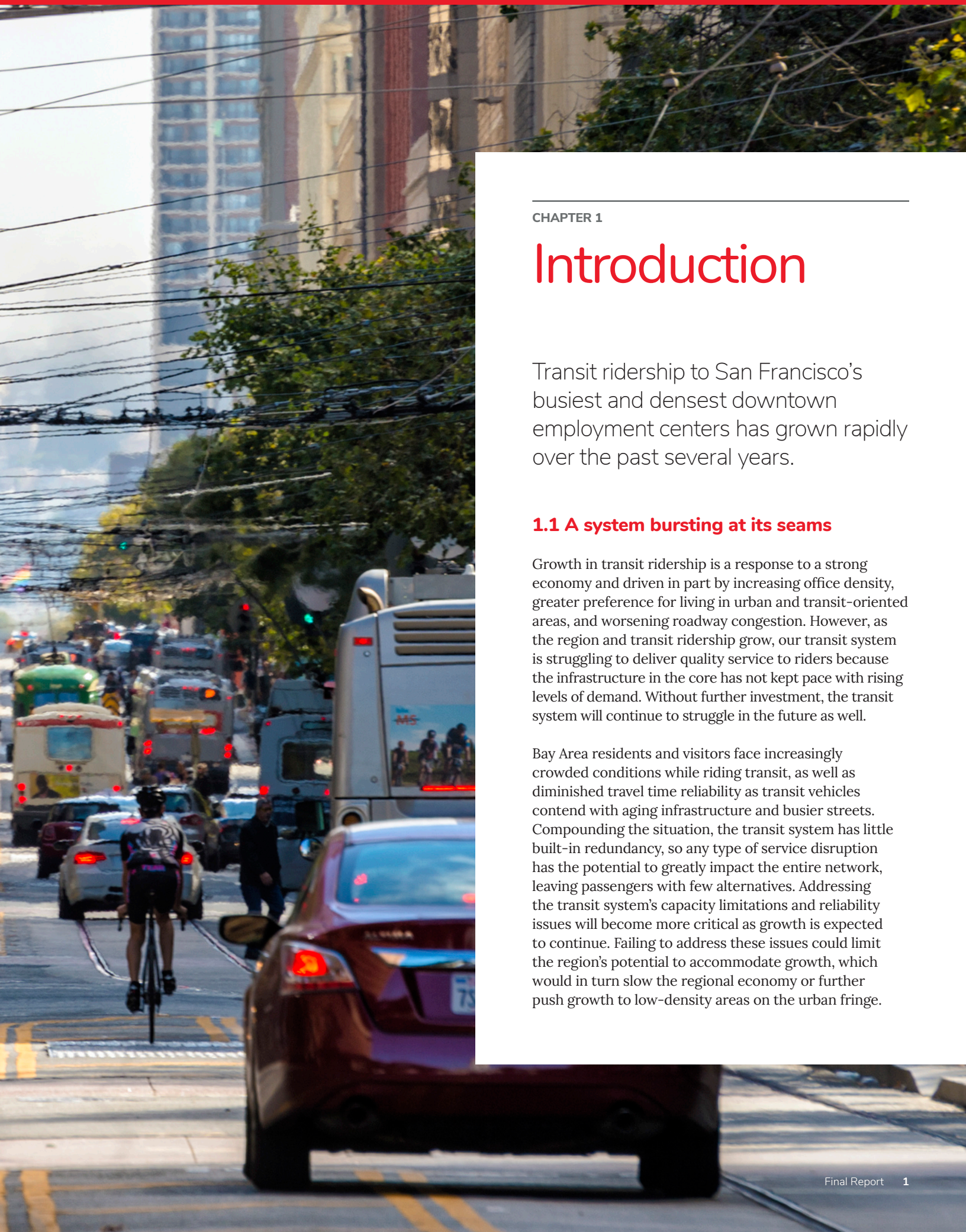
Photo: Sergio Ruiz



CHAPTER 1

Introduction

Transit ridership to San Francisco's busiest and densest downtown employment centers has grown rapidly over the past several years.

1.1 A system bursting at its seams

Growth in transit ridership is a response to a strong economy and driven in part by increasing office density, greater preference for living in urban and transit-oriented areas, and worsening roadway congestion. However, as the region and transit ridership grow, our transit system is struggling to deliver quality service to riders because the infrastructure in the core has not kept pace with rising levels of demand. Without further investment, the transit system will continue to struggle in the future as well.

Bay Area residents and visitors face increasingly crowded conditions while riding transit, as well as diminished travel time reliability as transit vehicles contend with aging infrastructure and busier streets. Compounding the situation, the transit system has little built-in redundancy, so any type of service disruption has the potential to greatly impact the entire network, leaving passengers with few alternatives. Addressing the transit system's capacity limitations and reliability issues will become more critical as growth is expected to continue. Failing to address these issues could limit the region's potential to accommodate growth, which would in turn slow the regional economy or further push growth to low-density areas on the urban fringe.

Photo: Sergio Ruiz

1.2 Answering the challenge: The Core Capacity Transit Study

The Bay Area Core Capacity Transit Study (CCTS) is a collaborative multiagency effort to examine the transit system's capacity limitations and identify and prioritize the major investments needed to address these limitations today and in the future. While all the transit operators serving San Francisco are independently considering various improvements to their respective systems, no prior study has brought the major transit operators together to address this regional issue in a comprehensive, coordinated manner.

The purpose of the CCTS is to answer the following question: what types of transit investments are needed, and when, to safely and reliably move a growing number of people to and from San Francisco's core job centers?

To answer this question, the study did the following:

1. Assessed current and future capacity and demand for travel to San Francisco's main job centers, both from within San Francisco and from the East Bay
2. Developed and assessed potential transit investment projects to address the challenges facing travelers, including transit congestion, reliability, and redundancy
3. Identified a recommended set of transit investments to address short- and medium-term challenges
4. Proposed potential long-term investment options to improve capacity and system resiliency in the future
5. Set a course for next steps to continue development of the recommended projects

1.3 Study partners

Led by the Metropolitan Transportation Commission (MTC), seven local and regional agencies directly participated in and supported the development of the CCTS. Given the complex nature of transit travel to San Francisco, each partner brought critical understanding of its service, operations, infrastructure, and funding mechanisms to bear on the study's development. The partners were as follows:

- Metropolitan Transportation Commission (Lead Agency)
- Alameda-Contra Costa Transit District (AC Transit)
- Bay Area Rapid Transit District (BART)
- Caltrain
- San Francisco Bay Area Water Emergency Transportation Authority (WETA), operator of the San Francisco Bay Ferry
- San Francisco Municipal Transportation Agency (SFMTA)
- San Francisco County Transportation Authority (SFCTA, funding and planning partner)

The CCTS is the first study in the region to bring together the relevant operating, planning, and funding partners to study this topic and identify challenges and solutions from a regional perspective, rather than leaving operators to work individually. The study's travel corridors are each served by multiple operators, so a joint study was necessary in order to produce comprehensive recommendations that reflect the needs and priorities of all of the operators.

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Study partner guidance

The study partners participated in the study's development in several ways.

PMT: The partners formed a Project Management Team (PMT), with members from each partner agency, which guided the study's day-to-day development through regular meetings and review of the study's work products. The PMT was supported by a consultant team, led by Arup.

ET: Executives from each study partner formed an Executive Team (ET) to provide direction and guidance to the PMT.

TAC: The study formed a Technical Advisory Committee (TAC) with a wider group of stakeholders to advise the PMT and offer diverse perspectives and insights on the study's development.

1.4 Guiding principles

From the outset, the partners agreed to a set of guiding principles for the study, setting the course for the study and the responsibilities of the partners. These principles establish transit as the priority mode for capacity investments into the San Francisco Core—an area that represents the city's established downtown and emerging employment centers in the South of Market (SoMa), Mid-Market, and Mission Bay neighborhoods—and emphasize cohesive operations, customer convenience and safety, and system resilience to unplanned events.

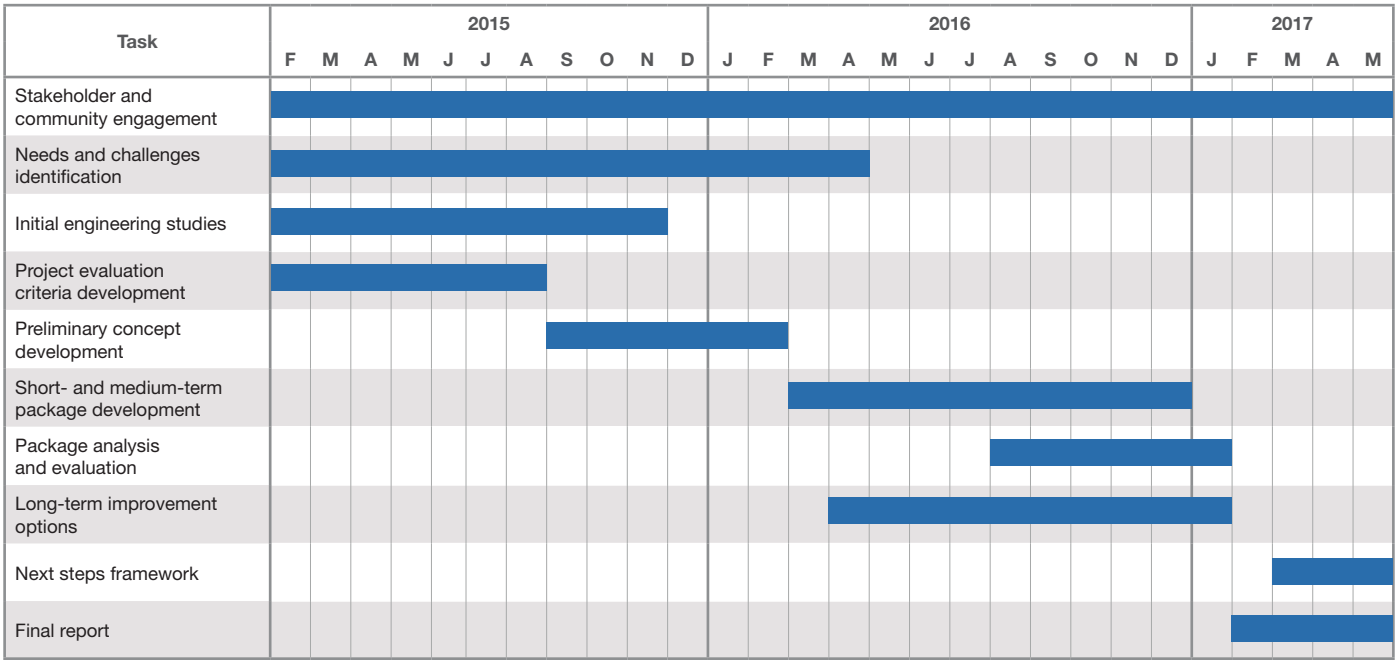
The guiding principles are as follows:

1. Transit will be the preferred mode to supply increased capacity for travel between the East Bay and the San Francisco Core, and for trips within San Francisco.
2. Regional transit service will be supportive of and consistent with adopted regional land use policies.
3. Transit operations and improvements will deliver safety, capacity, reliability, accessibility, speed, and quality service.
4. Transit services into and within the Core will be designed to operate as a system, regardless of agency or mode.
5. Transit infrastructure will be planned, designed, and constructed to provide operational redundancy, flexibility, and resilience to respond to unexpected events and conditions.
6. Infrastructure and other capital improvements will be designed for a project's or system's maximum value and implemented at the most optimal time for full economic benefit.
7. Highways and appropriate roadway facilities will be considered as suitable options for providing priority transit access for transit vehicles.

1.5 Timeline

Beginning in early 2015, the PMT developed the CCTS's key findings and recommendations over the span of approximately two years. Figure 1 depicts the phasing of the project's work streams.

Figure 1: Project timeline



1.6 Study credits

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Glossary

Conventional rail	Standard-gauge heavy-rail system, such as Amtrak and Caltrain, that is not compatible with the BART system and operates on the national rail network
HOV	High-occupancy vehicle
MMT	Muni Metro Tunnel
Peak direction	The major direction of travel flow during the peak commute hour
Peak hour	The hour in which the most people travel during the commute period, reported in the morning (AM) or evening (PM) by direction
San Francisco Core (the Core)	The city's established downtown and emerging employment centers in the SoMa, Mid-Market, and Mission Bay neighborhoods
Screenline	An imaginary line where passenger trips into the Core are measured
Transbay Transit Center	Transit terminal in downtown San Francisco for Transbay bus service and potential future rail service
Transbay Tube	Submerged rail tube carrying BART trains between Oakland and San Francisco, with one track per direction

CHAPTER 2

Fundamentals: Key study information and definitions

2.1 Study approach

The CCTS describes a detailed picture of transit travel to the San Francisco Core and identifies ways to improve transit service as demand grows. The study approach was as follows:

1. The study team articulated the challenges to accessing the Core by analyzing recent transit ridership and service data, preparing a tailored employment market assessment, and forecasting growth in transit ridership and capacity on major travel corridors accessing the Core.
2. Working with the transit operators, the study team developed, analyzed, and assessed short- and medium-term investment projects, including high-level engineering and cost estimates as appropriate, and bundled them into packages of investments.
3. The PMT prepared a number of long-term investment options for the Transbay Corridor.
4. The PMT recommended a single package of short- and medium-term investment projects for each corridor.

Photo: flickr user pussreboots / CC BY 2.0

2.2 The San Francisco Core

The CCTS focuses on improving transit capacity and connectivity to jobs in downtown San Francisco. As the largest employment center in the region and the focus of regional transit ridership, San Francisco's core area draws workers from all parts of the region.

For the purposes of the CCTS, the San Francisco Core (or simply, the Core) represents an area larger than the traditional downtown or Financial District. The Core covers an area approximately bounded by 17th Street to the south, Gough and 11th Streets to the west, the San Francisco Bay to the east, and California Street and Pacific Avenue to the north. This area enlarges the traditional central business district definition to include emerging job centers and defines subareas including the Financial District, South of Market (SoMa), Mid-Market, and Mission Bay.

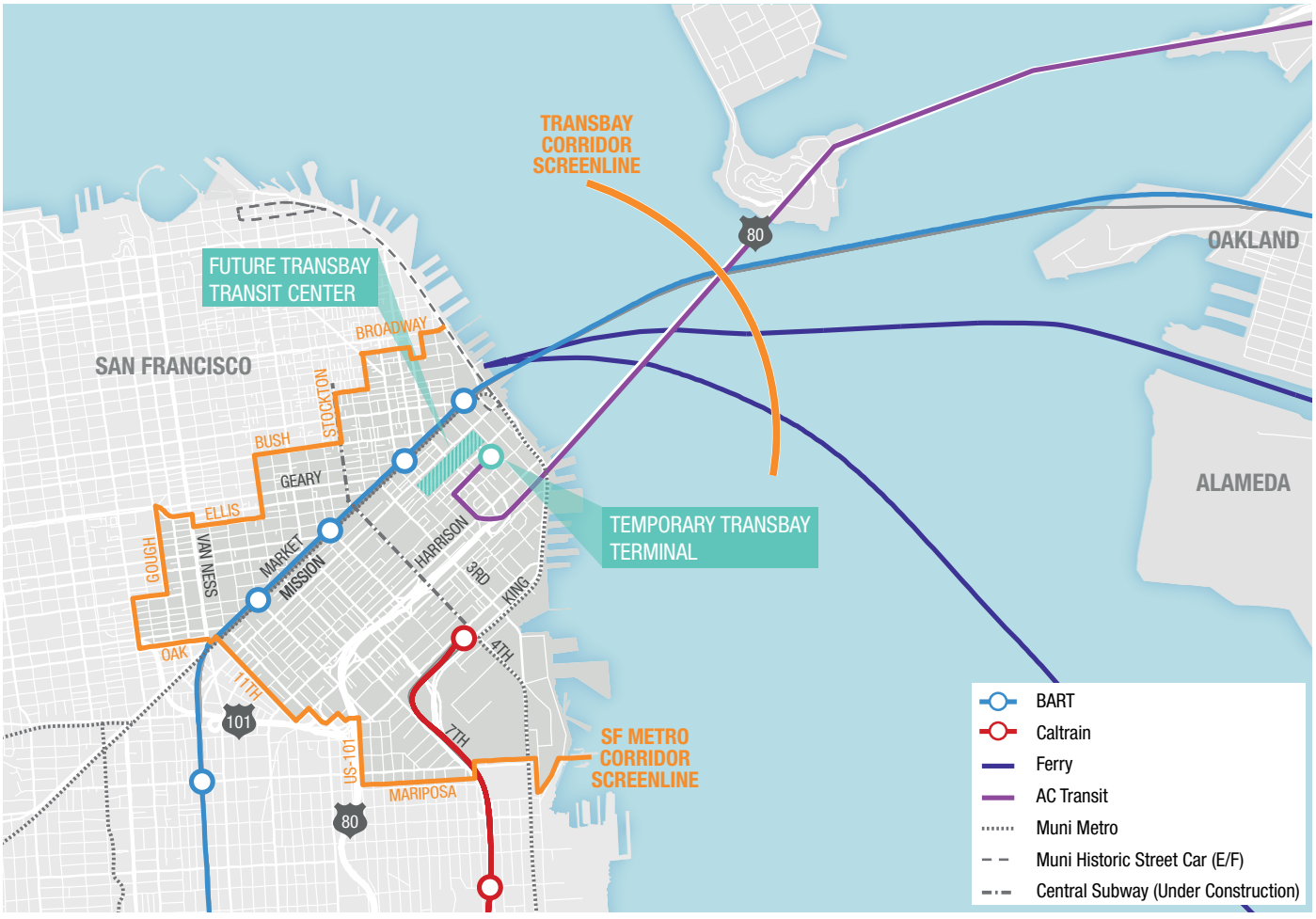
2.3 Travel corridors

The CCTS examines travel to the Core using two travel corridors: the Transbay Corridor and the SF Metro Corridor. Each corridor is served by different transit operators and faces different service and infrastructure challenges. Figure 2 depicts the screenlines for each corridor.

2.3.1 Transbay Corridor

The Transbay Corridor represents travel from the East Bay to San Francisco and is served by a variety of transit service options, including AC Transit buses on the San

Figure 2: Travel corridor screenlines



Francisco–Oakland Bay Bridge (the Bay Bridge), BART trains in the Transbay Tube, WETA's San Francisco Bay Ferry terminals and routes, and more. Shaped by the geography of the bay, this corridor is defined by the individual routes that serve the Core. Transit access to the Core in the Transbay Corridor is achieved via the following:

- BART Transbay Tube: This immersed twin-chamber tube incorporates one westbound and one eastbound track. The tube stretches 5.8 miles, from the Oakland Outer Harbor to the Embarcadero in San Francisco.
- Bay Bridge: Buses use the Bay Bridge, and starting east of the toll plaza, they have dedicated queue-jump lanes and other priority measures for westbound travel.
- San Francisco Bay: Used by ferries, the bay is another transportation resource that provides additional capacity to the Core.

2.3.2 SF Metro Corridor

The SF Metro Corridor represents travel from within San Francisco on the SFMTA's Muni Metro light rail, historic streetcar, and bus networks; BART service through the city's south and central neighborhoods; and Caltrain's rail service along the city's eastern edge. The SF Metro Corridor is divided in to the following five subareas to provide a clearer understanding of the different markets for travel into the Core (see Figure 3), with key transit links defining each subarea:

- Northern Neighborhoods: Muni bus lines serving the core
- Richmond: Muni bus lines serving the core
- Sunset: Muni Metro J, K, L, M, and N light-rail lines and Muni bus lines serving the core
- Mission: BART and Muni bus lines that serve the core
- Bayshore: the T-Third light-rail line and Caltrain and Muni bus lines serving the core

Figure 3: SF Metro Corridor subareas

2.4 Types of transit investments considered

2.4.1 Planned prerequisite projects: Critical but not all fully funded

The region's transit operators have already begun planning investments that will help them bring more riders into the San Francisco Core. The PMT describes these as prerequisite projects, because they are critical to operators' ability to continue increasing transit capacity in the years to come. These projects include modernization and technology upgrades, new or expanded fleets, and new transit routes and infrastructure. The following are few examples of prerequisite projects:

- **A new train control system** will allow BART to run more trains per hour through the Transbay Tube. In addition, the agency is in the process of replacing its fleet of rail cars with an expanded fleet of cars that can hold more passengers. The larger fleet will allow BART to run more maximum-length (10-car) trains.
- Through its **Muni Forward program**, SFMTA is making changes that will help to speed up buses and trains on crowded city streets. In addition, SFMTA operations staff has been studying and piloting various ways to increase capacity in the Muni Metro Tunnel (MMT) between West Portal and Embarcadero Stations.
- **San Francisco's new Transbay Transit Center**, when complete, will enable more Transbay bus service, and direct access ramps to and from the freeway will speed those buses on their way. AC Transit has ordered double-decker buses, which will nearly double bus capacity without taking up any additional room on the bridge.
- Caltrain is working to **convert from diesel operation to cleaner, faster electric trains** and is planning to extend service farther into the Core once the Downtown Extension (DTX) rail connection to the Transbay Transit Center has been completed.
- **New and expanded WETA facilities and fleet** will increase ferry service across the bay, expanding docking facilities at the existing San Francisco terminal, adding a new terminal in Richmond that will provide direct service to new areas in the East Bay, building a central maintenance and operations facility in Alameda, and replacing and expanding its fleet.

A complete list of the prerequisite projects is included in Appendices A and C.

While these and other prerequisite projects are essential to meeting continued growth in transit demand, they will not be sufficient to accommodate growing ridership in the future. In the Transbay Corridor, the Bay Bridge is already at capacity for vehicles, leaving a crowded transit system to absorb an increasing share of projected travel growth. Within San Francisco, transit demand in the SF Metro Corridor's Sunset subarea already exceeds capacity and will be stretched even further in the future.

Importantly, while the operators are planning for these investments, some prerequisite projects are not yet fully funded. The CCTS assumes the prerequisite projects will be implemented and focuses on identifying further transit capacity improvements. Thus, it is essential that the prerequisite projects be funded as a basis for moving forward; the projects developed in the CCTS depend on them.

In the special case of Treasure Island, the ongoing Treasure Island Mobility Management Agency (TIMMA) planning will recommend a combination of transit service and demand management that will minimize impacts to the Bay Bridge. This program of projects, though not included in this study, should also be considered prerequisite.

2.4.2 Short- and medium-term investment projects

Beyond the prerequisite projects, the CCTS identified and defined a variety of investments to improve transit capacity to the San Francisco Core in the short (within five years) and medium term (within 15 years). These projects build on the prerequisite projects and represent policy changes, service changes, and infrastructure improvements that will address transit operators' constraints over the following decade and a half. These projects may be relevant to one or both of the study corridors.

2.4.3 Long-term investment options

Finally, the study's PMT identified a number of potential long-term investment options to be implemented after 2030 that could meet future demand. The options consist primarily of new bay crossings that would add a new rail connection between San Francisco and the East Bay. The PMT considered a number of factors while developing the long-term options, including the interplay with projected employment growth and promising locations where a new crossing could land on either side of the bay.

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SPOTLIGHT

Utilization and policy capacity

The CCTS describes travel into the San Francisco Core in terms of the balance of demand (the number of people traveling) and capacity (the amount of service being offered). This balance is also known as the "utilization rate," and this report shows how much of the capacity offered by the operators in a given corridor is being filled by passengers under different circumstances and time periods.

Each operator has different standards for how many passengers can be safely and comfortably accommodated. Depending on the operator, this may include seated and standing passengers. This is known as the "policy capacity." Overcrowding occurs when the number of passengers on a given transit vehicle exceeds the policy capacity—in other words, when the utilization exceeds 100%.

CHAPTER 3

Understand: The context

3.1 Overall context

People traveling to and from the San Francisco Core on transit today typically experience overcrowded, uncomfortable conditions, particularly during peak commute hours.[1] With the region's economy rebounding strongly from the 2008 recession, both employment and travel demand to the Core have grown rapidly, resulting in a strained and congested transportation network. The Bay Bridge and major freeways into the Core are already operating near or at capacity, as are transit services. Addressing the transit system's current and future capacity limitations will become more critical as employment in the Core continues to grow and the region relies more heavily on transit to meet its travel needs.

Regional growth projections in *Plan Bay Area* 2040, the region's upcoming long-range transportation and land use plan, anticipate that 2.4 million more people will call the nine-county Bay Area home by 2040, and employers will add 1.3 million more jobs.[2] The land use vision articulated in *Plan Bay Area* channels new housing to mixed-use areas along the region's transit networks, aiming to enable more residents to commute to work via transit. Current plans will also lead to new housing and office space in and near the Core: the Financial District, SoMa, Civic Center, Market and Octavia, Showplace Square, and Mission Bay. Failing to increase transit capacity to serve expected ridership growth could limit the area's ability to accommodate projected growth, which could in turn slow the regional economy or push growth to low-density areas on the urban fringe, which would further exacerbate freeway congestion.

1 For transit, the CCTS defined the AM peak hour as the 60 minutes with the highest number of riders for each transit mode (typically a period between 7:30 and 9:30 AM). For automobiles, the AM peak hour was sourced from the Caltrans *Bay Bridge Managed Lanes Report* (2012).

2 Growth projections from 2010 base year. Metropolitan Transportation Commission (MTC) and Association of Bay Area Governments (ABAG), *Plan Bay Area 2040 Draft Plan March* 2017, 31, http://2040.planbayarea.org/sites/default/files/2017-03/PBA_2040_033017%20web%20print_0.pdf.

Photo: flickr user cclogg / CC0 1.0

3.2 Transbay Corridor capacity and demand: Infrastructure at capacity

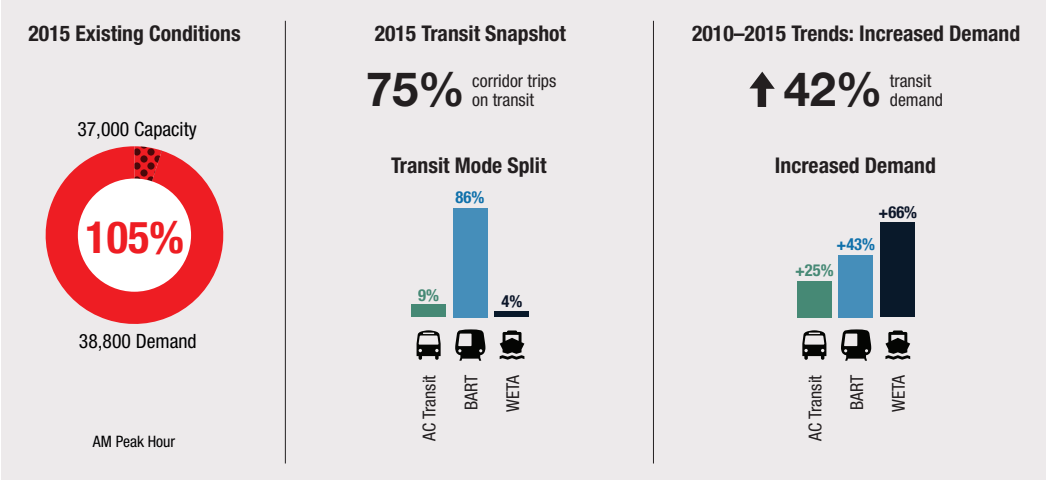
Conditions during the commute across the Transbay Corridor today are overcrowded, leading to congestion and diminished travel time reliability. Vehicle demand on the Bay Bridge has surpassed capacity, average weekday BART ridership has set records during the last several years, and passengers are lining up to board ferries. Unfortunately, many commuters have limited flexibility to avoid these conditions.

The current level of travel demand in the corridor is placing significant strain on the transit network, particularly operators serving the Core. In 2015, overall peak-hour demand was 38,800 morning peak-hour trips, of which nearly 29,000 trips (75%) were on transit, an increase of 42% since 2010 (see Figure 4).[3] Meanwhile, based on transit schedules and the operators' stated policy capacities per vehicle, the corridor had capacity for 37,000 peak-hour trips in 2015, of which 27,000 could be carried on transit; this means that demand exceeded capacity and the corridor had an occupancy rate of 105%. BART, which carries nearly two-thirds of all peak-hour trips in the corridor, operated at 110% of policy capacity. Figure 5 shows that over the last several decades, transit has carried an increasing share of trips in the corridor. Additionally, ridership on AC Transit Transbay buses and WETA ferries nearly reached their policy capacity levels (94% and 96%, respectively). With the corridor operating over capacity, even minor incidents like service delays and breakdowns can trigger major ripple effects throughout the entire system.

Recognizing the strain of rapid growth and overcrowding, each transit provider has been actively planning for capacity and operational improvements. However, not all of these prerequisite improvement projects are fully funded, such as BART's expanded fleet of new rail cars to enable more frequent service.[4] Delivering this round of projects is the highest priority for the corridor, and the CCTS reinforces this.

If transit demand in the corridor continues growing at a rate similar to 2010 through 2015, capacity will be inadequate to meet demand, even with planned prerequisite projects. Figure 6 illustrates how Transbay Corridor capacity compares to a range of potential growth in transit demand between 2015 and 2040. Past regional plans establish the upper and lower bounds for potential growth in demand, while the CCTS identifies a medium ('Market Assessment') growth line of 1.35% annually, which reflects forecasted employment growth over the period.[5] This medium growth rate is also approximately the same as the rate used by the preferred scenario for *Plan Bay Area 2040*, the update to *Plan Bay Area* expected to be approved in 2017.

Figure 4: Transbay Corridor snapshot (AM peak hour)



Growing at the medium rate from 2015, demand in the Transbay Corridor would increase by more than 14,000 trips by 2040. In the same period, planned projects are expected to increase capacity by 12,000 trips, which when combined with the 2015 capacity shortfall, results in a 4,000-trip capacity shortfall. Future growth in demand will need to be met by transit due to capacity constraints on the bridge.

Even with the implementation of the prerequisite projects, demand is likely to surpass capacity in the corridor if the region does not make additional short-, medium-, and long-term transit investments. To ensure that the Transbay Corridor's capacity meets future demand, the region must begin planning a coordinated path forward today.

3 See also the CCTS *Transbay Corridor Current Demand, Current and Planned Transit Capacity* memo, available online at: http://mtc.ca.gov/sites/default/files/CCTS_TransbayCapacityandDemandSummary_FINAL.pdf

4 BART has secured funding for 775 new rail cars. An additional 306 cars are not yet fully funded.

5 The high growth rate is based on MTC's *Transportation 2035*, while the low growth rate is based on *Plan Bay Area*.

Figure 5: Historic Transbay Corridor daily person trips by mode, 1994–2014

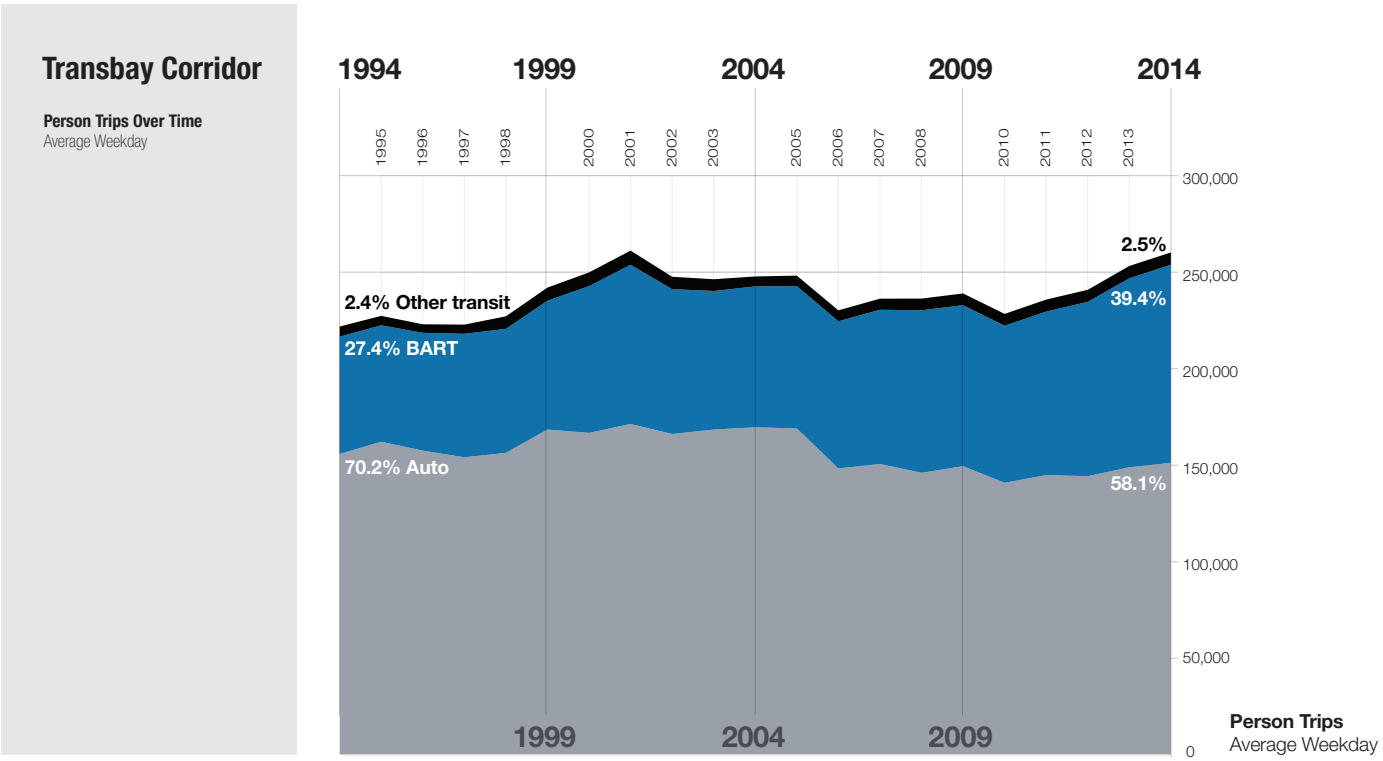
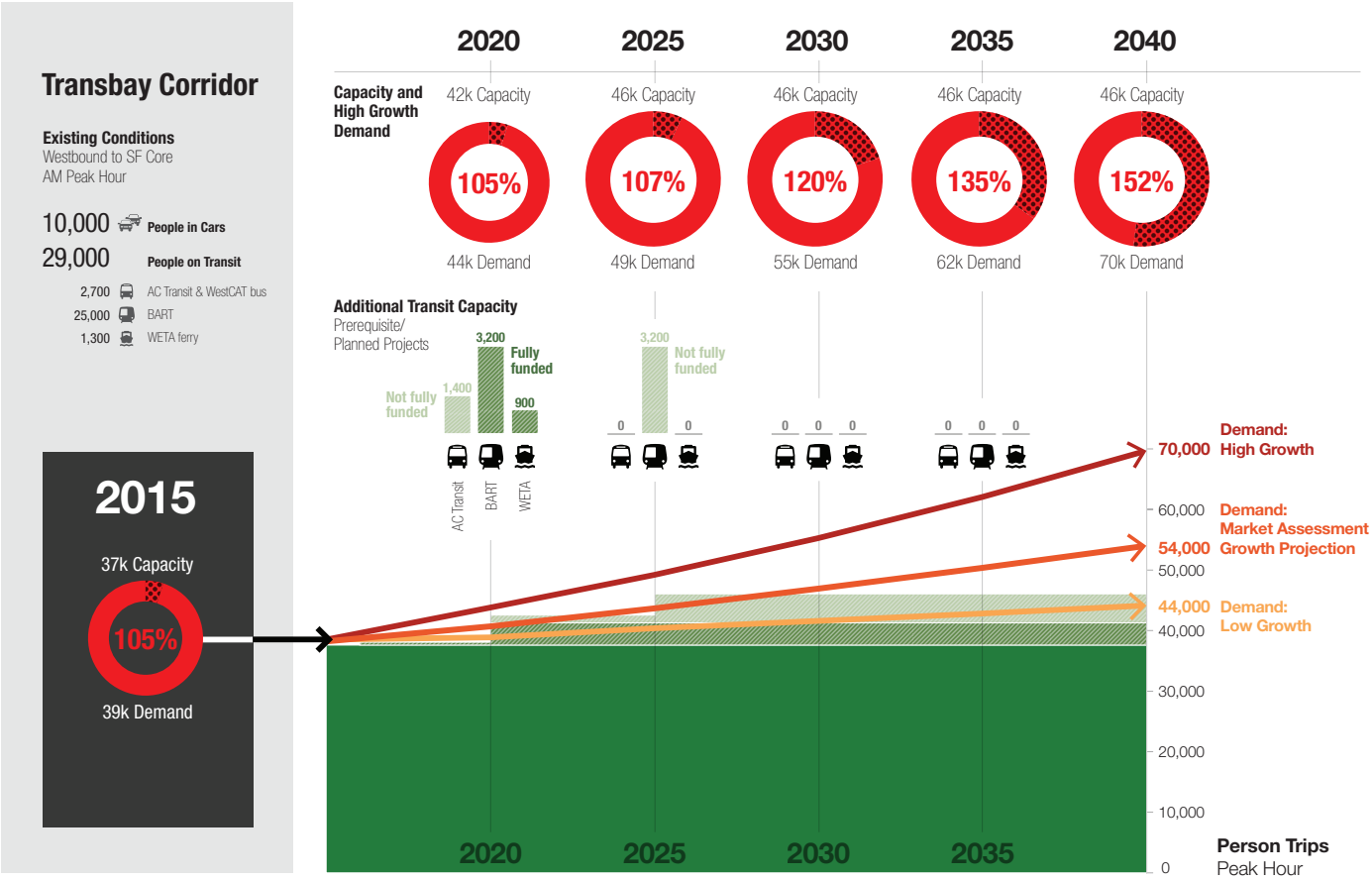


Figure 6: Forecast Transbay Corridor peak-hour capacity and demand 2015–2040

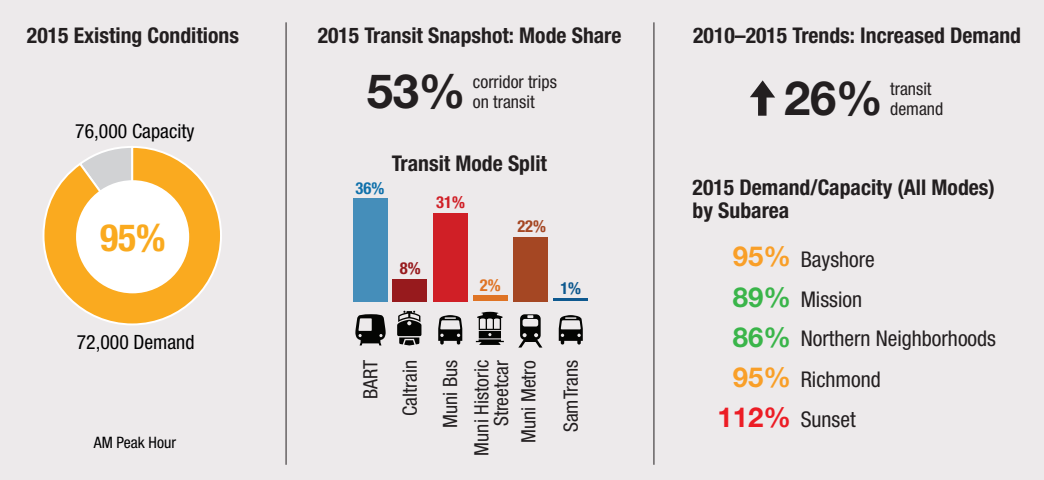


3.3 SF Metro Corridor capacity and demand: Congested surface streets

Overall, transit service to the Core in the SF Metro Corridor operates near full capacity. In 2015, the morning peak-hour transit demand in the corridor reached 38,100 trips, or 91% of the corridor's 42,100 capacity. This represents a 26% increase over 2010 trips.

However, the SF Metro corridor covers a large and diverse service area, and both transit modes and demand are not uniformly distributed throughout. While the overall corridor operated below full capacity in 2015, crowding still occurred regularly in different parts of the system (see Figure 7).[6] Some routes, such as the Muni Metro light-rail lines, are consistently overburdened, and in 2015 demand reached 124% of capacity on these routes, which represent about 16% of the entire corridor's capacity The remainder of corridor capacity is provided by BART, Caltrain, Muni bus, and other Muni Metro and streetcar lines. Muni bus and BART together provided two-thirds of transit capacity.

Figure 7: SF Metro Corridor snapshot (AM peak hour)



Given the diverse service area, the CCTS divided the SF Metro Corridor into the following subareas in order to provide a more nuanced understanding of capacity and demand across the city:

- Northern Neighborhoods
- Richmond
- Sunset
- Mission
- Bayshore

Each subarea offers a distinct mix of transit service to the Core. The Northern Neighborhoods, Richmond, and Sunset subareas are dominated by Muni bus service, serving local trips originating in San Francisco. The Mission subarea contains a mix of local trips originating in San Francisco, served by Muni and BART, and regional trips originating outside of San Francisco on BART. The Bayshore subarea contains a mix of local trips originating in San Francisco, served by Muni, and regional trips originating in San Mateo and Santa Clara Counties on Caltrain and SamTrans express buses.

In 2015, transit demand in the subareas varied. Demand reached 119% of capacity in the Sunset subarea, while it reached only 64% in the Northern Neighborhoods subarea. Transit demand in the remaining three subareas was approximately 85 to 87% of capacity. The variation among subareas is to be expected, since each has distinct development patterns and is served by a different mix of transit modes and providers.

Like the transit providers in Transbay Corridor, the providers in the SF Metro Corridor have been planning for improvements in capacity and operations, and only some projects are fully funded. Similarly, delivering these prerequisite projects is the region's and the study's first priority. Also similar to planning in the Transbay Corridor, operators' planned short- and medium-term prerequisite improvement projects will provide a modest amount of additional capacity, but additional investments will likely be needed to accommodate future growth in demand.

Based on travel patterns and trends in the five subareas, the Sunset and Richmond subareas are forecast to be over capacity in the future, even if all prerequisite projects are completed (see Figures 8 & 9).

In the Sunset subarea, Muni Metro and bus lines connecting the subarea to the Core are already overcrowded today, and conditions are projected to worsen by 2040. In the Richmond subarea, growth in demand will outstrip existing and planned capacity by 2025 without new investments. Future conditions in the other subareas are expected to vary.

6 See also the CCTS *SF Metro Corridor Current Demand, Current and Planned Transit Capacity* memo, available online at: http://mtc.ca.gov/sites/default/files/CCTS_SFMetro_CapacityandDemandSummary_FINAL.pdf

Figure 8: Forecast SF Metro Corridor Sunset subarea peak-hour capacity and demand 2015–2040

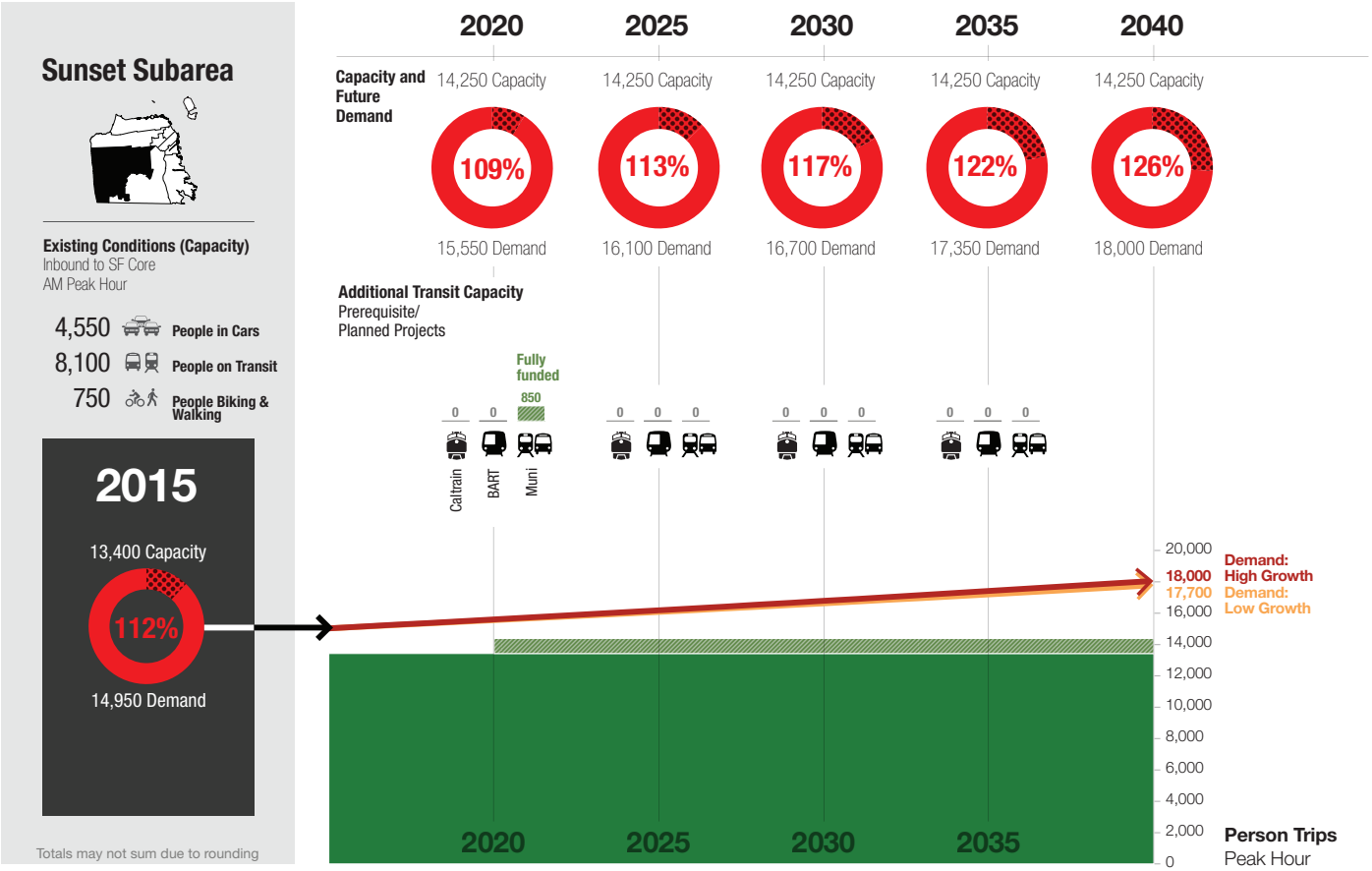
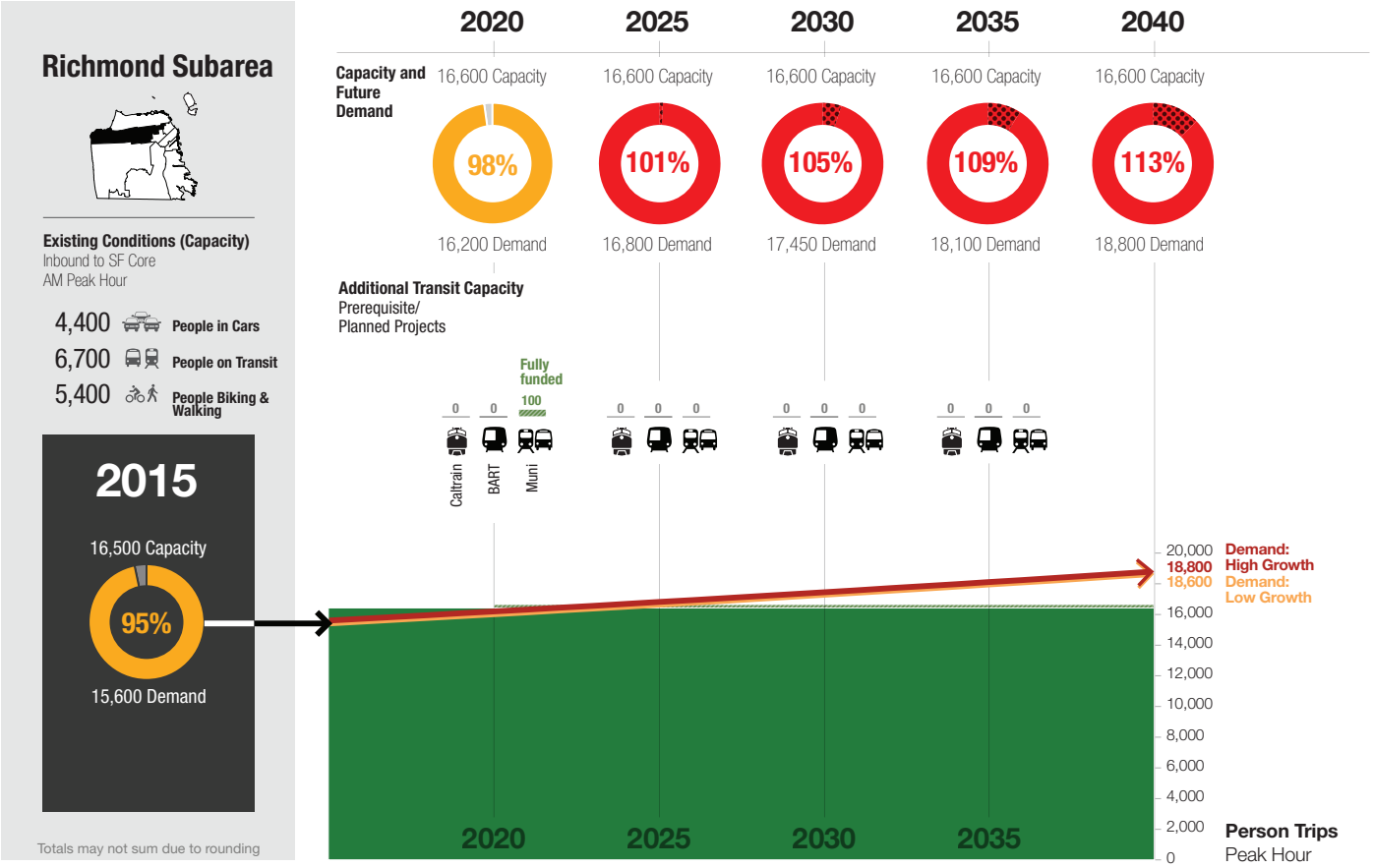


Figure 9: Forecast SF Metro Corridor Richmond subarea peak-hour capacity and demand 2015–2040



To ensure that the SF Metro Corridor's transit capacity meets future demands, the region must begin planning a coordinated path forward today, particularly to address capacity in the Richmond and Sunset subareas. Passengers are already experiencing crowding, diminished reliability, and limited travel flexibility in the corridor, and conditions are expected to worsen in the coming years.

3.4 Keeping pace with the market: How much more will we grow?

Growth in travel demand is driven by local, regional, and national demographic and real estate market trends. As the region has recovered from the Great Recession, the technology industry and related sectors have driven rapid and significant growth. Between 2010 and 2014 alone, San Francisco employment grew 25%, surpassing the projections from the last regional transportation plan, *Plan Bay Area*.[7] How and where employment growth occurs in the Core and the region will have significant impacts on long-term demand for transit service and thus where investments in expanded capacity will be necessary. The consultant team completed a market assessment as part of the CCTS, with the aim of providing a better understanding of employment growth trends in the Core. The assessment identified where employment growth will likely occur and the extent to which there is sufficient development capacity to accommodate that growth.

The San Francisco Core is the single largest employment center in the city and the region, accounting for 53% of jobs in San Francisco and 10% of those in the Bay Area in 2013—totaling over 337,000 jobs. Within the Core, more than half of jobs were located in the Financial District. Many of these jobs are in office-based professional and managerial services and information sectors, reflecting the expansion of the city and region's tech industry.

Plan Bay Area 2040 projects that between 2010 and 2040 San Francisco will grow by 138,000 households (40%) and that Alameda County will grow by 189,000 (35%).[8]

San Francisco is expected to accommodate 23% of the region's new jobs.[9] The CCTS market assessment found that the Financial District alone could add 50,000 to 70,000 jobs to its current total of more than 200,000 if employers continue a trend of increasing the number of employees per square foot of office space. The surrounding neighborhoods of SoMa, Civic Center/Mid-Market, and Mission Bay/Showplace Square could also grow significantly, albeit less than the Financial District. Collectively, these neighborhoods together could attract between 63,000 and 85,000 new jobs—growth of roughly 40 to 55% by 2040.

With falling office vacancy rates and higher rents, employers are beginning to consider alternate locations with comparable amenities, such as downtown Oakland. Already one of the key employment centers in the region, downtown Oakland has the largest concentration of employment in the East Bay and has experienced strong growth and rising rents in recent years. Residents and employers are drawn by the area's strong transit infrastructure, central location, and affordability relative to the San Francisco office market.

The CCTS market assessment found that downtown Oakland has potential to add 12,000 to 24,000 jobs through 2040, an increase of up to 31% over a total of 76,800 jobs in 2015. Downtown Oakland may also add between 6,500 to 13,000 housing units. While this growth could act as a transit-demand pressure release valve by shifting some trips to Oakland, it may also increase traffic on the local transportation network and impact transit routes that serve the Transbay Corridor, as many of the transit routes serving Oakland also serve the Transbay Corridor.

The San Francisco Core and downtown Oakland are vital employment centers today, heavily reliant on the region's transit system, and expected to grow larger and denser in the future. Coupled with major projected growth in housing near transit, development activity over the coming 25 years could create significant new travel demand. If transit capacity does not keep pace with anticipated growth, the transportation system may constrain economic development both in the Core and the region as a whole.

7 See also the *CCTS San Francisco Market Assessment* memo, available online at: http://mtc.ca.gov/sites/default/files/CCTS_SF_MktAssessment_FINAL.pdf

8 MTC and ABAG, *Plan Bay Area 2040 Draft Land Use Modeling Report*. Available online at: http://2040.planbayarea.org/sites/default/files/2017-03/Land_Use_Modeling_DPBA2040_Supplemental%20Report_3-2017_0.pdf

9 MTC and ABAG, *Plan Bay Area 2040 Draft Plan March 2017*, 44.

Photo: flickr user walkingsf / CC BY 2.0

3.5 A second transbay crossing: Why another study?

Adding significant new capacity to the Transbay Corridor will require a major new transit investment. Once the CCTS prerequisite projects are completed, BART will not be able to add new capacity without a second crossing, and the Bay Bridge is already at capacity for vehicles. Many past studies and independent proposals have outlined potential second transbay rail crossing options, including potential modes, alignments, and locations of new stations. These wide-ranging proposals have been developed to different levels of detail, some as conceptual designs and others as broader thought pieces.

To help evaluate the feasibility and risk of these proposals, the CCTS initial engineering analysis reviewed potential tunnel-crossing landing locations, second-crossing corridors, and tunneling techniques and technologies. Identifying promising landing sites, the effort narrowed the range of long-term options to those that were sensitive to the geological and technical constraints and that were more favorable for constructing and implementing a second crossing. The CCTS does not recommend a particular corridor, in part because additional work developing landside alignments and station locations is needed.[10] Additional work is also needed to understand how routes and services could be configured with a second crossing.

Chapter 6 discusses the potential crossing corridors and landing sites in more depth.

10 See also the *CCTS Initial Engineering Studies* memo, available online at: http://mtc.ca.gov/our-work/plans-projects/other-plans/core-capacity-transit-study

CHAPTER 4

Improve: Transbay short- and medium-term analysis and evaluation

This chapter addresses the potential investment projects to improve transit capacity in the Transbay Corridor.

4.1 Meeting the need in 2030

Demand will continue to exceed capacity over the short and medium term in the Transbay Corridor, even when taking into account planned prerequisite projects. These prerequisite projects will add significant capacity in the medium term, particularly on BART, but demand will outpace capacity if no other improvement projects are implemented. The choice to continue with business as usual—in other words, without identifying plans beyond the prerequisite projects—leaves few options to alleviate the overcrowded conditions that travelers are experiencing today. The study developed packages of projects that have the potential to address the gap in demand in the short and medium term. The analysis concluded with the identification of a recommended package.

Photo: Sergio Ruiz

4.2 Proposed package descriptions

Each package uses a different combination of projects to address capacity shortfalls in a distinct way. The PMT sought to characterize how each package accomplished this, with the major types of projects being service, infrastructure, tolling, and transit fare adjustments.

4.2.1 Types of projects to improve capacity

More transit service: Adding more service in the corridor increases overall passenger throughput capacity. Service can be augmented by increasing vehicle frequencies and fleet size. However, the roadway or rail infrastructure must be able to accommodate such service increases in order to reap the full benefits of investment in service. For instance, simply adding more vehicles to an already congested roadway will result in less realized capacity per hour due to delays.

New transit-priority infrastructure: To better accommodate existing or growing transit service, transit-priority infrastructure investments can be implemented to increase speed, improve travel time reliability, and ultimately help the system maximize person throughput. Improvements such as adding transit priority to surface streets and adding direct freeway access ramps reduce the impacts of congestion on bus travel and make transit a more appealing competitor to driving.

Policy changes: Policy changes that affect automobile tolls and fares can be implemented to influence travel behavior and reduce congestion, by encouraging travelers to switch their travel mode or change the time of day when they travel. The study considered two types of policy change:

- Toll adjustments: Adjusting tolls can achieve multiple outcomes, including shifting demand from automobiles to transit and high-occupancy vehicles (HOVs), influencing the time of day people travel, and reducing queues and travel time variability. The CCTS analyzed several levels of toll adjustments to forecast drivers' sensitivity to price, based on 2030 conditions. The analysis tested how driver behavior—in terms of shifting peak travel demand to other times and modes—would change at various levels. Table 1 shows the categories of toll increases considered.

Table 1: Automobile toll increase ranges considered

	Small toll increase	Medium toll increase	High toll increase
Toll increase	$1–2	$3–4	$5

- Transit fare adjustments: Adjusting the relative cost of transit is a tool to help distribute demand among modes, transit operators, and times of day. Changing fares can help shift demand from overburdened operators to those with more availability or more ability to increase service—such as from BART to bus and ferry services.

4.2.2 Overview of packages

The packages are focused on improving transit capacity in the short term (within five years) and medium term (within 15 years). The packages consist of three types of projects:

1. **Prerequisite projects:** Planned projects in the corridor with full or partial funding commitments identified by operators as necessary to be fully funded and implemented
2. **Projects common to all packages:** Projects identified by the PMT as important to include in every package under consideration
3. **Package-specific projects:** The headline projects that define the package theme and differentiate the corridor packages from one another

A swift way to add capacity is to add service on existing infrastructure where the full capacity is unused: more trains, buses, and ferries. Major new infrastructure projects require longer implementation timeframes and significant levels of investment, so projects completed in the short and medium term largely focus on increasing service and adding some transit-priority infrastructure.

In crafting the Transbay Corridor packages, the PMT focused on the following strategies to improve capacity and service reliability through expanding transit service, offering transit vehicles priority passage through congested roadways, and adjusting pricing policy:

- Increasing transit capacity by augmenting bus and ferry service, including expanded fleets and the necessary infrastructure to support the service
- Improving service reliability with new bus-priority infrastructure to the toll plaza and on surface streets leading up to it
- Improving service reliability to the Core with new bus-priority infrastructure on the Bay Bridge
- Managing travel demand on the Bay Bridge by adjusting Bay Bridge tolls
- Managing transit demand across transit modes by adjusting transit fares

The packages are summarized in Table 2. All packages include the Transbay Corridor prerequisite projects, and Packages 2–4b include a set of common projects. Pages 24–25 and Appendix A include a complete list of the projects included in each package.

Table 2: Transbay Corridor packages summary

#	Package	Summary	Key features
1	Tolls only	Manage Bay Bridge travel demand with increased peak-period auto tolls	• Raise tolls to reduce queues during peak commute periods • Reduce queues enough to ensure buses can access the high-occupancy vehicle (HOV) lanes leading to the bridge
2	Transit and tolls	Add new bus and ferry service and improve Transbay bus service reliability by raising Bay Bridge automobile tolls to reduce toll plaza queues	• Package 1 elements • Add 50 peak-hour bus trips • Increase ferry frequencies to 15- and 30-minute headways • If needed, adjust transit fares to balance passenger loads
3	Infrastructure, transit, and tolls	Add new transit infrastructure to the toll plaza to improve service reliability, implement additional bus and ferry service, and improve Transbay bus service reliability by raising Bay Bridge automobile tolls	• Package 1 and 2 elements (raise tolls, increase bus and ferry service) • Refurbish an old Key System tunnel to create a separate, dedicated bus access route to toll plaza • Make surface street improvements (such as bus lanes and priority features) to reduce bus travel time
4a	Contraflow lane, infrastructure, transit, and tolls	Provide a dedicated bus lane on the lower deck of the bridge in the morning, add new transit infrastructure to the toll plaza to improve service reliability, implement additional bus and ferry service, and improve Transbay bus service reliability by raising Bay Bridge automobile tolls	• Package 1, 2, and 3 elements (raise tolls, increase bus and ferry service, provide dedicated bus access route to toll plaza, improve surface streets to reduce bus travel time) • Raise tolls to reduce queues and increase bus and ferry service as above • Convert one lane of the Bay Bridge lower deck for morning westbound Transbay bus traffic
4b	Bus-only / bus + HOV lane, infrastructure, transit, and tolls	Provide a dedicated bus or bus + HOV lane on the upper deck of the bridge, add new transit infrastructure to the toll plaza to improve service reliability, implement additional bus and ferry service, and improve Transbay bus service reliability by raising Bay Bridge automobile tolls	• Package 1, 2, and 3 elements (raise tolls, increase bus and ferry service, provide dedicated bus access route to toll plaza, improve surface streets to reduce bus travel time) • Raise tolls to reduce queues and increase bus and ferry service as above • Convert one lane of the Bay Bridge upper deck for westbound Transbay buses or bus + HOVs

SPOTLIGHT: BART CARRIES TWO-THIRDS OF ALL PEAK-HOUR TRIPS IN THE TRANSBAY CORRIDOR

BART: Funding critical prerequisite and common projects

Growing ridership has placed extraordinary demands on BART service in the Transbay Corridor. In 2015 BART carried nearly two-thirds of morning peak-hour commuters in the corridor, and over the last decade, daily ridership on the whole BART system has increased 36%. Trains in the corridor exceed BART's standards for crowding during peak periods, and Embarcadero and Montgomery stations are approaching their effective capacity to process passengers.

BART has made significant progress developing near-term improvement projects to add capacity and help alleviate crowded conditions. These improvement projects are classified as both prerequisites and common projects because they are critical to the Transbay Corridor no matter which package is recommended. In particular, it is essential that the following projects be fully funded as a basis for moving forward:

- New and replacement BART cars
- New train control and power system
- New and expanded maintenance facility

Once these projects are complete, BART will have very little ability to add more peak-hour capacity in the Transbay Corridor because it will reach the maximum throughput of the Transbay Tube. After this point, a second transbay crossing will be necessary to increase BART capacity.

Transbay Corridor short- and medium-term packages

All packages: Prerequisite projects

All packages include the following Transbay Corridor prerequisite projects. These investments are critical to operators' ability to increase transit capacity in the years to come, but are not all fully funded:

- **AC Transit Bus Ramp to Transbay Transit Center**
- **AC Transit Fleet Expansion (40 buses)**
- **AC Transit Richmond Facility Reopening**
- **AC Transit New Bus Facility**
- **BART Additional Railcars – Core Capacity**
- **BART Additional Railcars – Fleet Transition**
- **BART Hayward Maintenance Complex, Phase 1**
- **BART Hayward Maintenance Complex, Phase 2**
- **BART Metro Program**
- **BART Traction Power System**
- **BART Train Control System**
- **Bay Bridge Forward**
- **I-80 Integrated Corridor Mobility**
- **Transbay Transit Center (Phase 1)**
- **WETA Maintenance Facilities Alameda, Vallejo**
- **WETA Richmond–SF Ferry Service**
- **WETA SF Ferry Terminal Expansion**
- **WETA SF Fleet Replacement & Expansion**

Packages 2–4: Common projects

The PMT identified the following set of projects that were important investments to include in Packages 2–4:

- **Increase Transbay Bus Service**
- **Ferry Feeder Bus Services**
- **Implement WETA 15-30 Minute Plan**
- **I-580 Bus Transitway**
- **Transbay Bus Park-and-Ride Facilities**
- **BART Platform Screen Doors at Montgomery & Embarcadero**
- **BART Vertical Circulation at Montgomery & Embarcadero**

Package 1: Tolls only

About this package

This package considers small, medium, and large peak-period auto toll increases to reduce auto congestion at the toll plaza to improve bus service reliability.

- **Benefits for buses:** Reduce vehicle queues at the toll plaza to help provide more reliable transit service, allowing buses to quickly access HOV lanes with minimal delay.
- **Incentivizing carpools and transit:** Incentivize people to make their commute by transit or carpool, or during another time of the day.

Key components

- Small, medium, or large automobile toll increase

Package 2: Additional transit service and tolls

About this package

- **Benefits for buses:** Increase AC Transit Transbay bus service during the peak hour for more service reliability. Reduce vehicle queues at the toll plaza to help provide more reliable transit service, allowing buses to quickly access HOV lanes with minimal delay.
- **Benefits for ferries:** Increase ferry service during the peak hour from Oakland, Alameda, and Vallejo. Add new ferry terminals in Alameda and new routes from Berkeley and to Mission Bay.
- **Incentivizing carpools and transit:** Incentivize people to make their commute by transit or carpool, or during another time of the day.

Key components

- More Transbay bus service
- More ferry service
- New ferry routes
- New bus park-and-ride lots
- New ferry terminals
- New ferry feeder service
- Small, medium, or large automobile toll increase

Photo: Sergio Ruiz

Transbay Corridor short- and medium-term packages

Package 3: Infrastructure, transit service, and tolls

About this package

- **Benefits for buses:** Implement new surface-street transit-priority lanes to the bridge and refurbish an old Key System tunnel to provide direct bus access to the toll plaza. Increase AC Transit Transbay bus service during the peak hour for more service reliability. Reduce vehicle queues at the toll plaza to help provide more reliable transit service, allowing buses to quickly access HOV lanes with minimal delay.
- **Benefits for ferries:** Increase ferry service during the peak hour from Oakland, Alameda, and Vallejo. Add new ferry terminals in Alameda and new routes from Berkeley and to Mission Bay.
- **Incentivizing carpools and transit:** Incentivize people to make their commute by transit or carpool, or during another time of the day.

Key components

- New bus tunnel to Bay Bridge toll plaza
- New surface-street transit priority lanes connecting to I-80, I-580
- More Transbay bus service
- More ferry service
- New ferry routes
- New bus park-and-ride lots
- New ferry terminals
- New ferry feeder service
- Small, medium, or large automobile toll increase

Packages 4a & 4b: Contraflow lane or bus-only / bus + HOV lane, infrastructure, transit service, and tolls

About these packages

- **Benefits for buses:** Provide continual direct bus right-of-way across the Bay Bridge with a bus-only or bus + HOV lane, refurbished bus tunnel, and new surface-street transit-priority lanes from the East Bay to Transbay Transit Center. Increase AC Transit Transbay bus service during the peak hour for more service availability. Reduce vehicle queues at the toll plaza to help provide more reliable transit service, allowing buses to quickly access HOV lanes with minimal delay.
- **Benefits for ferries:** Increase ferry service during the peak hour from Oakland, Alameda, and Vallejo. Add new ferry terminals in Alameda and new routes from Berkeley and to Mission Bay.
- **Incentivizing carpools and transit:** Incentivize people to make their commute by transit or carpool, or during another time of the day.

Key components

- **Package 4a:** New bus-only contraflow lane, westbound on lower deck
- **Package 4b:** Bus-only or bus + HOV lane with flow, westbound
- New bus tunnel to Bay Bridge toll plaza
- New surface-street transit priority lanes connecting to I-80, I-580
- More Transbay bus service
- More ferry service
- New ferry routes
- New bus park-and-ride lots
- New ferry terminals
- New ferry feeder service
- Small, medium, or large automobile toll increase

4.3 Package analysis

To assess how well each package addressed the capacity and performance issues facing the Transbay Corridor, the PMT identified priority evaluation criteria based on the CCTS guiding principles (Section 1.4). The criteria aim to answer key questions, including how well demand is served, how the appeal of transit improves, and how efficient and reliable the system is. The criteria are as follows:

- **Capacity:** How many more people can be carried by transit?
- **Utilization:** How much of the capacity offered is expected to be used?
- **Reliability:** To what degree is variability in travel time reduced, in order to make the transit trip more attractive and competitive for users?
- **Resiliency:** Does the package improve the transit network's ability to recover from or adjust to routine delays or extraordinary events?
- **Efficiency:** How much will it cost?

To assess the impacts of each package, the study team adopted an approach that incorporates MTC's regional travel demand model (Travel Model One) and a toll bridge queuing model (TBQM) to understand the how each package would impact travel demand in 2030 at different toll rates, as well as understand the extent to which each package could create free-flow conditions for Transbay bus service on the Bay Bridge.[11]

Travel Model One was used to understand the impacts of each package of improvements on travelers' mode and route choices, estimating future regional trips using MTC's 2030 population and employment forecasts.

The model results were prepared for a range of toll rates to estimate how tolls, in conjunction with infrastructure and service improvements, would impact peak-hour travel demand. For each package, the travel model produced quantitative metrics including transit ridership by operator, transit route load factors by operator, person miles per seat mile, traffic volumes by vehicle class (drive alone, carpool, and truck), and overall person trips (i.e., throughput) by mode of travel.

The model results were then used as input to the TBQM to calculate the physical impact of vehicle queue lengths at the toll plaza. This allowed the study team to estimate whether each package, at different toll rates, would sufficiently reduce queue lengths to enable buses to reach the three HOV access points at the toll plaza, thereby providing free-flow conditions for transit.

Appendix B provides selected model results for each package.

4.4 Package findings

The package analysis revealed that effectively managing toll plaza queues allows transit capacity to be increased. This is the first step to begin to address the gap between forecasted demand and available capacity in the short and medium term. In addition to increasing transit capacity, improving transit reliability is a key component to maintaining transit competitiveness compared to the car.

Delivering reliable transit capacity requires a combination of the following:

- Additional transit service (new bus and ferry fleet)
- New infrastructure (new transit-priority right-of-way, yards, and terminals)
- Toll increases to manage queues (small to medium increases)

11 Full details on the model runs are provided in *CCTS Transbay Travel Demand Results* memo, available online at: http://mtc.ca.gov/our-work/plans-projects/other-plans/core-capacity-transit-study.

Other key findings are as follows:

- **Each package performed differently in the toll plaza queuing analysis** with respect to the level of toll increase needed to provide buses free-flow access to the HOV access points at the plaza. Table 3 documents which level of toll increase is needed for each package.
    - Adding new transit-priority infrastructure would reduce the need for a high toll increase as new infrastructure allows buses to bypass some queues. However, new infrastructure alone is not sufficient to create transit free-flow conditions.
    - Without new transit-priority infrastructure, high toll increases are needed to incentivize changes in travel behavior to create transit free-flow conditions.
- **Transit fare adjustments are an effective tool** to manage demand but are not essential for meeting study objectives.
- **Neither a contraflow or bus-only / bus + HOV lane will fulfill the study's objectives when implemented alone**, but either could be considered as additional service reliability is needed after necessary tolling, service, and infrastructure improvements have been delivered.
- **A contraflow lane would improve transit reliability and is operationally viable** but would require additional infrastructure, conversion of a travel lane on the bridge's lower deck, and an education process to alert drivers to oncoming bus traffic.
- **A bus-only / bus + HOV lane would improve transit reliability but poses vehicle-weaving challenges** and would create longer auto queues behind the toll plaza due to the dedicated lane on the bridge.

SPOTLIGHT

Transit fare adjustments

Peak-period transit fare adjustments can incentivize travelers to switch from one mode to another. As part of the Transbay Corridor package analysis, the CCTS assessed the impact of transit fare adjustments on travel demand and found that this can be an effective tool to manage the distribution of trips between modes. The model results show that fare adjustments do not significantly increase transit capacity. Instead, results show that raising or lowering fares shifts riders between the different transit modes available, depending on how large the change. Although the primary focus of the CCTS is improving capacity, transit fare adjustments should be considered a viable option to manage demand if needed.

Table 3: Queuing analysis findings

#	Package	Toll increase needed to clear queue for buses to reach HOV access point
1	Tolls only	High
2	Transit and tolls	High
3	Infrastructure, transit, and tolls	Medium
4a	Contraflow lane, infrastructure, transit, and tolls	Small
4b	Bus-only / bus + HOV lane, infrastructure, transit, and tolls	Small

4.5 Recommended package

Based on the results of the analysis, following PMT and ET discussions, the ET concluded that any short- and medium-term package recommendation should reflect priorities of more service, supportive infrastructure to improve reliability, and toll increases to help manage queues and improve transit reliability. Transit fare adjustments are to be considered on an as-needed basis.

The PMT recommended and the ET agreed to advance a modified version of Package 3 (Infrastructure, Transit, and Tolls). This package adds additional bus and ferry transit service with increased bus and ferry fleets, new bus-priority infrastructure to ensure buses can travel quickly through the bridge toll plaza, surface street improvements to improve travel times leading up to the bridge in Oakland and Emeryville, and a small increase of Bay Bridge auto tolls.

The elements of the recommended package are detailed in Table 4. Improvements include Transbay Corridor prerequisite projects that are not yet fully funded, in addition to the short- and medium-term project recommendations. Estimated annual operating costs are shown in Table 5. Figure 10 illustrates the impact of the recommended package on corridor capacity and demand over time.

Figure 10: Transbay Corridor capacity and demand with recommended short- and medium-term package improvements

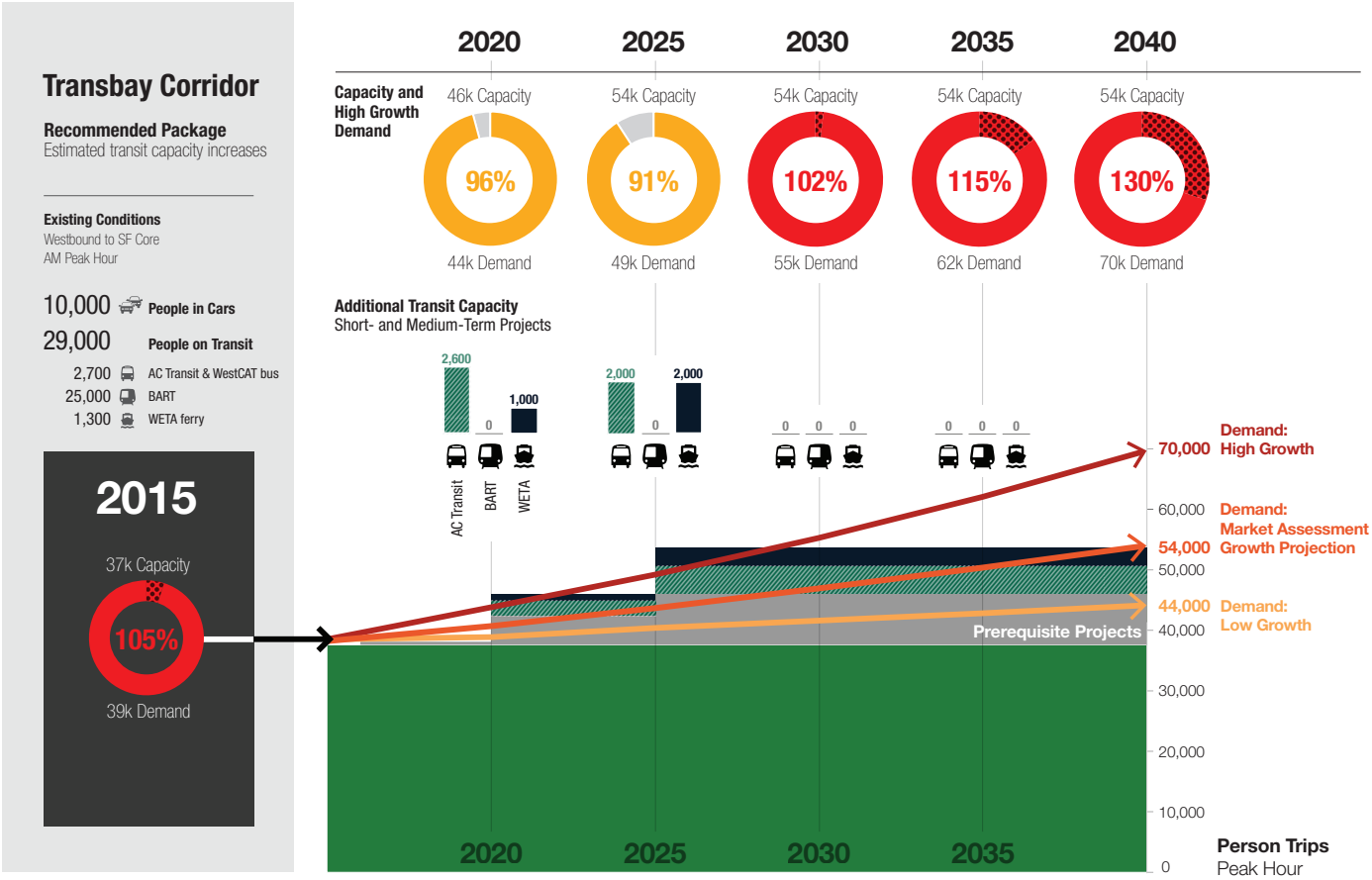


Table 4: Transbay Corridor recommended short- and medium-term package proposed capital improvements

Projects by operator		Unfunded cost
AC Transit		
1	Fleet: 110 buses	$90m
2	New Bus Facility	$100m
3	Infrastructure: • Park-and-ride, bus transitway, surface-street transit priority, bus tunnel	$240m
4	Ferry feeder service fleet	$15m
	Subtotal AC Transit	$445m
WETA		
1	WETA 15-30 Plan • Fleet: 11 vessels • Enhanced terminals: Alameda Main Street, Harbor Bay, Oakland • New terminals: Berkeley, Downtown North Basin, Mission Bay, Seaplane Lagoon	 $206m $46m $122m
	Subtotal WETA	$374m
BART		
1	Transbay Core Capacity Project* • Fleet: 306 railcars • Train control, traction power, Hayward Maintenance Complex Phase 2	$3.5bn
2	BART Metro*	$362m
3	Other supportive projects • Montgomery and Embarcadero platform screen doors, vertical circulation • Glen Park pocket track	$180m
	Subtotal BART	$4.0bn
Total recommended package		**$4.8bn**

Table 5: Transbay Corridor recommended package estimated annual operating costs

Improvements	Unfunded cost†
Bus: Transbay service	$33m/yr
Bus: Ferry feeder service	$13m/yr
Ferry: WETA 15-30 Plan service	$23m/yr
BART: Additional Transbay service	$16m/yr
Total annual operating costs	**$85m/yr**

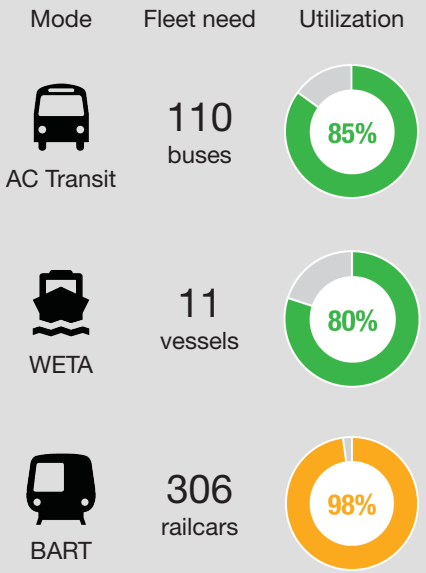
* Prerequisite project

† Assumes farebox recovery included

SPOTLIGHT

Fleet needs and capacity

To offer expanded service under the recommended package (including prerequisite and recommended projects), each operator will need to expand its fleet. The number of additional vehicles and the utilization goal for each operator is as follows:



CHAPTER 5

Improve: SF Metro short- and medium-term analysis and evaluation

This chapter addresses the potential investment projects to improve transit capacity in the SF Metro Corridor.

5.1 Meeting the need in 2030

A majority of transit travel to the San Francisco Core is reliant on rail services to transport high volumes of passengers to downtown destinations. The planned BART and Caltrain prerequisite projects will add new capacity in the Mission and Bayshore subareas, respectively. The study also anticipates that a Geary corridor bus rapid transit (BRT) project in the Richmond subarea will occur.[12]

The study's capacity and demand analysis estimates that demand will continue to exceed capacity over the short and medium term in the Sunset subarea. Due to this gap between transit capacity and demand, the PMT focused on developing a range of packages to improve the Muni Metro network.

12 While the Richmond subarea is facing continued crowded conditions into the future, the SFMTA is currently engaged in delivering the Geary corridor BRT project, which aims to address the capacity concerns in that subarea.

Photo: Arup

As the backbone of San Francisco's transit system, the Muni Metro network is operating over capacity—a problem that is expected to continue as there are no major prerequisite projects planned to increase capacity in the short term.

The Sunset subarea contains all of the Muni Metro light-rail lines, which operate both on surface streets and in the Muni Metro Tunnel (MMT). Capacity and crowding concerns are most urgent in the Sunset subarea, which faces issues around limits to scheduled capacity and limits to realized capacity.[13] These factors played an important role in guiding which improvements were considered for the short and medium term.

Muni Forward is a major improvement effort currently being implemented by SFMTA (and is an SF Metro Corridor prerequisite project). It addresses all modes that SFMTA operates but does not include planning for the T/Central Subway, and capital improvements have not been planned for all light-rail lines. Against this backdrop, the PMT discussed and concluded that the short- and medium-term packages considered in the CCTS should move beyond the planned Muni Forward improvements to cover the entire light-rail network.

13 The current amount of scheduled capacity is based on four-car trains. In reality, the current maximum are two-car trains (L, M, and N lines) and some routes use only one-car trains in operation (K/T and J lines). The ability to deliver the amount of scheduled capacity is also limited by delays caused on the surface (interactions with cars, etc.), which prevents the MMT from being utilized to its fullest capacity. The MMT has a potential to push 40+ trains per hour, of which 36 trains per hour are typically scheduled. In reality, often fewer than 36 trains travel through the MMT during peak hours.

5.2 Proposed package descriptions

The PMT developed three packages focused on improving light-rail service over the short and medium term, as described in Table 6. See pages 34-35 and Appendix C for a complete list of projects included in each package.

The CCTS also developed a fourth package, which proposed joining trains to increase the capacity of the MMT. This package would reinstate a retired SFMTA practice of joining one- and two-car trains together at specific locations in order to create four-car trains as they travel through the tunnel. The CCTS determined that this practice could not reasonably be expected to deliver additional capacity due to the need for perfect schedule adherence and geometric/physical conditions required to conduct the procedure as part of revenue service. The package was removed from further consideration.

5.3 Package analysis and findings

The PMT developed evaluation criteria to understand how the different short- and medium-term packages would perform in the corridor. Five high-priority criteria were identified:

- **Capacity:** How many more people can be carried by transit?
- **Utilization:** How well will the space be used?
- **Resiliency:** Will the new capacity improve or provide alternatives in the event of routine delays or extraordinary events?
- **Reliability:** Will the transit trip be attractive and competitive for users?
- **Efficiency:** How much will it cost?

Table 6: SF Metro Corridor packages summary

#	Package	Summary	Key features
1	Surface optimization (focus on improving train operations on city streets)	Builds on the current suite of Muni Forward investments, focusing on surface station and roadway improvements to improve transit travel times and reliability, and reduce delays	• Lengthen trains throughout the system • Limit travel time variability on the surface
2a	Minor system restructure (simplify the structure of the system)	Reduces the number of surface operating lines that enter the tunnel. Minor restructure: remove the J-Church line from the tunnel to remove operational constraints	• Lengthen trains on key lines • Reduce tunnel exposure to surface travel time variability
2b	Major system restructure (simplify the structure of the system)	Reduces the number of surface operating lines that enter the tunnel. Major restructure: reconfigure the light-rail network into a spine-transfer system, where only the M-Ocean View and N-Judah lines enter the tunnel and passengers on other lines must transfer to reach the Core	• Lengthen trains on key lines • Reduce tunnel exposure to surface travel time variability

The analysis focused on understanding how well each package performed against the evaluation criteria. The analysis relied on the use of SF-CHAMP, San Francisco's travel demand model, to understand how changes in the rail network's structure may impact how the system is used and whether service reliability improves. The packages were coded and run through SF-CHAMP to generate model outputs to be post-processed for future forecasts.

Based on this analysis, the study's conclusions for each package are as follows:

- **Surface optimization (Package 1):** Performed neutral or positive across the evaluation criteria for capacity, utilization, reliability, and resiliency. This is due to reduced travel times and longer train lengths.
- **Minor system restructure (Package 2a):** Offers limited benefit compared to today's level of service and performs worse than Package 1 on capacity and utilization.
- **Major system restructure (Package 2b):** Offers largest improvement in capacity, reliability, and resiliency compared to today. However, it provides only marginally more capacity and has lower utilization rates than Package 1.
- **For both minor and major system restructure packages:** There are notable downsides because the new scheduling approach under these options would require some passengers to transfer who currently do not and lower frequencies on less-crowded parts of the system.

SPOTLIGHT

Train coupling: Conceptually feasible but difficult in practice

Train coupling is a practice in which train cars are joined to form a single longer train. The SFMTA used this practice at certain points in the system where lines merge together (e.g., at West Portal) between 1981 and 1998, but ultimately phased it out as the current generation of Breda vehicles was put into service. Today, few rail systems merge trains when passengers are on-board, although some operators do so successfully.

To better understand the feasibility and potential of reinstituting coupling on the Muni Metro system, the CCTS developed a fourth package that proposed joining trains at West Portal and Duboce Portal. With accompanying increases in service on key lines, this would theoretically increase the capacity of the MMT by increasing the length of each train using a "slot" in the tunnel.

In theory, the practice could boost capacity at crowded stations along the MMT. However, doing so successfully would require that trains arrive at merge points with near-perfect predictability, and given the many sources of potential delay along the surface-running portions of the Muni Metro system, train arrival times today are highly variable.

While the tunnel's automatic train control system was designed to allow coupled operation, the system has not been tested under day-in, day-out operations. SFMTA has done limited tests of coupling with its existing technology and found that the process works better in manual operation.

Coupling would also reduce SFMTA's operations flexibility and introduce complexity for outbound passengers. Any off-schedule operation would disrupt timed train coupling and degrade service. Further, outbound passengers would have to ensure they board the proper car on trains destined to be decoupled once leaving the MMT.

The CCTS project team concluded that coupling should not continue as an option based on the level of coordination, logistical details, and perfect schedule adherence required for successful execution.

SF Metro Corridor short- and medium-term packages

All packages: Prerequisite Projects

All packages include the following SF Metro Corridor prerequisite projects. These investments are critical to operators' ability to increase transit capacity in the years to come but are not all fully funded.

- **BART Additional Railcars – Core Capacity**
- **BART Hayward Maintenance Complex, Phase 1**
- **BART Hayward Maintenance Complex Phase 2**
- **BART Metro Program**
- **BART Traction Power System**
- **BART Train Control System**
- **Caltrain CalMod 2.0**
- **Caltrain Downtown Extension**
- **Caltrain Electrification**
- **Caltrain Operations Improvements – North Terminal**
- **Candlestick & Hunters Point Express Bus Service**
- **SF Better Market Street**
- **SFMTA 16th Street Corridor Transit Priority**
- **SFMTA Central Subway**
- **SFMTA Fleet Expansion (light rail and bus)**
- **SFMTA Muni Forward**
- **SFMTA Muni Forward Phase 2**
- **SFMTA Van Ness Avenue Bus Rapid Transit**
- **SFMTA SFgo**
- **SFMTA T-Third Mission Bay Loop**
- **SFMTA Transit Facilities Improvements**

All packages: Common projects

The PMT identified the following set of projects that were important investments to include in all packages:

- **Adjust Policy at Muni Metro Embarcadero Turnback to Optimize ATCS Operation**
- **BART Glen Park Pocket Track**
- **BART Platform Screen Doors at Montgomery and Embarcadero**
- **BART Vertical Circulation at Montgomery and Embarcadero**
- **Complete Off-Board Fare Collection on Surface**
- **Forest Hill Policy Change to Enable Four-Car Trains in Tunnel**
- **Muni Metro Four-Car Brannan Street Pocket Track**
- **Geary Corridor Bus Rapid Transit**
- **Secure Muni Metro Folsom Street Portal**

Package 1: Surface optimization (improving train operations on city streets)

About this package

- **Benefits for light-rail trains:** Significantly improve reliability. Increase capacity and resiliency. Reduce operating costs overall.

Key components

- **Transit signal priority:** Stoplights equipped to turn or stay green when a train is approaching
- **Left-turn restrictions:** Prevent cars from blocking trains while they wait to turn left
- **Improved boarding islands:** Longer islands to facilitate easy boarding of all doors of each train car
- **Two-way stops with traffic calming:** Remove stop signs along train routes and implement measures to maintain pedestrian safety by slowing down private-car traffic
- **Stop consolidation:** Reduce the number of times a train stops by optimizing stop spacing

Muni Metro system with Package 1
(same as existing)

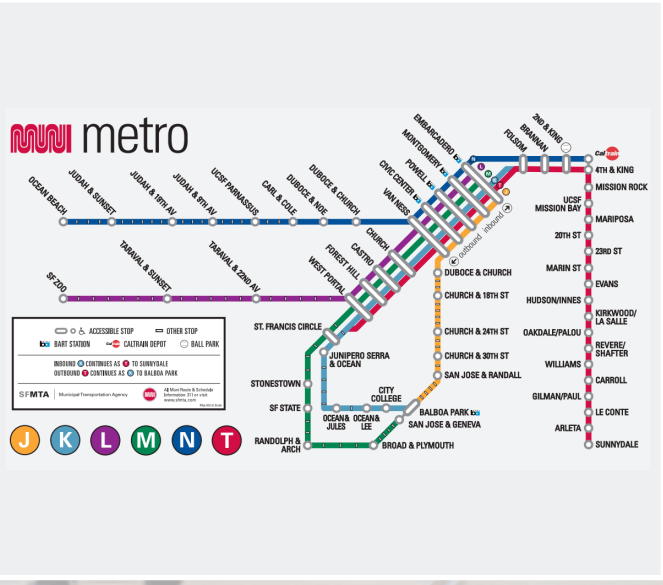


Photo: Sergio Ruiz

SF Metro Corridor short- and medium-term packages

Package 2a: Minor system restructure (simplify the structure of the system)

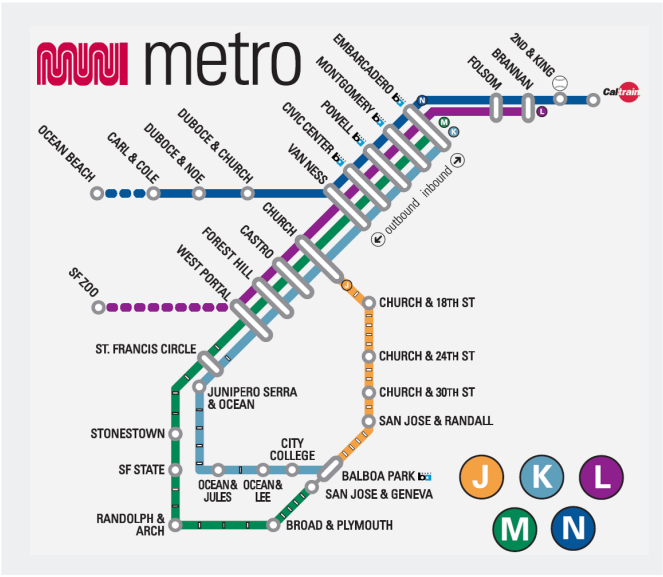
About this package

- **Benefits for light-rail trains:** Reduce the extent to which lines traveling in the MMT are exposed to the unpredictable surface operating conditions that currently make it difficult to put trains in the right order or to create the ideal amount of space between them.
- **Challenges to the system:** Trade "one-seat" trips for J-Church passengers for improved reliability in the MMT. For J-Church riders who would need to transfer to reach the Core, travel times could be slower than current delay-free trips.
- **Requires sufficient, timely capacity** at Church Street station for transfers from the J-Church line

Key components

- J-Church removed from the MMT, stopping the line at Church Street Station
- Passengers on the J-Church transfer to other lines serving the Core

Muni Metro system with Package 2a



Package 2b: Major system restructure (simplify the structure of the system)

About this package

- **Benefits for light-rail trains:** Improve operations at stations where lines currently merge. Limit the extent to which lines traveling in the MMT are exposed to the unpredictable surface operating conditions. Reduce the number of unexpectedly long trips caused by delays.
- **Challenges to the system:** Trade "one-seat" trips on certain lines for improved reliability in the MMT. For riders who would need to transfer to reach the Core, travel times could be slower than current delay-free trips.
- **Requires sufficient, timely capacity** at transfer stations
- **Offers the largest improvement in reliability** of the three packages, improving capacity and resiliency at the same time.
- **Delivers the highest level of capacity at today's most crowded points**

Key components

- Only the M-Ocean View and N-Judah surface lines enter and operate in the MMT
- Passengers on other lines transfer to the higher-frequency service and longer trains on core lines to reach the Core

Muni Metro system with Package 2b

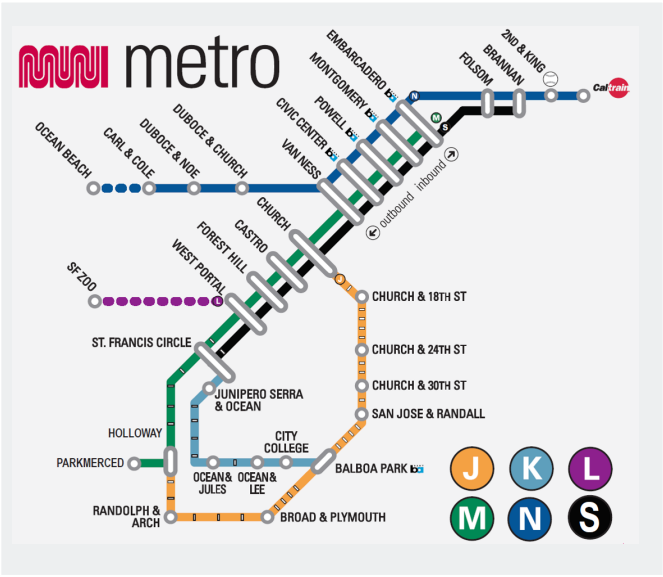


Photo: flickr user torbakhopper / CC BY-ND 2.0

5.4 Recommended package

Based on the analysis and model findings, the PMT recommended and the ET agreed to advance Package 1 (surface optimization) as the recommended package for prioritization in the short and medium term. The elements of recommended package are detailed in Table 7. Improvements include SF Metro prerequisite projects that are not yet fully funded, in addition to the short- and medium-term project recommendations. Estimated annual operating costs are shown in Table 8.

Figure 11 illustrates the package's impact on capacity and demand in the Sunset subarea. Figure 12 illustrates the package's impact on capacity and demand in the Richmond subarea. Although the package focuses on improvements to the Muni Metro system, it also includes the Geary corridor BRT project, which is common to all packages. As a result, the Richmond subarea will also experience an increase in capacity.

Implementing the improvements in Package 1 will comprehensively progress the enhancements begun in Muni Forward through to the rest of the light-rail lines. Prioritizing surface optimization does not preclude simplifying the Muni Metro system in the future. Once Muni Forward and the recommended surface optimization package improvements are complete, the SFMTA may pursue further study on both the minor and major system restructure packages.

Table 7: SF Metro Corridor recommended short- and medium-term package proposed capital improvements

Projects		Unfunded cost
1	SFMTA: Fleet and yard	$787m
2	Surface Light-Rail Safety and Capacity Project	$100m
3	Surface improvements: • Station improvements • Roadway improvements • Transit-priority traffic control improvements	$51m
4	Geary Corridor Bus Rapid Transit (BRT)	$300m
Total recommended package		**$1.2bn**

Table 8: SF Metro Corridor recommended package estimated annual operating costs

Improvements	Unfunded cost*
SFMTA: Light rail	$19m/yr
SFMTA: Geary Corridor BRT	$12.5m/yr
Total annual operating costs	**$31.5m/yr**

* Assumes farebox recovery included.

Figure 11: SF Metro Sunset subarea capacity and demand with recommended short- and medium-term package improvements

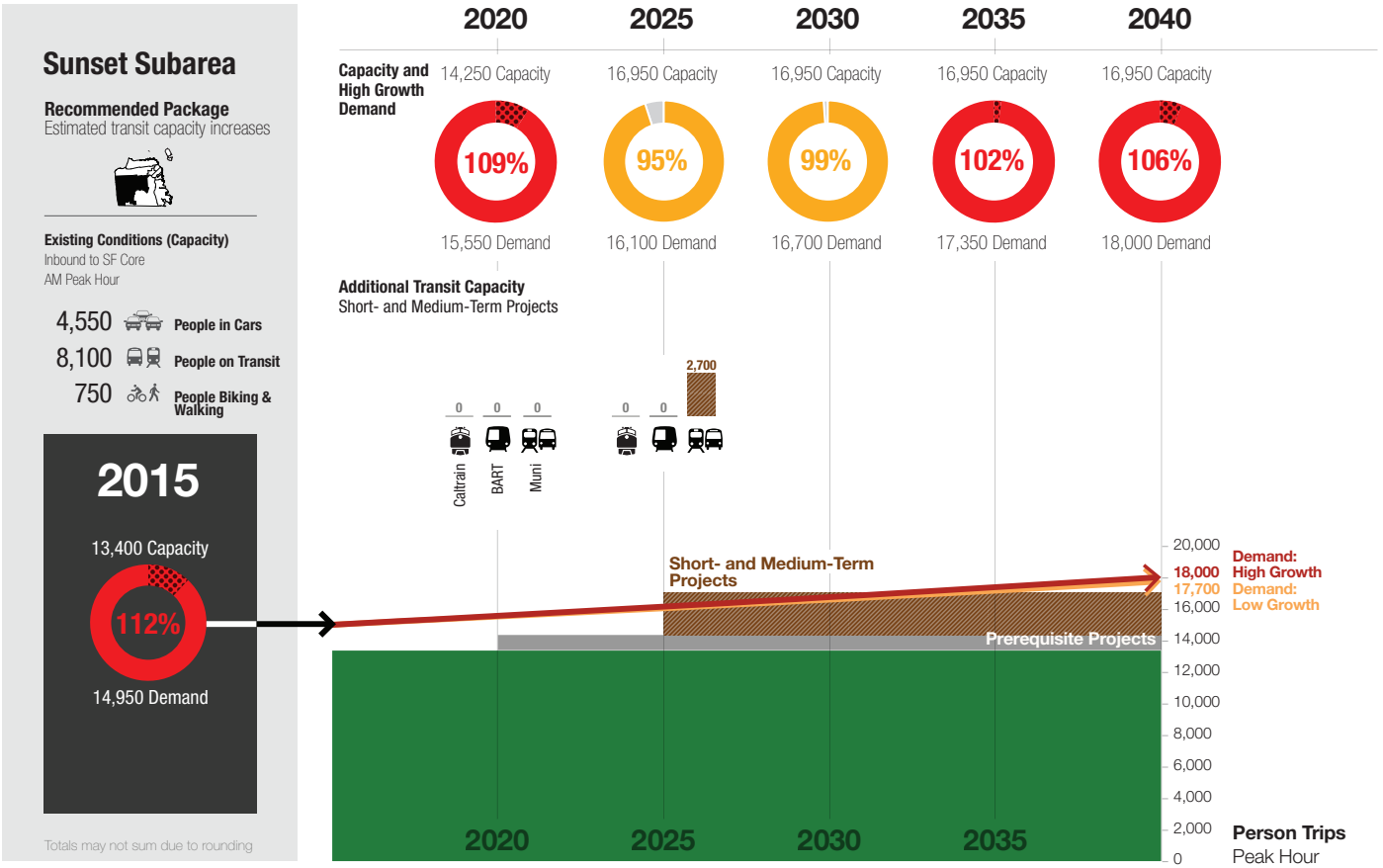
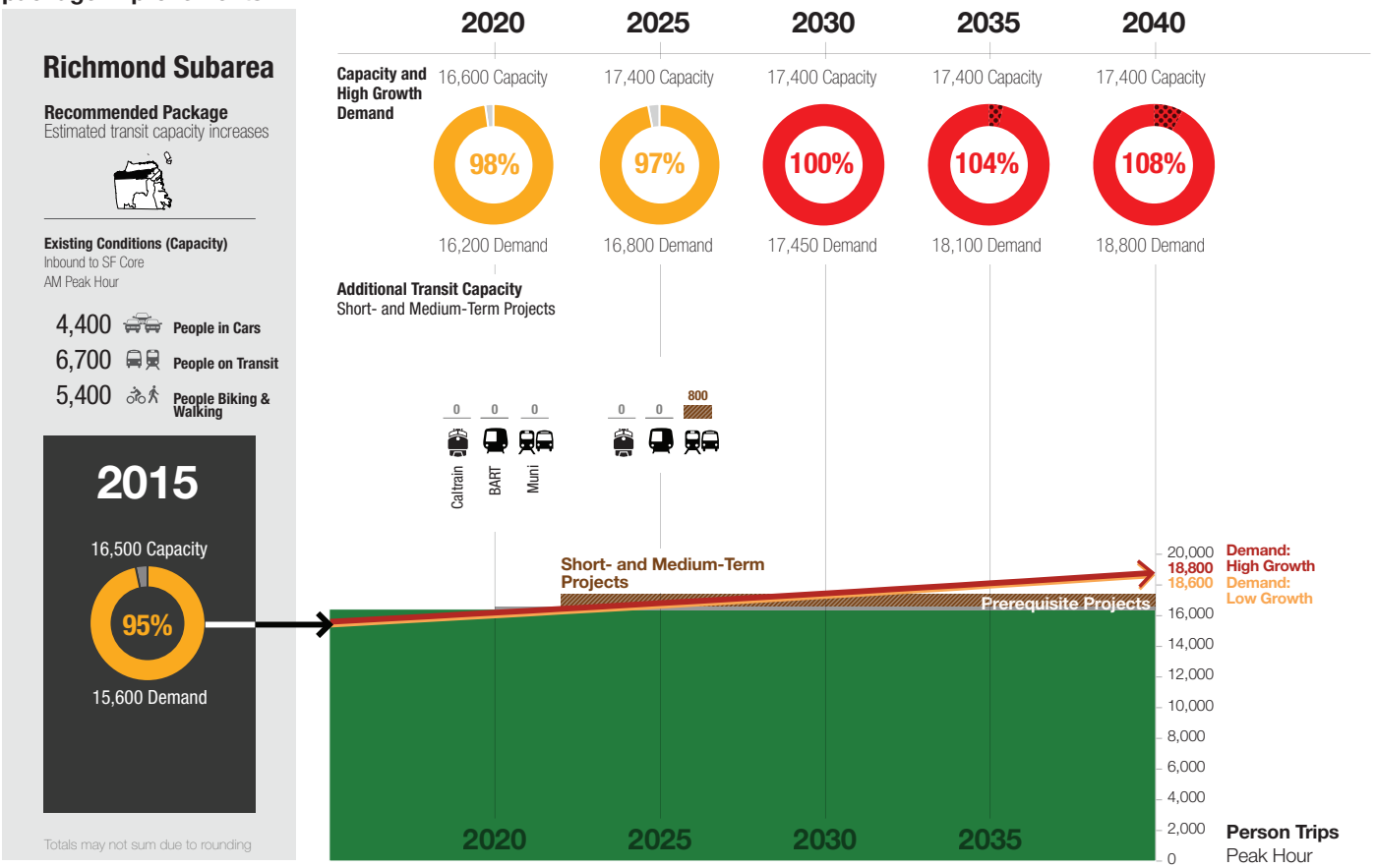


Figure 12: SF Metro Richmond subarea capacity and demand with recommended short- and medium-term package improvements



5.5 Looking beyond the short and medium term

The City and County of San Francisco is currently engaged in ConnectSF, a parallel exercise to develop a long-term vision for the city. Thus, the CCTS did not develop formal long-term options, but instead the PMT identified potential ideas and concepts that could be considered by ConnectSF. These ideas and concepts would need further development in a future study to determine their feasibility and potential benefit. The options are presented in Table 9, organized by subarea.

Table 9: SF Metro Corridor long-term ideas and concepts

Subarea	Concept
Bayshore	• Add Hunters Point branch of the T Line • Implement a Caltrain Metro service concept with grade separations, tying into the San Francisco Subway Vision Plan
Mission	• Link with potential Transbay Corridor long-term options • Integrate fares to simplify transfers between agencies
Northern Neighborhoods	• Augment the bicycle network with additional lanes and a potential bicycle boulevard • Enhance the pedestrian environment by widening sidewalks • Implement right-of-way protections and transit priority for transit vehicles
Richmond	• Enhance Geary corridor BRT with better-protected right-of-way and four lanes of BRT for local/express service • Convert Geary corridor BRT to a subway using either rail or bus technology, with longer stop spacing akin to regional rail and avoiding Market Street/Geary congestion • Connect to San Francisco Subway Vision Plan, with several potential connections such as Geary/Daly City, Geary/Ocean Beach BRT or LRT, Muni Metro LRT
Sunset	• Implement additional surface operations improvements (beyond short- and medium-term improvements) to take better advantage of the MMT, such as right-of-way protection and straightened alignments • Add a parallel/redundant facility, such as a tunnel for the N line and/or connection to a potential connection between the Geary corridor and Daly City • Restructure the Metro system using a trunk line concept in the MMT

Photo: Arup

CHAPTER 6

Improve: Transbay long-term options

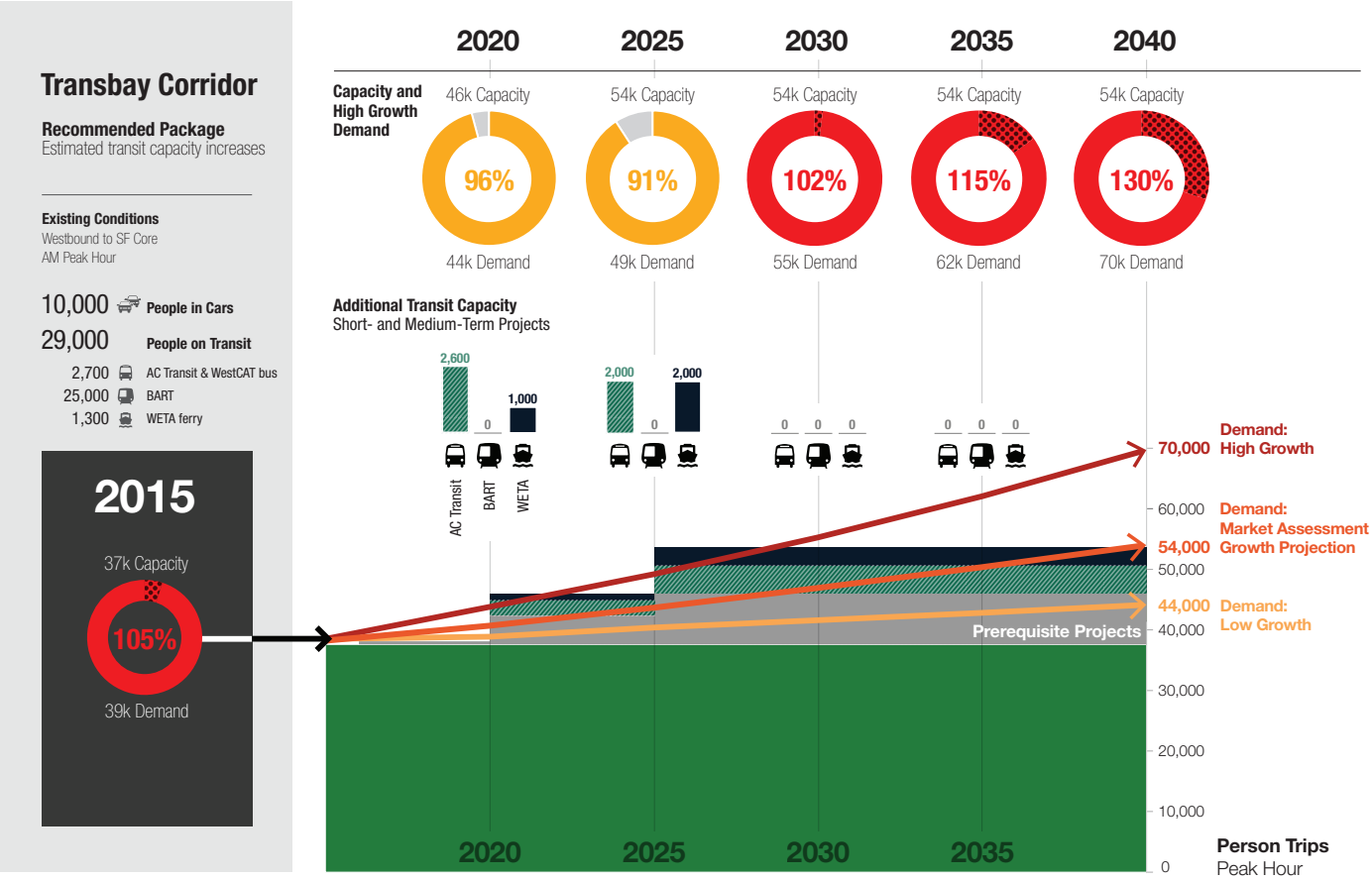
In addition to developing packages of projects to increase transit capacity to the San Francisco Core over the short and medium term, the CCTS also developed options to address potential capacity shortfalls over the long term. This chapter discusses the potential long-term options developed by the PMT.

6.1 Meeting the need in 2040

By 2040, demand will reach and soon exceed the corridor's capacity. If transit demand grows faster than the market demand estimate, demand will outstrip capacity even sooner—possibly by 2030. In either case, new investments to add capacity between 2030 and 2040 will be needed. As illustrated in Figure 13, even with the implementation of the recommended short- and medium-term package, further investments in the long term will be needed.

Photo: Sergio Ruiz

Figure 13: Transbay Corridor capacity and demand with recommended short- and medium-term package improvements



In order to address opportunities in the long term, the PMT had to consider and understand a different set of issues and concerns compared with the short and medium term. The PMT focused on several topic areas in developing the long-term options, including new transit markets, system redundancy, technical and operational considerations, and issues of governance and ownership. The long-term options were designed to be large-scale in nature, reflecting the continued need to provide additional transit capacity into the long term. The following sections describe the various focus areas that informed how the long-term options were developed for assessment.

6.2 Long-term options

The CCTS long-term options were developed through a number of activities, including the following:

- PMT study workshops
- Initial engineering studies
- Market assessments
- Review of previous long-term concepts

The options reflect different opportunities to address transit capacity while also considering other local and regional policy objectives. The long-term options are as follows:

- Long-term option 1: Maximize existing assets
- Long-term option 2: BART Market Street redundancy
- Long-term option 3: BART new markets
- Long-term option 4: Greater regional rail connection

Table 10 summarizes the key features of each option, as well as the opportunities and constraints that each presents. Figures 14 through 19 illustrate the options (including suboptions).

An option that combines a BART and conventional crossing was not specifically assessed as a stand-alone option, but it is expected that it would be included in a future study.

Even with the new capacity gained from the short- and medium-term improvements shown in Figure 13, a gap between travel demand and capacity will remain if demand in the corridor grows faster than the market assessment forecast.

Table 10: Transbay Corridor long-term options

#	Option	Summary	Key features	Key opportunities and challenges
1	Maximize existing assets	Maximize and/or improve the Transbay Corridor's existing infrastructure assets, including maximizing utilization of the Transbay Transit Center capacity, increasing BART station capacity at Embarcadero and Montgomery Stations, and creating a more robust ferry network	• More Transbay bus service • More transit-priority infrastructure • More ferry service • BART side platforms* at Embarcadero and Montgomery stations	Opportunities: • Maximizes use of Transbay Transit Center • Maximizes existing bus and ferry services • Less capital cost compared to other long-term options Challenges: • Requires additional fleet and infrastructure to maintain reliability and new service levels • Amount of estimated new capacity may be fully utilized by opening day
2	BART Market Street redundancy	Provide redundancy for BART in the Market Street corridor serving the Financial District, providing BART with similar access and service to the Core's most job-dense subarea, and capacity relief to existing stations	Third Street suboption: • Serves new markets in SoMa • Station connection feasibility at Powell Station • Independent line • Utilizes either I-980 or Broadway corridor option in East Bay	Opportunities: • Creates transfer opportunity to Market Street corridor • Provides new East Bay access to Mission Bay/SoMa • Provides highest estimated capacity of all long-term options • Potential to serve major new corridor in San Francisco Challenges: • Lengthy connection to Montgomery Station • May not relieve crowding at Embarcadero and Montgomery stations as much as the Mission Street suboption
			Mission Street suboption: • Could serve Transbay Transit Center • Independent line • Utilizes either I-980 or Broadway corridor option in East Bay • Could serve new markets outside of downtown	Opportunities: • Creates redundant Market Street corridor service and transfer opportunity to Transbay Transit Center • Provides highest estimated capacity of all long-term options Challenges: • Does not open to new markets in downtown San Francisco
3	BART new markets	Provide new regional transit access to areas of the Core not currently served by BART	Brannan Street suboption: • Includes merge/breakout concept • Potential need for side platforms at Embarcadero and Montgomery • Utilizes either I-980 or Broadway corridor option in East Bay	Opportunities: • Provides direct connection to Market Street • Provides new East Bay access to Mission Bay/SoMa Challenges: • Breakout option reduces overall capacity through the Market Street corridor and provides less new capacity when compared to the independent line • Breakout option creates significant capacity constraints and potentially unacceptable operational constraints
			Mission Bay suboption: • Includes merge/breakout concept • Potential need for side platforms at Embarcadero and Montgomery • Utilizes either I-980 or Broadway corridor option in East Bay	
4	Greater regional rail connection	Provide a conventional rail crossing centered on the new Transbay Transit Center, transitioning it to a run-through terminal and connecting Peninsula rail to East-Bay-and-beyond rail service	• In San Francisco, connects to Caltrain corridor via planned Downtown Extension • In the East Bay, utilizes the I-980 corridor and connects to BART service at MacArthur Station and Amtrak/Capitol Corridor service in Emeryville	Opportunities: • Increases rail capacity of Transbay Transit Center • Connects to proposed Downtown Extension connection through SoMa and Mission Bay Challenges: • Complex governance and ownership issues • Amount of estimated new capacity may be fully utilized by opening day if implemented without BART improvements • Significant operational (slot) challenges on both Peninsula and Capitol Corridor, no right-of-way, and requirement for completely new station on the East Bay side

* See section 6.4 for more information.

Figure 14: Long-Term Option 1: Maximize existing assets

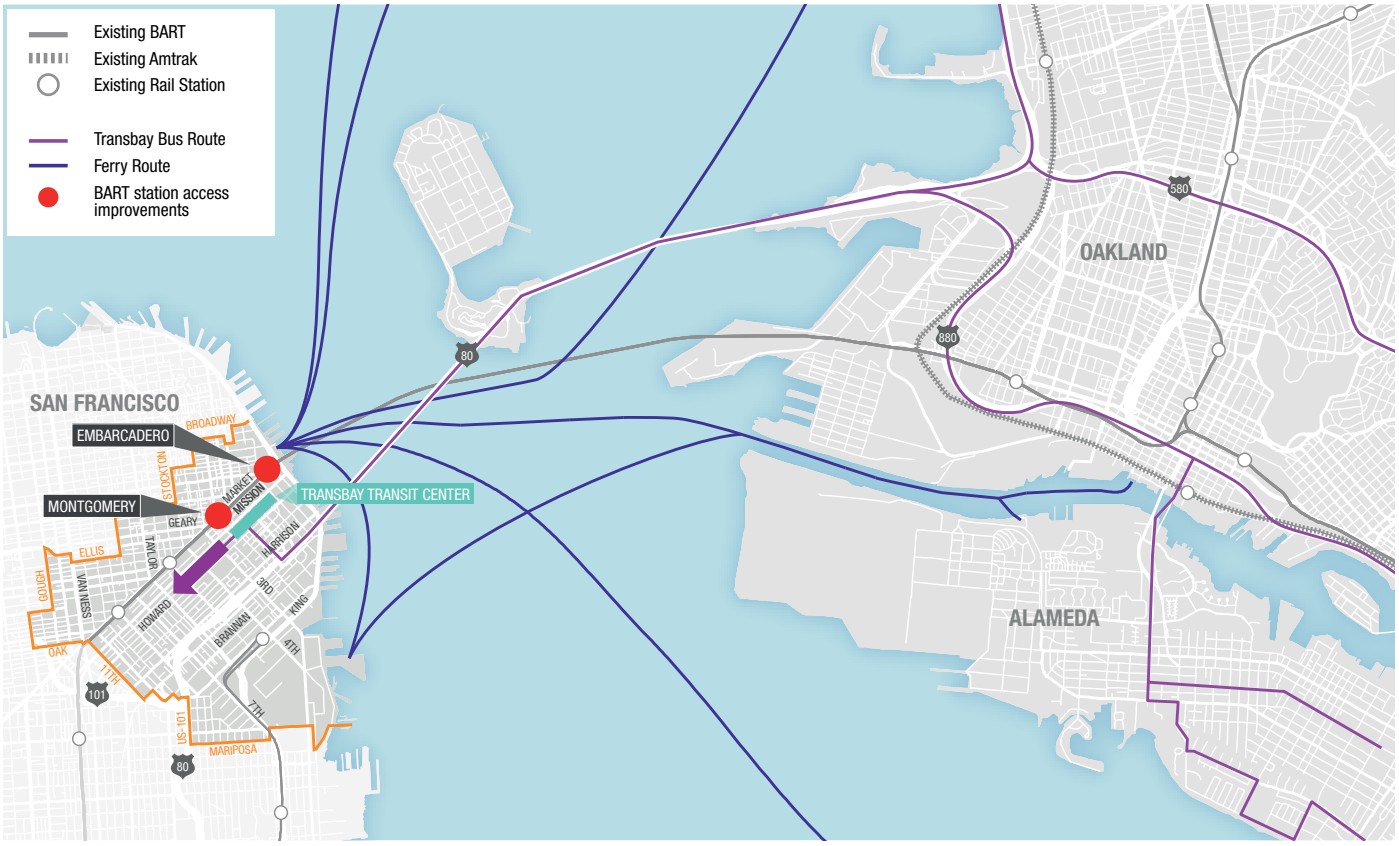


Figure 15: Long-Term Option 2a: BART Market Street redundancy – Third Street suboption

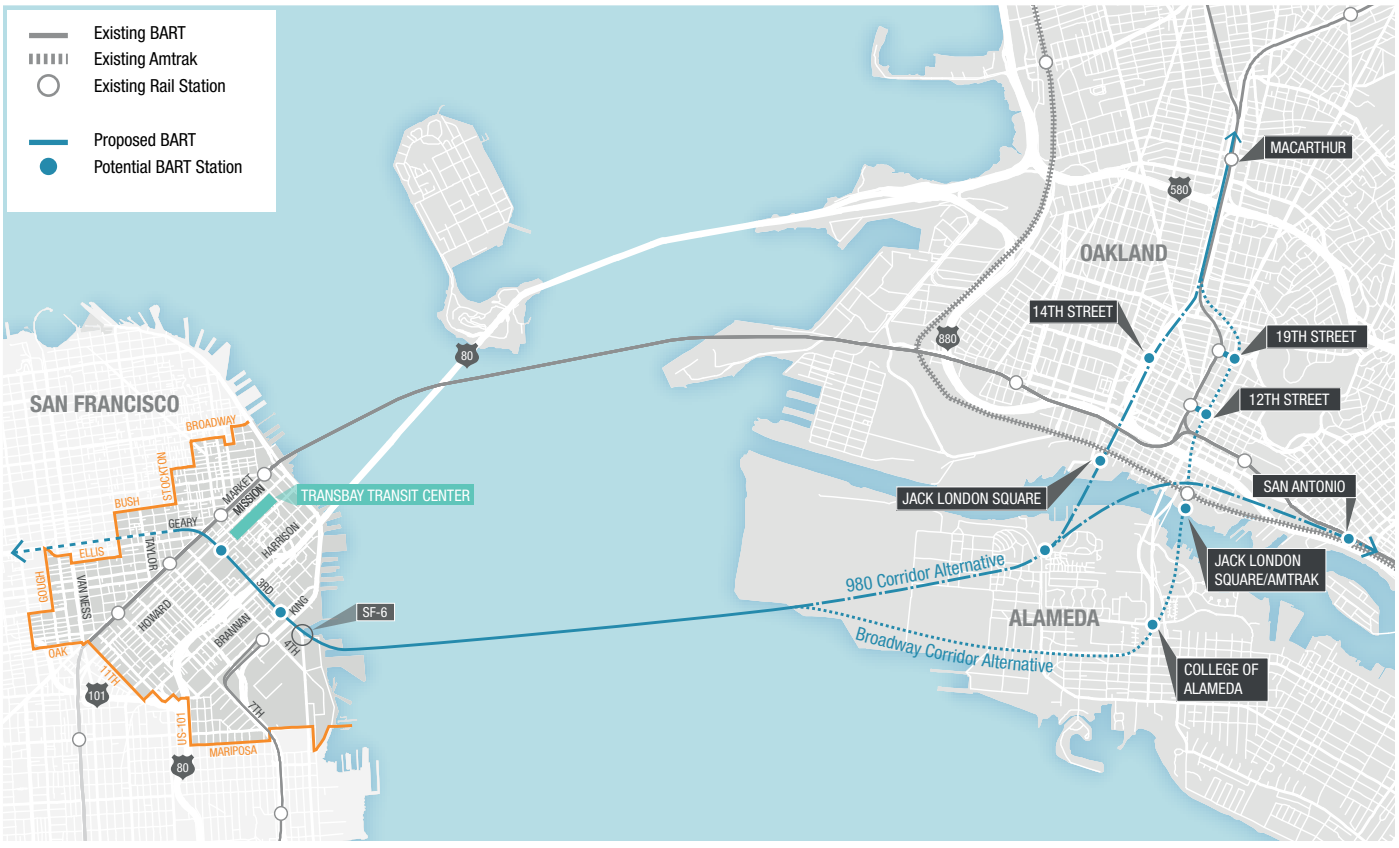


Figure 16: Long-Term Option 2b: BART Market Street redundancy – Mission Street suboption

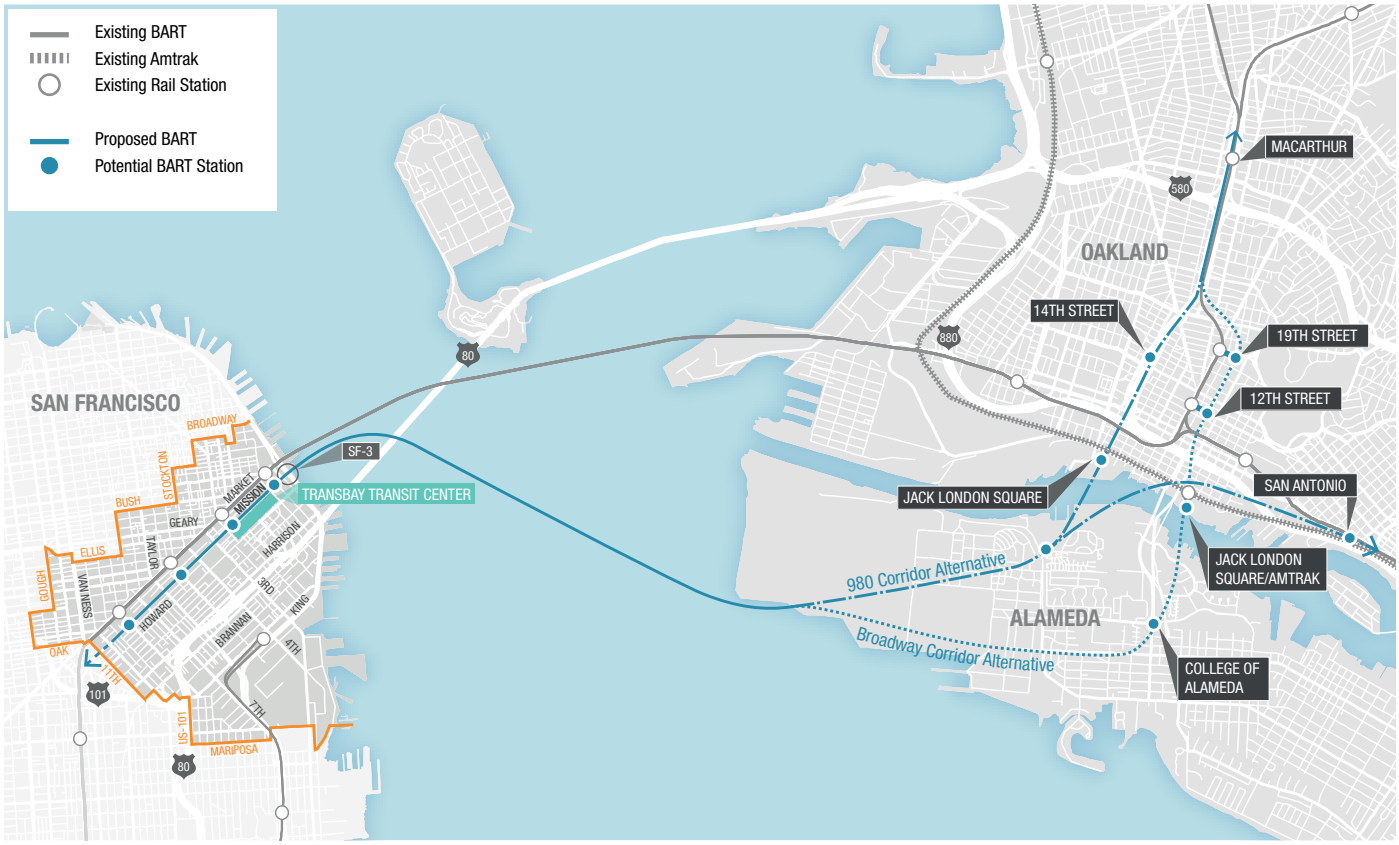


Figure 17: Long-Term Option 3a: BART New Markets – Brannan Street suboption

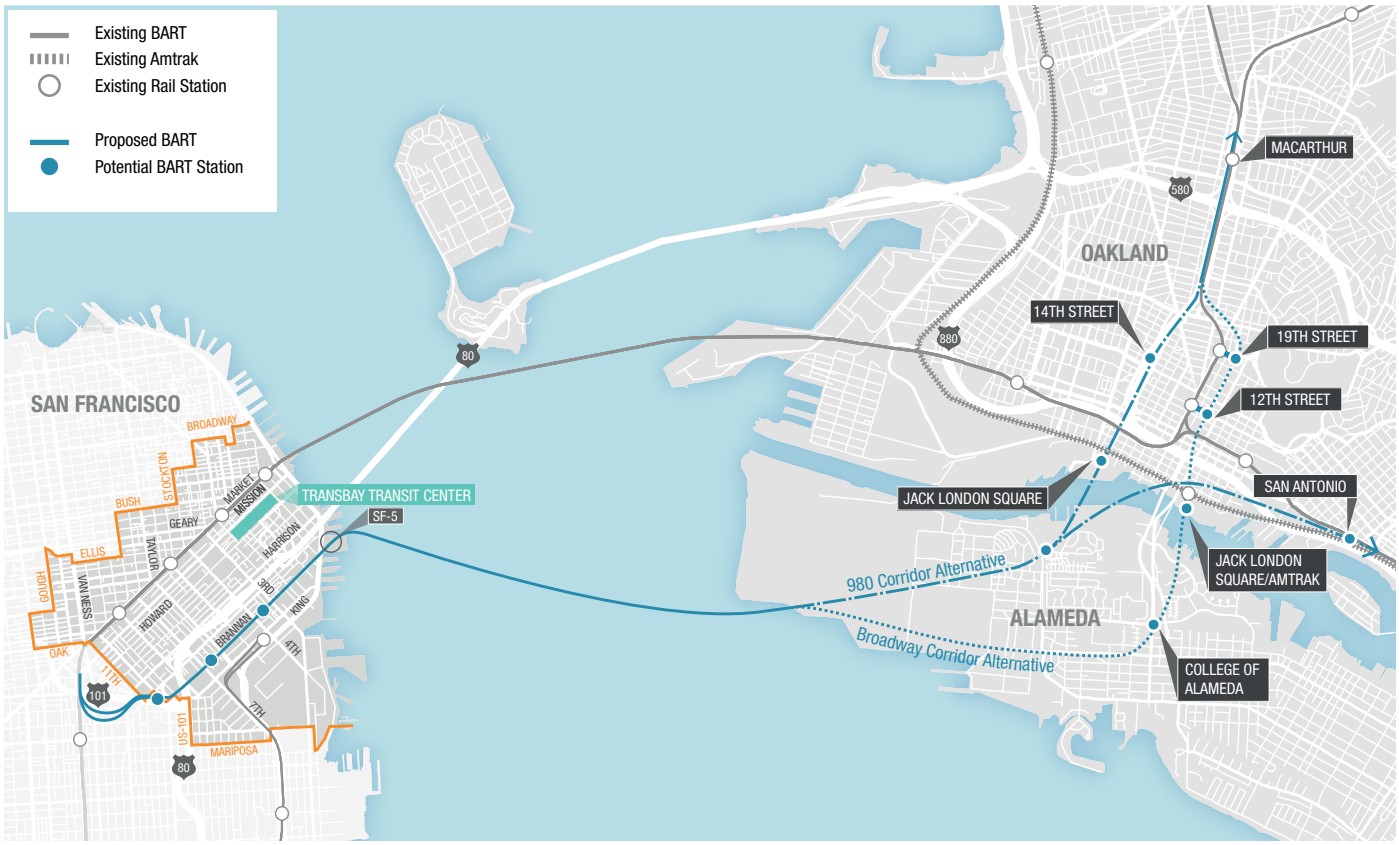


Figure 18: Long-Term Option 3b: BART new markets – Mission Bay suboption

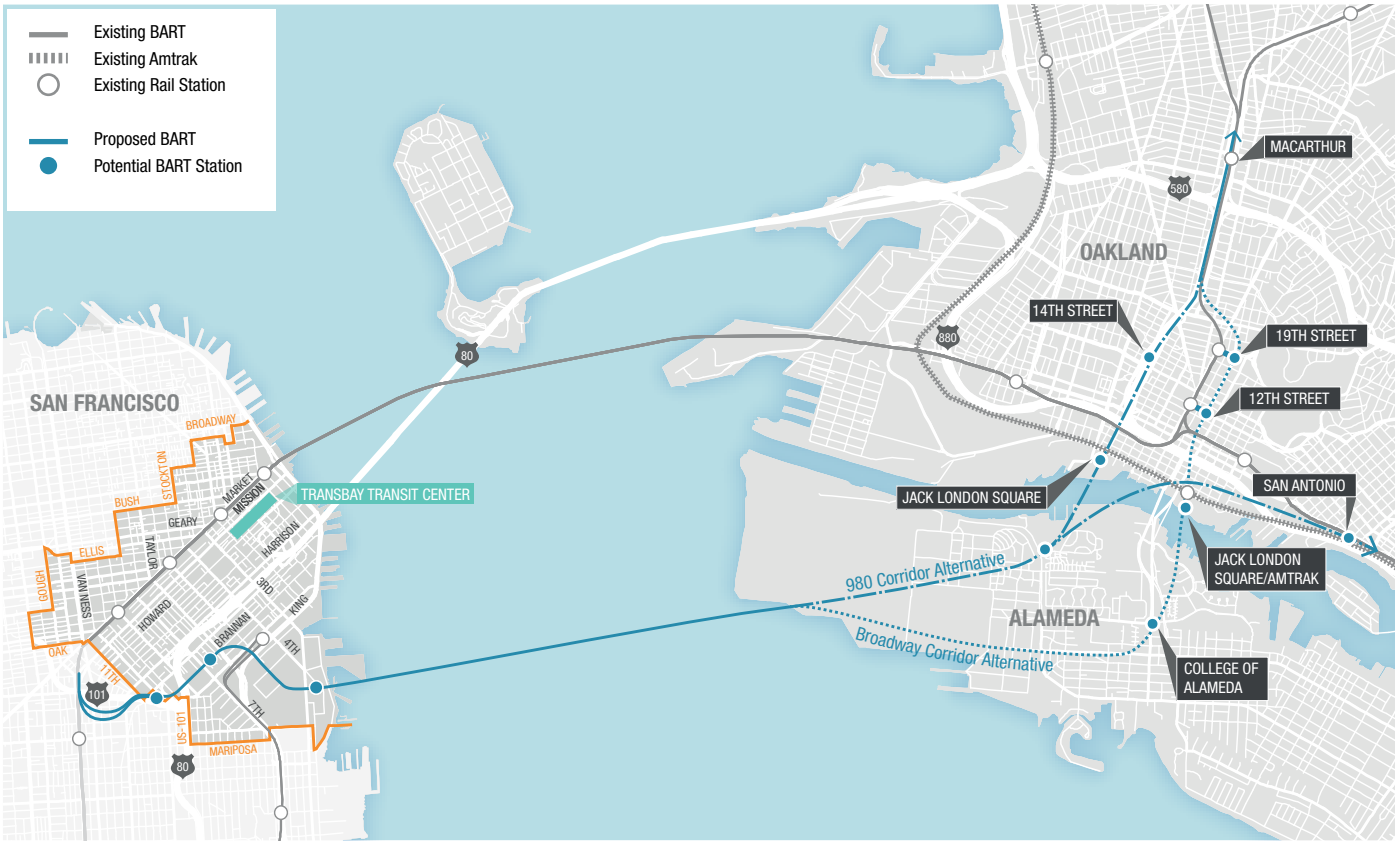


Figure 19: Long-Term Option 4: Greater regional rail connection

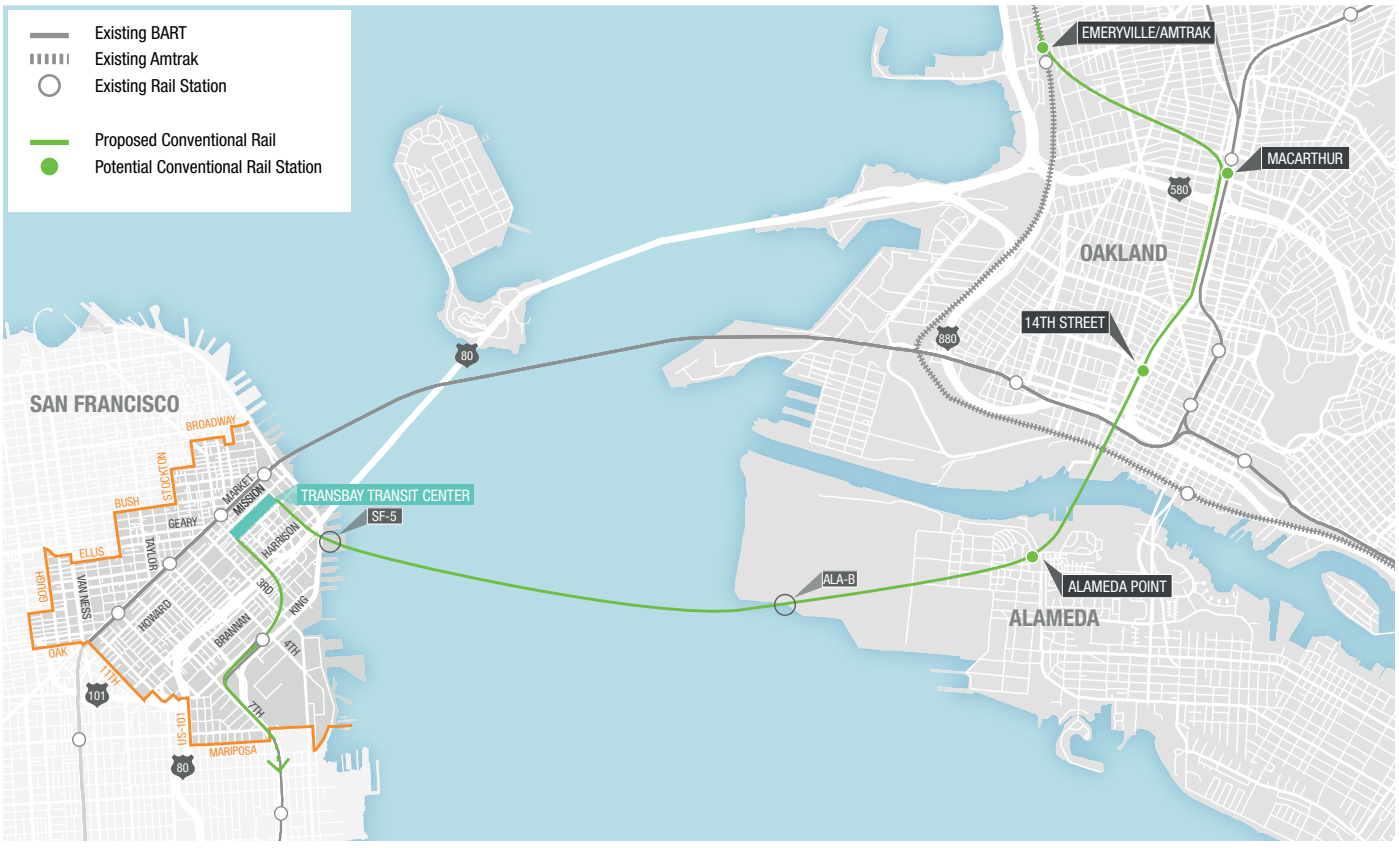


Table 11 shows that each of the long-term options delivers different capacity levels. Option 1 (maximizing existing assets), Option 3 (BART new markets), and the lower range of Option 4 (greater regional rail connection) do not fill the gap between demand and capacity at the high growth rate. Option 2 (BART Market Street redundancy) and the higher range of Option 4 do deliver more capacity than demand at the higher growth rate. If both a BART and regional rail option are built, this would deliver capacity for an additional 48,000 trips. Figure 20 illustrates the capacity gains provided by each long-term option.

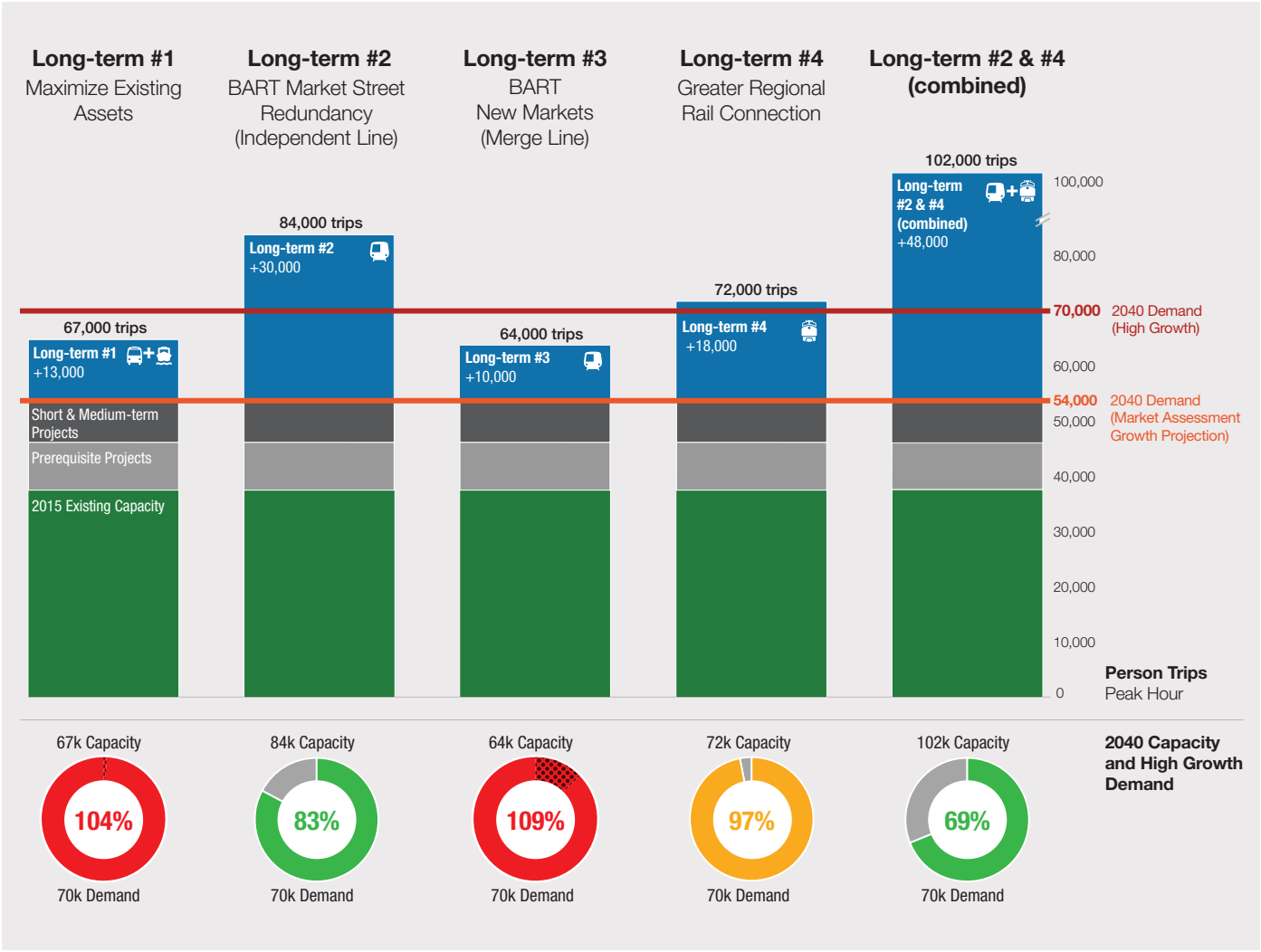
Table 11: Long-term options service, capacity, and capital cost estimates

#	Option	Assumed frequency	Estimated new capacity (peak hour)	Estimated capital cost
1	Maximize existing assets	300 buses/hour; 24 ferries/hour	13,000	$1.5bn
2	BART Market Street redundancy	28–30 trains/hour	30,000	$5–12bn
3	BART new markets (merge/breakout)	12 trains/hour	10,000	$5–12bn
4	Greater regional rail connection*	10–12 trains/hour	12,000–18,000**	$5–11bn

* This option would require significant expenditures on the Peninsula and Capitol Corridor to support this level of service.

** Regional rail capacity is a conservative estimate using an indicative service pattern based on potential Caltrain service. The estimate may not represent the ultimate potential capacity of this facility.

Figure 20: Transbay Corridor long-term option capacity estimates



6.3 Developing the long-term options

Prior to developing potential alignments and station locations in the long term, the CCTS advanced specific engineering studies and market assessments in order to identify and address any fatal flaws in the early stages of option development. This provided needed information at the onset while also reducing future analysis efforts during later stages of the study.

6.3.1 Promising landing sites

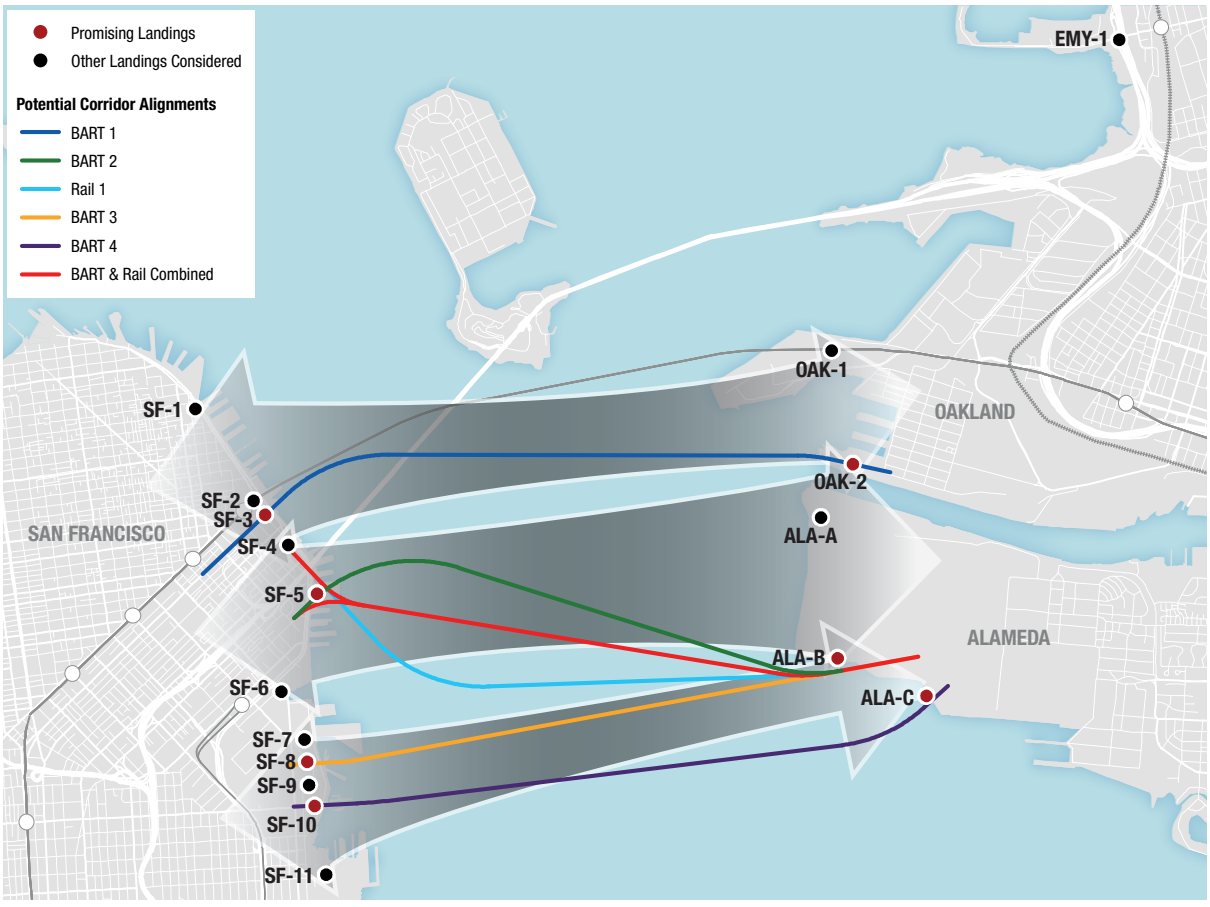
Initial engineering studies were undertaken to review potential tunnel crossing landing locations, second-crossing corridors, and potential tunneling techniques and technologies. In order to identify promising landing sites, the effort narrowed the range of long-term options to those that were sensitive to the geological and technical issues and that were more favorable for constructing and implementing a second rail crossing.

The landing review identified promising landing sites based on the following:

- Rail geometry and connectivity (BART/rail): How the landing site accommodates and meets BART and/or rail horizontal or vertical alignment requirements
- Geotechnical conditions: Existing geotechnical conditions, especially noting locations with poor conditions and associated risks for constructability and costs
- Environmental risks: Broad risks associated with environmental hazards, permitting risks, and some typical risks considered as part of the California Environmental Quality Act / National Environmental Policy Act process
- Constructability risks: Risks related to and driven by geotechnical conditions and tunneling technology used
- Construction impacts: Impacts of building major launching/receiving shafts, transition structures, hauling extensive spoils, etc., at landing location compared against potential impacts to residential, commercial, or industrial use

Between San Francisco and the East Bay, seven promising landing sites were identified (four in San Francisco and three in the East Bay). The potential landing sites are shown in Figure 21.

Figure 21: Potential landing sites in San Francisco and the East Bay

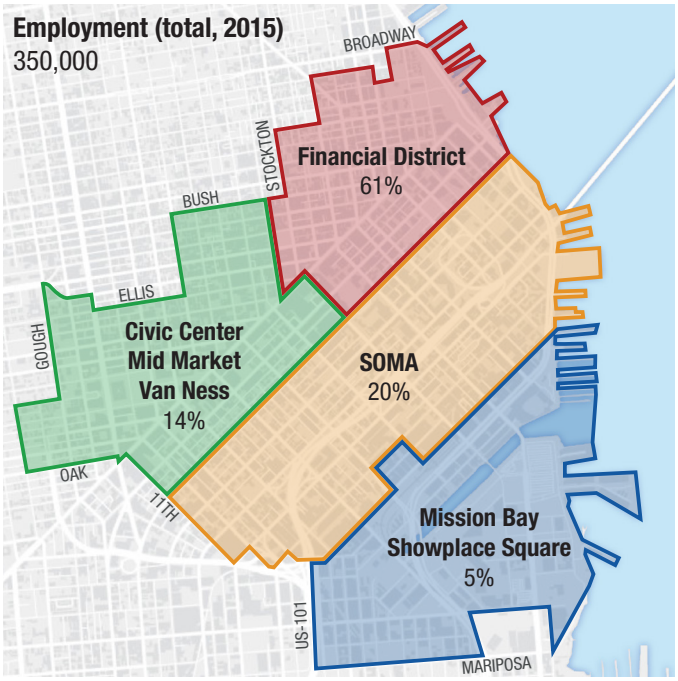


6.3.2 Market assessment

Two market assessments of the existing and future real estate market in the San Francisco Core and downtown Oakland were completed. In San Francisco, the assessment sought to understand employment trends around the scale and location of jobs within the San Francisco Core and provide a range of employment growth projections. For the purpose of analysis, the Core was divided into subareas. Figure 22 illustrates the share of total 2015 Core employment in each subarea. In Oakland, the assessment sought to understand the potential for future employment and residential growth in the inner East Bay, with a focus on downtown Oakland.

The San Francisco market assessment concluded that approximately 100,000 to 140,000 new jobs are expected in the Core by 2040. These new jobs will be located in new offices with higher employee densities than today's average and in existing buildings that are remodeled to house more workers. Although some subareas will grow at much faster rates, the traditional Financial District will remain the major concentration of jobs in 2040. Table 12 details the estimated employment growth for each subarea.

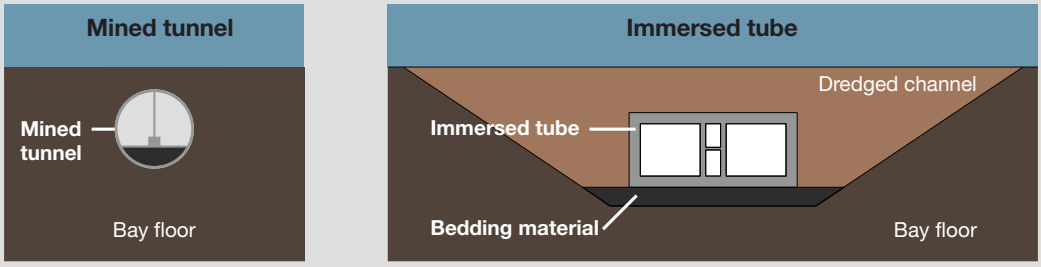
Figure 22: San Francisco Core subareas with share of total employment



SPOTLIGHT

Transbay crossing tunnel technology

In addition to potential landing sites, the CCTS initial engineering analysis also compared two tunnel technologies for their viability in different crossing alignments: immersed tube tunnel, which was used for the existing BART Transbay Tube, or mined tunnel. Either technology is expected to be viable for most of the alignments studied. The engineering analysis concluded that if the region decides to build additional crossings for both BART and conventional rail, it would likely be more prudent and less costly to construct two mined tunnels, one for each mode, rather than a four-track immersed tube tunnel, due to the cost of disposing of a significant quantity of potentially contaminated dredging spoils. The analysis also concluded that there are not economies of scale to constructing the BART and conventional rail crossings on the same alignment or at the same time. Each mode could therefore plan for a future crossing that meets its needs in terms of alignment, landside connections, and operating requirements.



Drawings not to scale

Table 12: Estimated San Francisco Core subarea 2040 employment growth

Core subarea	Definition	2015 jobs	2040 jobs (high forecast)	Change (#)	Change (%)
Financial District	North of Howard Street, east of Grant Street	213,300	269,200	+55,900	26%
Civic Center/ Mid-Market	North of Howard Street, west of Grant Street, east of Gough Street	51,300	73,000	+21,700	42%
SoMa	South of Howard Street, north of Townsend Street, east of 11th Street	68,800	98,800	+30,000	44%
Showplace Square/ Mission Bay	South of Townsend Street, east of Vermont Street	17,100	49,700	+32,600	191%
Total		**350,500**	**490,700**	**140,200**	**40%**

The Oakland market assessment concluded that future employment growth is tied to several factors, including economic competitiveness, timing of new office development, and availability of prime offices that thus far have played a factor in how much growth the inner East Bay and downtown Oakland can expect to be realized. Focused exclusively on downtown Oakland (shown in Figure 23), the assessment found that between 2015 and 2040, between 12,000 and 24,000 new jobs will be created, which will require significant new office space to accommodate the growth. To the extent that jobs in Oakland attract San Francisco residents, that travel pattern can fill otherwise unused seats on reverse-commute trips. If these jobs attract residents from outer East Bay suburbs, that could exacerbate capacity issues.

Figure 23: Downtown Oakland market area

Taken together, the San Francisco Core and the downtown Oakland business district will remain the major employment center for the region. San Francisco will continue to be the beneficiary of a majority of the employment growth between the two locations, although Oakland is potentially on the threshold toward more aggressive office growth in the near future. Nevertheless, should Oakland grow by the market assessment's high growth estimate, San Francisco will still dominate as an employment destination.

6.3.3 Alignment considerations

The findings from the initial engineering studies narrowed the range of potential alignment routings based on the most promising landing sites. Considerations for where the transit alignment would be routed were developed for San Francisco and the East Bay. In San Francisco, priority landing-site needs include the following:

- Providing system redundancy to the Market Street corridor
- Providing connections (pedestrian or direct station transfer) to existing BART system
- Opening new markets to regional transit service[14]

Priority landing-site needs in the East Bay include the following:

- Providing system redundancy to the Broadway corridor in downtown Oakland
- Providing connections (pedestrian or direct station transfer) to existing BART system
- Providing direct connection to Capitol Corridor/Amtrak service
- Opening new markets to regional transit service[15]
- Allowing track connections to existing BART network

14 Only markets within the study's Core boundary were considered as new markets. New markets refers to portions of SoMa, Showplace Square, and Mission Bay that are not within close proximity to a regional transit station or require transfers to access.

15 In the East Bay, new markets refers to the I-980 corridor, which has been raised as a potential reuse opportunity if the 980 freeway is removed.

The priority needs are reflective of either a future BART or conventional rail long-term option, or both.

6.3.4 Operational considerations

Adding a new transit crossing over the San Francisco Bay that connects into the existing regional transit network is a complex endeavor. From the operational perspective, the new linkage must enable new service patterns, while not creating operational problems or constraints on the existing system.

In San Francisco, there is a strategic desire both to provide redundancy to the existing network and to serve new markets. These two priorities can be in conflict, and one solution may not be able to address both strategic desires. Two options were therefore considered: an independent line and a merge/breakout line.

- **Independent line:** This option creates an entirely separate new BART crossing that operates as an independent second BART line in San Francisco. At minimum, there would be an opportunity to create a pedestrian connection to the Market Street corridor rail service, and at maximum, a direct station connection, such as SFMTA's Third Street Light-Rail Powell Street Station connection, which is currently under construction. The feasibility of providing a direct station connection will need to be assessed in a future study. This option does not have the same operational and constructability challenges as the merge/breakout option and would deliver the most new capacity of all the long-term options.
- **Merge/breakout line:** This concept is to construct a breakout point for a new BART crossing to merge into the existing system in downtown San Francisco. It would allow the second crossing to directly connect into the existing BART mainline, creating a loop feature between the East Bay and San Francisco. This option has significant operational and constructability challenges, and the feasibility of constructing and operating this concept will need to be assessed in a future study. In addition, a merge/breakout reduces the amount of capacity that can operate through the Mission Street corridor and overall produces significantly less new capacity for the Transbay Corridor than the independent line for the second Transbay crossing.

In the East Bay, operational considerations focus on how to incorporate a new crossing that can serve BART and conventional rail lines to the north (serving Richmond and Pittsburg/Bay Point terminals for BART and Sacramento for conventional rail) and south (serving Warm Springs/Berryessa and Dublin for BART). East Bay connections with a new crossing will likely concentrate on a few major connection points, including the following:

- **MacArthur Station:** MacArthur currently is a major transfer point between three BART lines, and a new second crossing could add a fourth line. The study identified MacArthur Station as a potential major transfer point for both BART and potential conventional rail second crossing options.
- **Broadway corridor:** Like the Market Street corridor in San Francisco, an alignment concept under consideration is providing parallel BART service to the Broadway corridor through downtown Oakland. The feasibility of providing direct station connections between the new and current alignments will need to be assessed in a future study.
- **I-980 corridor:** An alternative consideration to the Broadway corridor, this concept focuses on providing service (either BART or conventional rail) along the I-980 corridor. This would be an opportunity to establish access for new markets and potentially influence new growth in the neighborhood. The effort to close the I-980 freeway will need to be monitored in order for this alternative to be considered feasible in the future.
- **New transfer station at San Antonio:** A new transfer station in the San Antonio district in Oakland would potentially provide connections for travelers heading to destinations along the Warm Springs or Dublin/Pleasanton lines, similar to the way MacArthur Station functions for the Richmond and Pittsburg/Bay Point lines.

6.3.5 Regional connectivity considerations

A conventional rail crossing is an opportunity to maximize the use of the Transbay Transit Center as a regional rail hub, with the potential to extend the commuter rail network, providing a one-seat ride between the East Bay and the job centers in San Francisco, the Peninsula, and San Jose. This additional connectivity also extends the opportunities for megaregional heavy-rail connections to Sacramento using the Capital Corridor or to the Central Valley and Los Angeles via the future California High-Speed Rail service or the San Joaquins service. Caltrans is exploring this concept through the development of its 2018 California State Rail Plan, and long-term improvements envisioned by Capitol Corridor in its 2014 Vision Plan would align with a long-distance megaregion conventional rail network. However, a conventional rail crossing and a larger megaregion conventional rail network do not currently have an identified sponsor, nor have any of the many issues regarding governance, rail operator, or ownership been fully identified or studied.

The upcoming draft State Rail Plan is expected to discuss the implications of a conventional rail tube between San Francisco and the East Bay. While the final plan has not yet been released, discussions with study participants indicate that the study's analysis determines that a transbay conventional rail link would create significant and dynamic passenger benefits throughout the entire state-sponsored system, including increasing transit mobility and supporting new economic growth. A conventional rail link would also allow for a blending or merging of multiple systems into one seamless network, linking Caltrain's Peninsula rail service with the Capitol Corridor in the East Bay to Sacramento, with future connections to the southern part of the state through California High-Speed Rail.[16] This would also require significant investment in right-of-way and infrastructure in the East Bay.

6.4 Additional considerations

- **Governance for a regional rail crossing:** Governance is a major challenge to delivering a transbay conventional rail crossing. None of the current conventional rail operators are currently charged with providing future rail service across the bay. The absence of a clear responsible rail operator for a conventional rail crossing creates challenges regarding designating a sponsor to advance planning and engineering studies as well as an advocate for funding sources.
- **Combined BART and conventional rail crossing:** The initial engineering studies found that combining a BART and conventional rail crossing in a single structure is feasible but significantly more costly than constructing two separate crossings, one for each mode. The study did not examine in depth at an option to construct both a BART and conventional rail crossing, although Figure 20 reports a capacity estimate for this potential option. A future study will need to conduct a feasibility analysis of this option.
- **BART side platforms at Montgomery and Embarcadero Stations:** The continued growth of BART ridership has placed significant strain on the ability for Montgomery and Embarcadero Stations—the two busiest stations in the system—to process passengers efficiently and comfortably. Under consideration is the need to expand or create new platform capacity. The study notes that without a second transbay crossing to alleviate demand on the existing BART crossing, side platforms will likely need to be built at these stations. Thus, Long-Term Option 1 will likely require side platforms, and further studies will need to determine whether side platforms are needed for Long-Term Option 3, due to the merge/breakout concept, which still routes all trains through these stations. Further studies will analyze whether side platforms are needed with Long-Term Option 3. Long-Term Option 2 does not require side platforms.
- **Conventional rail crossing capacity:** The new capacity estimated for a conventional rail crossing could keep pace with the high growth demand forecast. However, if transit demand grows at the high growth rate shown in Figure 20, the capacity provided by this new crossing would nearly be filled by opening day in 2040. This option alone may not provide sufficient future capacity.
- **East Bay conventional rail network:** Unlike on the San Francisco peninsula, where Caltrain owns and operates its rail network, the commuter/intercity rail network in the East Bay is owned by the Union Pacific railroad and may not be available for expanded services without significant investment in new trackage, alignments, and right-of-way.
- **Benefits of a BART line serving new markets for the SF Metro Corridor:** In addition to adding capacity to the Transbay Corridor, an independent BART line option may also address capacity issues for SF Metro by accommodating some demand from within San Francisco. Depending on where the new BART line is routed, there may be opportunities to pair it within San Francisco with SFMTA services.
- **Coordination with SF Metro long-term options:** It will be important to coordinate and maintain consistency with the SF Metro long-term options, as these present complementary long-term opportunities to the Transbay long-term options.
- **Megaregion opportunity:** It will be important to coordinate and maintain consistency with California's State Rail Plan, currently under development, to begin to understand and analyze any potential for extending a conventional rail second crossing with plans for a larger megaregion rail network. Connecting with the regional rail network or with the future California High-Speed Rail network should be further studied.

16 More information on the California State Rail plan is available online at: http://www.dot.ca.gov/californiarail/

Photo: flickr user sillygwailo / CC BY2.0

Photo: Arup

CHAPTER 7

Implement: Summary and next steps

The CCTS recommends a package of short- and medium-term projects for both the Transbay and SF Metro Corridors. Immediate action is needed to advance the recommended packages toward implementation, including programming them into regional and state funding plans for prioritization. In particular, it is critical that unfunded prerequisite projects are prioritized for funding. Suggested funding plans include *Plan Bay Area* 2040, any future bridge toll increases, and California Senate Bill 1.

The CCTS developed a range of long-term ideas and concepts for the study corridors. The SF Metro Corridor long-term ideas and concepts will help inform ConnectSF as it considers the challenges and potential solutions facing San Francisco in the coming decades. The planning process to further refine the Transbay Corridor long-term options should continue in order to implement a project by 2040.

The next steps in developing the Transbay Corridor long-term options are as follows:

- Conduct a scoping exercise to develop a second crossing continuation study framework, with input from CCTS Executive Team
    - Articulate key scoping questions
        - Appropriate geographic scale: corridor, regional, megaregional
        - Institutional governance and other policy considerations
- Prepare the second crossing continuation study
    - Consider BART and conventional rail options for a second Transbay Corridor crossing
    - Assess market demand and identify the service, operations and infrastructure needed to meet the demand
    - Identify study leadership, in partnership with BART, to lead the project's conventional rail portion and to fill a program management role
    - Extend CCTS PMT participation and add new stakeholders as necessary

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Appendices

A. Transbay Corridor Short- and Medium-Term Capacity Projects

B. Transbay Corridor Selected Travel Demand Model Findings

C. SF Metro Corridor Short- and Medium-Term Capacity Projects

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Appendix A: Transbay Corridor Short- and Medium-Term Capacity Projects

CORE CAPACITY TRANSIT STUDY

APPENDIX A
Transbay Corridor Short and Medium-Term Capacity Projects

1 Transbay Prerequisite Projects

Tier	Timeframe	Sponsor	Project
1	Short Term	AC Transit	AC Transit Richmond Facility Reopening
1	Short Term	BART	BART Additional Railcars – Fleet Transition
1	Short Term	Caltrans	I-80 Integrated Corridor Mobility
1	Short Term	TJPA	AC Transit Bus Ramp to Transbay Transit Center
1	Short Term	TJPA	Transbay Transit Center (Phase 1)
1	Short Term	WETA	WETA Maintenance Facilities Alameda, Vallejo
1	Short Term	WETA	WETA Richmond-SF Ferry Service
1	Short Term	WETA	WETA SF Ferry Terminal Expansion
1	Short Term	WETA	WETA SF Fleet Replacement & Expansion
2	Short Term	AC Transit	AC Transit Fleet Expansion (40 buses)
2	Short Term	AC Transit	AC Transit New Bus Facility
2	Short Term	BART	BART Hayward Maintenance Complex, Phase 1
2	Short Term	MTC	Bay Bridge Forward
2	Medium Term	BART	BART Additional Railcars – Core Capacity
2	Medium Term	BART	BART Metro Program
2	Medium Term	BART	BART Traction Power System
2	Medium Term	BART	BART Train Control System
2	Medium Term	BART	BART Hayward Maintenance Complex, Phase 2

2 Transbay Projects Common to All Packages

Timeframe	Sponsor	Project
Short Term	AC Transit	Increase Transbay Bus Service
Short Term	AC Transit, Soltrans	Ferry Feeder Bus Services
Short Term	WETA	Implement WETA 15-30 Minute Plan
Medium Term	AC Transit	I-580 Bus Transitway
Medium Term	AC Transit	Transbay Bus Park and Ride Facilities
Medium Term	BART	Platform Screen Doors at Montgomery & Embarcadero
Medium Term	BART	Vertical Circulation at Montgomery and Embarcadero

3 Tolls Only Specific Projects

Timeframe	Sponsor	Project
Medium Term	BATA	San Francisco Oakland Bay Bridge Automobile toll increase

4 Transit and Tolls Specific Projects

Timeframe	Sponsor	Project
Medium Term	BATA	San Francisco Oakland Bay Bridge Automobile toll increase

5 Infrastructure, Transit and Tolls Specific Projects

Timeframe	Sponsor	Project
Medium Term	AC Transit/ ACTC	Bus Tunnel from Mandela Parkway to Bay Bridge
Medium Term	AC Transit	Surface Street Transit Priority Connecting to I-80, I-580
Medium Term	BATA	San Francisco Oakland Bay Bridge Automobile toll increase

6 Contraflow, Infrastructure, Transit and Tolls Specific Projects

Timeframe	Sponsor	Project
Medium Term	AC Transit/ ACTC	Bus Tunnel from Mandela Parkway to Bay Bridge
Medium Term	AC Transit	Surface Street Transit Priority Connecting to I-80, I-580
Medium Term	BATA	Automated Toll Collection
Medium Term	BATA	San Francisco Oakland Bay Bridge Automobile toll increase
Medium Term	Caltrans	Bus Only Contraflow Lane, Westbound on Lower Deck

7 Bus Only/Bus + Carpool, Infrastructure, Transit and Tolls Specific Projects

Timeframe	Sponsor	Project
Medium Term	AC Transit/ ACTC	Bus Tunnel from Mandela Parkway to Bay Bridge
Medium Term	AC Transit	Surface Street Transit Priority Connecting to I-80, I-580
Medium Term	BATA	Automated Toll Collection
Medium Term	BATA	San Francisco Oakland Bay Bridge Automobile toll increase
Medium Term	Caltrans	HOV Bus Only/Bus + Carpool Lane with Flow, Westbound

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Appendix B: Transbay Corridor Selected Travel Demand Model Findings

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APPENDIX B
Transbay Corridor Selected Travel Demand Model Findings

1 Transbay Travel Demand Model Findings

Table 1: 2015–2030 peak-hour change in travel demand by mode

	2015 Observed Peak-Hour Trips	2030 Baseline Peak-Hour Trips	% Change
Non-HOV	4,400	10,855	148%
HOVs	6,800	10,567	55%
BART	25,000	31,679	27%
Bus	2,700	3,845	41%
Ferry	1,300	1,871	46%
Total	40,200	58,817	46%

Table 2: Mode shift from a small toll increase

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with Small Increase	% Change
Non-HOV	10,855	10,193	-6%
HOVs	10,567	10,182	-4%
BART	31,679	31,639	0%
Bus	3,845	4,076	6%
Ferry	1,871	1,846	-1%
Total	58,817	57,936	-1%

Table 3: Mode shift from a medium toll increase

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with Medium Increase	% Change
Non-HOV	10,855	9,583	-12%
HOVs	10,567	11,278	7%
BART	31,679	31,545	0%
Bus	3,845	4,288	12%
Ferry	1,871	1,858	-1%
Total	58,817	58,551	0%

Table 4: Mode shift from a high toll increase

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with High Increase	% Change
Non-HOV	10,855	8,522	-21%
HOVs	10,567	11,787	12%
BART	31,679	31,534	0%
Bus	3,845	4,536	18%
Ferry	1,871	1,832	-2%
Total	58,817	58,210	-1%

Table 5: Increase in travel demand by mode with Package 2, Transit and Tolls

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with Transit and Tolls	% Change
Non-HOV	10,855	9,579	-12%
HOVs	10,567	11,496	9%
BART	31,679	30,945	-2%
Bus	3,845	6,827	78%
Ferry	1,871	4,218	125%
Total	58,817	63,064	7%

Table 6: Increase in travel demand with Package 3, Infrastructure, Transit and Tolls

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with Infrastructure, Transit and Tolls	% Change
Non-HOV	10,855	10,178	-6%
HOVs	10,567	11,286	7%
BART	31,679	30,632	-3%
Bus	3,845	7,678	100%
Ferry	1,871	4,175	123%
Total	58,817	63,949	9%

Table 7: Increase in travel demand with Package 4a, Contraflow lane, Infrastructure, Transit and Tolls

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with Contraflow lane, Infrastructure, Transit and Tolls	% Change
Non-HOV	10,855	10,208	-6%
HOVs	10,567	11,177	6%
BART	31,679	30,490	-4%
Bus	3,845	7,229	88%
Ferry	1,871	4,192	124%
Total	58,817	63,296	8%

Table 8: Increase in travel demand with Package 4b, Bus-Only/HOV Lane, infrastructure, transit, and tolls

	2030 Baseline Peak-Hour Trips	2030 Peak-Hour Trips with Bus Only / Bus + HOV Lane	% Change
Non-HOV	10,855	9,446	-13%
HOVs	10,567	9,162	-13%
BART	31,679	29,287	-8%
Bus	3,845	6,663	73%
Ferry	1,871	3,812	104%
Total	58,817	58,371	-1%

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Appendix C: SF Metro Corridor Short- and Medium-Term Capacity Projects

CORE CAPACITY TRANSIT STUDY

APPENDIX C
SF Metro Corridor Short and Medium-Term Capacity Projects

1 SF Metro Prerequisite Projects

Tier	Timeframe	Sponsor	Project
1	Short Term	SFMTA	SFMTA Candlestick and Hunters Point Express Bus Service
1	Short Term	SFMTA	SFMTA Central Subway
1	Short Term	SFMTA	SFMTA 16th Street Corridor Transit Priority
1	Short Term	SFMTA	SFMTA Muni Forward
1	Short Term	SFMTA	SFMTA SFgo
1	Short Term	SFMTA	SFMTA T-Third Mission Bay Loop
1	Short Term	SFMTA	SFMTA Van Ness Avenue Bus Rapid Transit
2	Short Term	BART	BART Hayward Maintenance Complex, Phase 1
2	Short Term	SFMTA	SF Better Market Street
2	Short Term	SFMTA	SFMTA Fleet Expansion (light rail and bus)
2	Short Term	SFMTA	SFMTA Muni Forward Phase 2
2	Medium Term	BART	BART Additional Railcars – Core Capacity
2	Medium Term	BART	BART Hayward Maintenance Complex Phase 2
2	Medium Term	BART	BART Metro Program
2	Medium Term	BART	BART Traction Power System
2	Medium Term	BART	BART Train Control System
2	Medium Term	Caltrain	Caltrain CalMod 2.0
2	Medium Term	Caltrain	Caltrain Electrification
2	Medium Term	Caltrain	Caltrain Operations Improvements – North Terminal
2	Medium Term	SFMTA	SFMTA Transit Facilities Improvements
2	Medium Term	TJPA	Caltrain Downtown Extension

2 SF Metro Projects Common to All Packages

Timeframe	Sponsor	Project
Short Term	SFMTA	Four-Car Brannan Street Pocket Track
Short Term	SFMTA	Geary Bus Rapid Transit
Medium Term	BART	BART Glen Park Pocket Track
Medium Term	SFMTA	Adjust Policy at Embarcadero Turnback to Optimize ATCS Operation
Medium Term	SFMTA	Complete Off-Board Fare Collection on Surface
Medium Term	SFMTA	Forest Hill Policy Change to Enable Four-Car Trains in Tunnel
Medium Term	SFMTA	Platform Screen Doors at Montgomery and Embarcadero
Medium Term	SFMTA	Secure Folsom Street Portal
Medium Term	SFMTA	Vertical Circulation at Montgomery and Embarcadero

3 Surface Optimization Specific Projects

Timeframe	Sponsor	Project
Medium Term	SFMTA	Additional Surface Optimization, Building on Muni Forward
Medium Term	SFMTA	Adjust Policy to Allow 3-4 Car Trains on Surface

4 System Restructure Specific Projects

Timeframe	Sponsor	Project
Medium Term	SFMTA	Increase System Flexibility by Adding Turnbacks
Medium Term	SFMTA	Optimize M Surface Street Corridor for Four-Car Operations
Medium Term	SFMTA	Restructure Muni Metro System to Simplify Operations

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METROPOLITAN TRANSPORTATION COMMISSION

SEPTEMBER 2017