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An Assessment of Opportunities for Bus Rapid Transit in the San Francisco Bay Area

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ABSTRACT

This report presents the findings from an investigation of opportunities to implement bus rapid transit systems in the San Francisco Bay Area with a focus on bus transit routes that travel on the state's highway system. A primary component of this project has been the consideration of inter-connectivity and regional aspects of bus rapid transit systems deployment in the Bay Area. We examined approximately 200 bus transit routes in the Bay Area that lie on the state highway system from which five routes were identified as likely candidates for bus rapid transit implementation. Two of the five routes ─ VTA's Line 22 and SamTrans' Lines 390/391 ─ were selected for follow-up case study analysis because they involve bus routes on the same roadway, SR 82, which includes not only multi-jurisdictional issues by including two counties and numerous local cities, but also two transit properties making this selection uniquely qualified to consider inter-connectivity and regional aspects of bus rapid transit systems deployment in the Bay Area. .

Bus rapid transit activities are underway along the SR 82 corridor in the context of two distinct enterprises corresponding to VTA's plans for the new route 522 in Santa Clara County and SamTrans' plans for enhancement to transit service for its Route 390 in San Mateo County. These two systems' primary connection point is the Palo Alto Transit Center for which enhancements are being planned. From a macroscopic perspective, the level of cross-county travel, both current and forecasted, does not now warrant development of a single and integrated BRT corridor between Santa Clara and San Mateo counties and into San Francisco County. Nonetheless, whether a single integrated corridor or two-system solution is eventually selected to satisfy levels of service needs, institutional cooperation and coordination is a continuing essential component to the transportation system along the peninsula of the Bay Area. We recommend that the two-system solution be maintained together with continued development of the Palo Alto Intermodal Transit Center while simultaneously initiating a comprehensive data collection effort together with an evaluation to fully understand the tradeoffs between these two alternatives coupled with more accurately determining the level of inter-county demand.

Key Words: bus rapid transit, state route system, San Francisco Bay Area

EXECUTIVE SUMMARY

This report constitutes the final deliverable for PATH Project RTA 20829 under contract 65A0141 — "Assessing Opportunities for Bus Rapid Transit in the San Francisco Bay Area". The project has examined opportunities for implementing bus rapid transit systems in the San Francisco Bay Area by performing a review of bus rapid transit activities, analyzing bus transit on state routes in the Bay Area, selecting candidate bus rapid transit corridors for potential follow-up investigation, and performing a corridor-specific case study on two of these selected candidate corridors.

In this study we focused on bus transit routes that travel on the California state highway system, whether arterial roadways or freeways and took a more top-down approach than what is customarily done where the initiative is taken by a local and/or regional transit property to determine the feasibility of and potential impacts associated with bus rapid transit within its jurisdictional boundaries, e.g., intra-county, through the transportation planning process. A primary component of this project was to consider the inter-connectivity and regional aspects of bus rapid transit systems deployment in the San Francisco Bay Area region. Considering state routes assisted the team in identifying more regional opportunities for partnerships to help address unmet public transit service needs across jurisdictional boundary lines.

We initially identified approximately 200 Bay Area bus transit routes on the state highway system and examined these routes relative to a set of BRT-related attributes that essentially served as filters to subsequently select a small number of bus transit routes with a high potential for upgrading to BRT status. As part of the analysis, we looked at the length of the bus transit routes that travel on state routes, service characteristics related to schedule and route structures based on passenger demand level, external factors, bus routes that function essentially as one service, and level of passenger demand. At the conclusion of this process, we were left with the following five bus routes each with average weekday ridership greater than 7,000 passengers:

1. AC Transit routes 82-82L on SR 185 (Telegraph Av/International Blvd./E. 14th St)
2. AC Transit routes 72-72M-72R on SR 123 (San Pablo Avenue)
3. Sam Trans routes 390 & 391 on SR 82 (El Camino Real)

4. Santa Clara VTA route 22 on SR 82 (El Camino Real)
5. SF Muni's route 9X on US 101 (San Bruno Express)

These five candidate corridors very closely match ongoing bus rapid transit corridor activities in the San Francisco Bay Area. Thus the different approach taken in this project to identify bus route corridors on state routes with a high potential to be upgraded to BRT systems has led us to basically the same corridors that have already been selected by the more traditional approach taken directly by transit agencies. For follow-up investigation, we selected the two bus routes on SR 82 ─ VTA's Line 22 and SamTrans' Lines 390/391 ─ in the western and southern portions of the San Francisco Bay Area. This has led to multi-jurisdictional issues by including not only two counties and numerous local cities, but also two transit agencies.

California State Highway 82 traverses Santa Clara and San Mateo Counties with a northern terminus just at the southern outskirts of San Francisco while in the south, it begins in the proximity of Gilroy near US 101 and SR 152 known for much of its route as El Camino Real and forms an alternative to US 101 and I-280 between San Jose and San Francisco. The total length is approximately 52 miles and it traverses two counties: Santa Clara and San Mateo.

The case study corridor comprises the primary portion of the urbanized areas of San Mateo and Santa Clara Counties. VTA's Line 22 is 27 miles long of which 15 miles is situated on California State Route 82. Line 22's northern and southern termini are, respectively, the Menlo Park Caltrain Station (in San Mateo County) and the Eastridge Transit Center in the city of San Jose. SamTrans's Lines 390 and 391 range from approximately 27 to 34 miles in length, respectively, of which 25 miles is situated on SR 82 Bus Route 390 encompasses the corridor from the Palo Alto Caltrain Station in the south (Santa Clara County) to Daly City in the north while bus route 391 traverses the corridor from the Redwood City Caltrain Station in the south to San Francisco in the north.

There are infrastructure and service assets along SR 82 corridor that contribute to understanding opportunities for a successful bus rapid transit system here. Infrastructure assets include both roadway and rail assets; Roadway assets include U.S. 101 and Interstate 280; rail assets include

the Altamont Commuter Express, Bay Area Rapid Transit, Caltrain, and Santa Clara Valley Transportation Authority's light rail transit line. Service assets include regional express bus lines, especially in San Mateo County.

There are new corridor activities that also need to be examined when taking in the full measure of opportunities to implement bus rapid transit along the SR 82 corridor. Such activities include a plan to implement a regional express bus service plan and a rapid bus proposal, in areas overlapping with the corridor, the Silicon Valley Rapid Transit corridor (BART extension to San Jose), plans for the El Camino Real Grand Boulevard in San Mateo County, and Caltrain's Baby Bullet express service.

Line 22 and Line 390 buses all meet at the Palo Alto Transit Center in the northern part of Santa Clara County. There is schedule coordination between VTA and SamTrans, for Lines 22 and 390 mainly during the off-peak periods when headways are likely to be approximately one hour. An important aspect of ongoing linkages and coordination between VTA and SamTrans is the extent of transfer volume activity between VTA's Line 22 and SamTrans' Line 390. While precise numbers are not known because the needed studies to quantify cross agency transfers have not been conducted, it is generally felt that the level of transfer activity between Lines 22 and 390 is not insignificant.

The Santa Clara County Valley Transportation Authority is currently in the construction phase of implementing a BRT system along SR 82, while San Mateo County Transit District is at a considerably earlier stage of BRT development along SR 82. VTA is implementing numerous improvements by providing features, including passenger information at stops, queue jump lanes at congested locations, transit signal priority along the corridor for buses to reduce bus travel time, and high capacity buses. SamTrans is currently studying the potential impacts of transit signal priority systems along Line 390. Because both San Mateo and Santa Clara counties are each individually moving toward implementing enhanced bus transit services along SR 82, it is implicit from these individual developments that there is sufficient demand to implement bus rapid transit systems on SR 82 within each of these two counties. Moreover, development plans for bus rapid transit by VTA and SamTrans have proceeded fairly independently of each another.

We determined that in terms of county-to-county travel, it appears as though inter-county travel demand may not be sufficiently large ─ either currently or forecasted to the year 2030 ─ to warrant a single integrated bus rapid transit line traversing the Bay Area's peninsula counties without additional more microscopic investigations at the corridor level.

The Palo Alto Transit Center is currently the primary transfer point between VTA (Line 22) and SamTrans (Line 390) and would likely continue in this role between VTA's new BRT line and SamTrans' Enhanced Bus Service.

A corridor-wide bus rapid transit system could be implemented by 1) establishing a single integrated system or 2) maintaining already existing separate services including a transfer at the Palo Alto Transit Center. The former would likely bring into play numerous institutional stakeholders along the corridor with a diverse and potentially conflicting set of priorities that would have to be reconciled. The latter would necessitate a continued focus on the transfer process to make it as seamless as possible to minimize adverse travel behavior due to penalties associated with various actions required of passengers during the transfer process, such as out-of-vehicle waiting time.

Based on peninsula-area transportation developments over the past five years, there is consensus to continue maintaining separate county-wide enhanced bus transit services along SR 82 coupled with redevelopment plans to transform the Palo Alto Transit Center into a major intermodal transportation hub on the peninsula. If fully implemented, these plans have the potential to greatly contribute to providing a seamless connection among the various transit alternatives that converge at the Palo Alto Transit Center, in particular, between the VTA and SamTrans bus rapid transit/enhanced bus systems.

The primary challenges to implementing bus rapid transit along the El Camino Real corridor in San Mateo and Santa Clara Counties deal with funding issues and institutional coordination. As a result of each county's separate development efforts in addition to plans for redevelopment of the Palo Alto Transit Center, a bus rapid transit system along the El Camino Real corridor in San Mateo and Santa Clara counties is, de facto, being implemented. Each county's efforts are

progressing in an incremental and step-by-step fashion. While plans have been developed for these separate systems as well as for their primary interface at the Palo Alto Intermodal Transit Center, all funding sources have not been identified and so full funding has not yet been secured for these projects.

To help increase the likelihood that inter-county bus rapid transit service will be successful, focus will have to be placed on making the connection between SamTrans' and VTA's BRT service at the Palo Alto Transit Center as seamless as possible. Schedule coordination will likely have to be enhanced and fare coordination should be considered as well to foster the trip's seamlessness.

The case study analysis has shown that there are two primary alternatives for implementing bus rapid transit along the El Camino Real corridor of SR 82: 1) Two-system solution joined as seamlessly as possible at the Palo Alto Intermodal Transit Center and 2) A single integrated system. When planning for the implementation of bus rapid transit in either of these two contexts, the two transit agencies ─ VTA and SamTrans ─ and Caltrans will, at a minimum, play primary roles.

It is recommended that the simpler and more conservative approach be taken and maintain the two-system solution, while simultaneously conducting a thorough evaluation to fully understand the tradeoffs between these two alternatives coupled with more accurately determining the level of inter-county demand.

In the context of rail transportation in the Bay Area, multi-county regional partnerships have been established and successfully maintained to help satisfy previously unmet transit service needs. These partnerships have established a precedent for institutional arrangements that may be considered for use in the case of regional/express bus transport along the SR 82 corridor as well as along other corridors. Tradeoffs must also be recognized and expected among the number of participating organizations/stakeholders and the extent of customer benefits and complexity of institutional issues.

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1.0 PROJECT OVERVIEW

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1.1 Motivation

Bus rapid transit (BRT) systems are commonly viewed as an alternative travel mode to help make bus transit more attractive by enhancing customer level of service with an ultimate goal of increasing ridership that contributes to relieving traffic congestion. The implementation of bus rapid transit in both northern and southern California has steadily grown in popularity with transit properties over the course of the last seven years since leadership at the federal level in this area began with the formation of the U.S. BRT Consortium by the Federal Transit Administration. Originally, three California transit agencies were selected as members of the Consortium, consisting of

- Alameda Contra-Costa County Transit District (AC Transit)
- Los Angeles County Metropolitan Transportation Authority (MTA)
- Santa Clara Valley Transit Authority (VTA)

In southern California, the San Diego Metropolitan Transit System, Riverside Transit Agency, Omnitrans (San Bernardino County), and the Orange County Transportation Authority have all conducted bus rapid transit-related studies in their respective regions and are in various stages of implementation. In northern California, BRT-related endeavors have expanded beyond Santa Clara VTA and AC Transit and now include San Mateo County Transit District (SamTrans), the San Francisco Municipal Railway (MUNI) in the Bay Area and Sacramento Regional Transit

District in the Sacramento region. These are summarized in Table 1. Full details are provided in Appendix A on the status of these transit agencies' bus rapid transit system enterprises from a deployment perspective.

TABLE 1 Bus Rapid Transit Enterprises in California

Transit Agency	Location of Corridor(s)	Current Status
AC Transit	San Pablo Ave. (SR 123)	Operational
AC Transit	Telegraph Ave./E. 14th Street/International Blvd (SR 185)	Planning Phase
Los Angeles County MTA	Wilshire and Ventura Boulevard Lines plus eight others	Operational
Los Angeles County MTA	Orange Line (San Fernando Valley)	Under construction
Los Angeles County MTA	Ten corridors criss-crossing the county	Planning Phase
Metropolitan Transit Development Board/SANDAG	Showcase Project: San Diego CBD to San Diego State University	Planning Phase
Orange County Transportation Authority	Harbor and Westminster Boulevards	Planning Phase
Riverside Transit Agency	Magnolia Avenue	Feasibility study
Sacramento Regional Transit	Stockton Boulevard	Operational
San Bernardino (OMNITRANS)	'E' Street	Planning
Santa Clara VTA	El Camino Real (SR 82)	Under construction
San Francisco MUNI	Van Ness Avenue (US 101)	Planning Phase
San Francisco MUNI	Geary Boulevard	Planning Phase
San Francisco MUNI	Potrero Avenue	Under study
San Mateo (SamTrans)	El Camino Real (SR 82)	Field testing and evaluation
Santa Monica Big Blue Bus	Lincoln Boulevard	Operational

The implementation of bus rapid transit for the above referenced systems provides examples of the customary planning approach used when implementing new transit systems. The initiative is taken by a local and/or regional transit property to begin a process of studying the feasibility of and potential impacts associated with bus rapid transit within its jurisdictional boundaries, e.g., intra-county. The means through which these investigations are conducted include Major Investment Studies as well as other types of alternatives analyses.

This project is motivated by a desire to expand beyond this intra-jurisdictional approach to consider more of the inter-connectivity and regional aspects of bus rapid transit systems deployment in the setting of the San Francisco Bay Area. This will help identify more regional opportunities for innovative types of partnerships to help address unmet public transit service needs across jurisdictional boundary lines.

The San Francisco Bay Area was selected primarily because of the rather unique features associated with its public transportation system and the opportunities these offer for developing alternative strategies to foster deployment of bus rapid transit. The Bay Area consists of nine counties and 100 cities with 6.8 million people residing within its 7,000 square miles. There are over two dozen transit properties, seven of which are primary ones[1] that together carry an average weekday ridership of about 1.5 million people. Its transportation network is diverse and multi-modal, traveled by single-occupancy vehicles, high-occupancy vehicles such as vanpools and buses, other motorized vehicles and bicycles, as well as light rail, rapid rail, and commuter rail transit, cable cars, ferries, and bus rapid transit. This will help identify more regional opportunities for innovative types of partnerships to help address unmet public transit service needs across jurisdictional boundary lines.

1.2 Objectives

The overall objective of this project is to identify and study those bus route corridors on state routes that have a high potential for being upgraded into bus rapid transit corridors in the San Francisco Bay Area. The selection of bus routes traveling at least a part of their run on state routes will help identify more regional opportunities for innovative types of partnerships to help address unmet public transit service needs across jurisdictional boundary lines.

1.3 Contents of the Report

This is the first of six sections. Section 2 provides a review of planning and implementation issues of bus rapid transit systems from the literature. Section 3 discusses institutional issues associated with bus rapid transit systems implementation and Section 4 offers a summary of findings from research already performed earlier in the project; the corridor-specific case study is presented in Section 5 followed in Section 6 by an exploration of bus rapid transit and light rail transit. Finally, conclusions are presented in Section 7.

[1] BART, AC Transit, SamTrans, Santa Clara VTA, MUNI, Golden Gate Bridge, Highway, and Transportation District, and Caltrain.

2.0 BUS RAPID TRANSIT: SYSTEMS, PRACTICES, AND IMPLEMENTATION ISSUES

For purposes of this project, we use the following definition of bus rapid transit taken from the recently completed Transit Cooperative Research Project A-23 (1 and 2):

"A flexible, rubber-tired form of rapid transit that combines stations, vehicles, services, running ways, and intelligent transportation systems into a fully integrated system with a strong image and identity. BRT applications are designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments (from rights-of-way totally dedicated to transit to streets and highways where transit is mixed with traffic."

Running ways for BRT include mixed traffic lanes, curbside bus lanes, and median busways on city streets; reserved lanes on freeways; and bus-only roadways, tunnels, and bridges. Most stations are located curbside or on the outside of bus-only roadways and arterial median busways. Similarly, BRT stations have low platforms since many are already or will eventually be served by low-floor buses. Conventional standard and articulated diesel buses are in wide use for BRT operations, though, there is a trend toward innovations in vehicle design, including environmentally clean or green vehicles, such as diesel-electric vehicles and compressed natural gas-fueled vehicles, dual mode operations in particular environments such as tunnels, low-floor buses, additional as well as wider doors, and use of distinctive and dedicated bus rapid transit vehicles. Service innovations include fare collection procedures, station design and location, and more attractive vehicle designs. Intelligent transportation systems range from existing and more customary automatic vehicle locations systems, transit signal priority systems, and passenger information systems to more advanced systems including collision warning systems (frontal, side, and rear), and automation technologies including lane assist systems — precision docking and automatic steering systems — and automatic speed and spacing control systems.

The *earliest* deployments of automation technologies in road vehicles will likely be on heavy vehicles — *buses* (and trucks) — operating on their own special rights-of-way because:

- It is easier to develop and acquire rights-of-way for public purposes like transit service

- In some cases, buses already operate on separate facilities, which could, if demand warranted, be switched over to automation
- Costs of the technologies are a smaller percentage of total bus costs and buses are used much more intensively so these costs are amortized faster
- Benefits in travel-time reduction, trip reliability and safety can be translated more directly into cost savings and revenue increases than for private passenger cars
- Customized, small-lot production of vehicles makes it possible to introduce automation technologies into the bus production process faster than for automotive mass production
- Packaging of new technological elements is easier on buses than on passenger cars
- Buses already have more onboard electronic infrastructure (such as data buses and electronic engine controls) to use as a foundation for more advanced capabilities than passenger cars
- Maturing technologies can be used more safely by professionally trained bus drivers on professionally maintained buses than by the general public on passenger cars that may not be well maintained (3).

For the remainder of this section, we describe the four primary components and tradeoffs among them that are essential in the deployment of bus rapid transit systems:

- Technology aspects: What technologies will the system be comprised of?
- Design attributes: What will the system look like
    - On its vehicles (interior, exterior)
    - At its stops and stations, and
    - On the roadway?
- Operational and service plans: How will the system operate and what services will it deliver to passengers?
- Implementation issues: What, if any, are the conflicts among stakeholders arising from decision-making and actions taken relative to planning for and implementing a bus rapid transit system?

2.1 Technology Aspects

There are several technological systems that may be involved in the implementation of bus rapid transit systems. They include advanced public transportation systems, collision warning systems, transit signal priority systems, precision docking and automatic steering control systems, and automatic speed and spacing control systems.

2.1.1 Advanced Public Transportation Systems

These systems may be split among those that are operations oriented such as fleet management, e.g., automatic vehicle location (AVL) systems and automatic passenger counters, and electronic fare payment systems and customer/passenger oriented, namely passenger information systems. AVL systems automatically determine and track the real-time geospatial location of a bus. Several different technologies may be used to perform AVL, such as GPS, ground-based radio, signpost and odometer, dead-reckoning, and combinations of these. Automatic passenger counters are devices that count passengers automatically as they board and alight transit vehicles, typically buses. Most common technologies include treadle mats or infrared beams. Electronic fare payment systems provide an electronic means of collecting and processing fares. Customers can use a magnetic stripe card, smart card, or credit card instead of tokens or cash to pay for transit trips. Smart cards have the ability to store monetary value and other information on an embedded integrated circuit or micro-chip.

2.1.2 Collision Warning Systems

Collision warning systems could augment the driver's normal driving and could provide alerts to hazards of which he may be unaware, and could also help out in conditions in which the driver is distracted or less than fully alert, e.g., due to fatigue. Such systems may take the form of forward, rear, and side hazard warnings and can be delivered to the driver by either auditory, haptic[2], or visual cues. The driver retains responsibility for corrective actions based on the warnings provided. Technologies that may be used in these systems include radar, ultrasound or laser sensors and threat assessment software and the driver interface. Benefit opportunities include a reduced risk of property damage, injuries, and fatalities; reduced liability and vehicle repair expenses; improved vehicle utilization, and improved rider/passenger perception of bus performance. The primary incremental cost generator is for the installation of warning systems on vehicles.

[2] Of or relating to or proceeding from the sense of touch

2.1.3 Transit Signal Priority Systems

Transit signal priority systems in its simplest form makes it possible for a bus approaching an intersection during the final seconds of the green signal cycle to request an extension of the green cycle so that the bus can pass through before the signal turns red, thereby saving the bus and its passengers the red cycle time. This tends to provide some ancillary time saving benefits to the other vehicles traveling in the same direction as the bus, while increasing the time delays to the crossing traffic. Technologies that may be utilized include vehicle detection, identification, and location systems to identify a bus and communicate to a roadside signal controller cabinet, Global Positioning Systems (GPS), Differential GPS, dead-reckoning for vehicle positioning, and wireless communication. Benefit opportunities include reduced travel time for passengers, higher utilization of the bus fleet, improved schedule adherence (assuming a schedule-based operational policy), and improved service effectiveness in terms of passengers per revenue hour or mile). Incremental cost generators include vehicle and roadside equipment such as vehicle detection systems, signal controllers, and wireless communication systems, and added delays to cross street traffic (4).

2.1.4 Electronic Guidance Systems

Electronic guidance systems consist of precision docking systems and automatic steering systems.

Precision docking systems involves the low-speed positioning of buses relative to the curb or loading platform at bus stops and/or stations under the direct bus driver supervision. The lateral position of the bus is precisely controlled with 1to 2 cm. tolerances. Technologies that may be utilized include roadway magnetic marker sensors or visual/optical sensing systems with an electronically-controlled steering actuator. The benefit opportunities associated with precision docking include reduced bus dwell times, saving time for both passengers and fleet operators; a safer and easier boarding and alighting for handicapped/disabled passengers; less wear and tear on bus tires resulting from scuffing at curbs; reduced level of driver stress; and enhanced comfort for passengers. Incremental cost generators include electronically-controlled steering actuator, lateral-position sensing system, and reference markings at bus stops/ stations.

Automatic steering systems enable buses to stay centered in their traveling lane. Typical technologies include roadway magnetic marker sensors, vision/optical sensing systems with an electronically-controlled steering actuator. Benefit opportunities include the ability to operate buses in narrower lanes, thereby saving rights-of-way (ROW) and construction costs, enabling operations in locations that would be too narrow for conventional buses, a smoother lateral ride quality, and reduced driver stress. Incremental cost generators include electronically-controlled steering actuator, lateral position sensing system, and reference markings along the vehicle lanes (3).

2.1.5 Automatic Speed and Spacing Control Systems

Automatic speed and spacing control systems have vehicle speed under automatic control rather than under manual or driver control. Vehicles can be operated very close together due to the spacing control. Typical technologies include forward ranging sensors such as radar or laser systems, electronic control of the engine and brakes, and vehicle-to-vehicle data communication systems. Benefit opportunities include an enhanced bus capacity using bus platoons (from close spacing), smooth ride quality for passengers, and a reduction in fuel consumption and level of emissions. Incremental cost generators include sensing and communication devices and electronic brake control actuators (3).

2.2 Design Attributes

Design attributes of bus rapid transit systems deal with the physical attributes of the system, namely, the vehicle and the infrastructure, that is, the bus and both the running way and bus stops and stations, respectively. Running ways for BRT may be on- or off-street in nature. Generally on-street BRT running ways provide downtown and residential distribution, and serve corridors where market factors, costs, or right-of-way availability preclude providing busways (or reserved freeway lanes) (1 and 2).

2.2.1 Running Ways

On-street running ways, which are various in type may be the first stage of future off-street BRT development and establish ridership during an interim stage. BRT operations that are implemented in *mixed traffic flow* can be readily implemented at minimum cost; however, it places buses under normal conditions of everyday traffic, including its delays. Yet even in this situation, BRT operations may still have a sense of BRT identity. For example, in Los Angeles, the Metropolitan Transportation Authority has currently implemented its bus rapid transit system — *Metro Rapid* — on five corridors with very distinctive red and white buses and similarly colored bus stops along each of the corridors. Another type of running way is *concurrent flow curb bus lanes* that are easy to install with low costs and they minimize the street space devoted to BRT. They are, however, usually difficult to enforce and are the least effective in BRT travel time saved. Conflicts between right turning traffic and pedestrians may delay buses. *Contra-flow curb lanes* enable buses to operate two-way on one-way streets, may increase the number of curb faces available for passenger stops, completely separate BRT from general traffic flow, and are generally self enforcing. However they may disperse BRT onto several streets, thereby reducing passenger convenience. They require buses to run against the prevailing traffic signal progression; limit passing opportunities around stopped or disabled buses (unless multiple lanes are provided); conflict with opposing left turns; and may create safety problems for pedestrians. *Concurrent flow interior bus lanes* remove BRT from curbside frictions; allow curb parking to be retained; and far side bus "bulbs" at stops for passenger convenience. However, they generally require curb-to-curb street widths of 60 to 70 feet, and curb parking maneuvers could delay buses. *Median arterial busways* physically separate the BRT running ways from general traffic, provide a strong sense of BRT identity, eliminate conflicts between buses and right turning cars, and can enable the busways to be grade separated at major intersections. However they require prohibiting left turns from the parallel roadways, or providing special lanes and signal phases for these turns. They also require wide streets – generally more than 80 feet curb-to-curb, and their costs can be high. *Bus-only streets* remove BRT from general traffic, increase walking space for pedestrians and waiting space at stations, improve BRT identity, and improve the ambience of the surrounding areas. They need, however, nearby parallel streets for the displaced traffic, and provisions for goods delivery and service access from cross streets or off-street. They are generally limited to a few city blocks (1 and 2).

Off street BRT running ways for "line-haul" BRT operations can permit high speeds and minimize traffic interferences. A desirable goal is to provide as much of the BRT route mileage in reserved freeway lanes or special busways as possible. The following considerations should underlie BRT development in special bus-only roads and in freeway corridors.

2.2.2 Stations and Stops

Most stations are located curbside or on the outside of bus-only roadways and arterial median busways. Similarly, BRT stations have low platforms since many are already or will eventually be served by low-floor buses.

Bus stops, stations and terminals, and associated facilities such as park-and-ride lots, form the interface between passengers and the BRT system. They should be permanent, weather-protected facilities that are convenient, comfortable, safe, and accessible to disabled passengers. These facilities should support a strong and consistent identity for BRT in the community, while respecting and enhancing the surrounding urban context.

BRT facilities should be viewed as urban-design assets. Integration of a BRT guideway into an urban setting presents an opportunity to improve and enrich streetscapes by incorporating new amenities such as landscaping and recreational trails. Because guideway construction may displace lighting, sidewalks and street furniture, these elements can and should be reconstructed or replaced so as to reinforce new, unified design themes.

Station development calls for high quality designs and passenger amenities, establishing consistent themes of form, material and color for stations and other BRT elements, having context-sensitive design and relating BRT stations to adjacent land uses. Other key BRT station concepts and guidelines include: Providing a full range of amenities at stations including shelters, passenger information, telephones, lighting and security provisions, designing for station access by disabled customers, providing a consistent pattern of station location, configuration and design to the maximum extent practical, separating BRT, local buses, automobiles and pedestrian movements in station design, coordinating station platform design with vehicles and fare collection policies, having station configurations support the service plan and operating philosophy of the BRT route, providing bypass capabilities where express and local BRT services are provided on the same running way, sizing station berths, platforms, and access facilities to serve expected riders without overcrowding or spillback, to provide capacity for future growth, and to achieve reasonable levels of service, increasing berth capacity by fostering fare prepayment and or multi-door boarding, developing station locations and designs cooperatively with the surrounding community, providing far-side stops where running ways cross streets at grade, providing convenient transfers between BRT and intersecting transit routes. Placing BRT and local bus stops in separate areas where both services use a common route, but allow for convenient transfers among them, and allowing independent bus arrival and departures at major transit centers and bus terminals for routes that terminate at the station (1 and 2).

2.2.3 Buses

Conventional standard and articulated diesel buses are in wide use for BRT operations, though, there is a trend toward innovations in vehicle design, including environmentally clean or green vehicles, such as diesel-electric vehicles and compressed natural gas-fueled vehicles, dual mode operations in particular environments such as tunnels, low-floor buses, additional as well as wider doors, and use of distinctive and dedicated bus rapid transit vehicles. Service innovations include fare collection procedures, station design and location, and more attractive vehicle designs.

BRT vehicles should be carefully selected and designed because of their impacts on travel times, service reliability and operating/maintenance costs; their impacts on the environment, and their identity and appeal to passengers. They should be customized for the markets that they will serve. They should use body styles and propulsion systems that have been proven in revenue service. Among the desire features of BRT vehicles include the following: Buses should provide sufficient passenger capacity for expected ridership levels. They may be standard 40-foot or articulated 60-foot buses for mainline service, or smaller buses for collector/distributor service.

Vehicles should be easy for boarding and alighting achievable by using low-floor buses with floor heights 12 to 15 inches above street level and wide, multi-use doors. Buses using high-platforms at stations can also speed boarding, but they may require the use of precision docking systems. A sufficient number of doors should be provided, especially where coordinated with off-vehicle fare collection. Generally, about one-door channel should be provided for each 10-feet of vehicle length (two double-stream doors for a 40-foot bus). Providing doors on both sides of buses (as with light rail vehicles) enables both center island and side station platforms to be used. Internal vehicle design generally should maximize the number of people each bus can carry, rather than the number of seated passengers. This is less relevant for routes with long person-trips where vehicles should accommodate as many seated passengers as possible. Wide aisles should be provided to maximize internal circulation space. The minimum aisle width of 34 inches available on some specialized BRT vehicles is preferable to the 24-inch width used on most North American buses. Bus propulsion systems should be "environmentally friendly" by minimizing air pollution and noise. Conventional diesel buses can reduce emissions by using catalytic converters and ultra-low sulfur fuel. Other low-pollution options include compressed natural gas (CNG) diesel-electric hybrids, electric trolley buses, and dual-mode trolley/diesel propulsion. Vehicles should have a distinctive BRT identity and image that should be clearly marked and recognizable to convey the BRT theme. Ideally, BRT routes should only be served by dedicated BRT vehicles. Vehicles should have a high passenger appeal and give passengers a comfortable ride with desirable features including air conditioning, lighting, panoramic windows, automated station announcements, and upholstered seats. Vehicles should be reliable with a long mean distance between failures. Life service costs should be reasonable, both to acquire and operate. Conventional articulated buses cost about $400,000 to $600,000 and have a 12-15 year design service life as compared to some of the BRT "purpose built" vehicles that cost about $1,000,000 with an 18-25 year design life. Existing BRT vehicles range from conventional single unit and articulated buses to "special purpose" vehicles that resemble light rail vehicles. They include articulated low floor vehicles (conventional) and specialized BRT vehicles. BRT vehicles may also have automated, multi-axle rear-wheel steering systems that permit precision docking at stations (1 and 2).

2.3 Operations and Service Planning

Bus rapid transit system service should be clearly marked to customers, direct, frequent and rapid. Fare collection should permit rapid boarding of buses. Service patterns and frequencies should reflect the types of running way, city structure, potential markets, and available resources. Buses may run totally or partially on dedicated rights-of-way when such running ways are available. Service should be simple, easy to understand, direct, and operationally efficient. Providing point-to-point one-seat rides should be balanced against the need for easy-to-understand high frequency service throughout the day. It is generally better to have few high frequency BRT routes than many routes operating at long-headways. The busway route structure should include a combination of basic all-stop service that is complemented by express (or limited stop), feeder and connector service. The all-stop service can run all-day, from approximately 6 AM to midnight, seven days a week, and the express service should operate weekdays throughout the day, or just during morning and afternoon peak periods. The basic BRT all-stops service should operate at 5 to 10 minute intervals during morning and afternoon peak periods and 12 to 15 minute intervals at other times.

BRT running ways may be used by all transit operators in a region where vehicles meet established safety requirements. They can share running ways with high-occupancy vehicles in reserved freeway lanes, where the joint use does not reduce travel times, service reliability, and BRT identity. Running times and average operating speeds should be maximized by providing wide station spacing and by reducing dwell times at stops. Fares should be integrated with the rest of the bus system, but they may not necessarily be the same. Fare collection systems should facilitate multiple door boarding, at least at major stops during busy periods. Off-board collection (preferred) or on-board multi-point payment should be encouraged. Marketing should emphasize the unique features of BRT such as speed, reliability, service frequency and span, and comfort. It should create a unified system image and identity that clearly "brands" BRT. Distinctive logos, color combinations and graphics should be applied to vehicles, at stations and on printed materials (1 and 2).

3.0 BUS RAPID TRANSIT: INSTITUTIONAL AND POLICY ISSUES

The previous section has thus far has focused on the more technical, design, and operational aspects of bus rapid transit systems, ranging from system requirements, available technologies and practices, system architecture, and simulation tools for system testing and evaluation. The implementation of bus rapid transit systems traverses numerous stages of system design, development, testing (simulation and field), evaluation, and deployment culminating in a completed and fully operational system. Moreover, all these activities take place in a context with organizational stakeholders participating at various levels. As each stage of BRT implementation proceeds through its more technological, design, and operational aspects, questions may arise concerning the impacts of actions to be taken or decisions to be made. These impacts are often of a non-technical nature and are referred to as institutional issues. Such less technical or operational questions and issues resulting from them need to be considered and addressed as well to successfully implement a bus rapid transit system.

All field-deployed bus rapid transit systems will not necessarily experience the same set of institutional issues because each BRT deployment will be affected by local and regional factors. Moreover, even when the same issues arise in different settings, there will likely be local and regional site-specific differences. The importance of identifying and working out such issues should not be underestimated as they contribute to the overall success of implementing bus rapid transit systems in terms of how transit operations and quality of service for passengers are enhanced.

When planning for the deployment of bus rapid transit systems, there are, at a minimum, two distinct types of stakeholders playing primary roles. One is the local and/or regional transit agency whose interest lies foremost in reducing its own costs while also enhancing the quality of transportation services that it delivers to its passengers. The other primary stakeholder is the local and/or regional highway and traffic department along the route the transit agency's bus runs and this latter stakeholder could include multiple operators depending on whether the bus runs through multiple political jurisdictions. Other stakeholders can certainly include the regional metropolitan planning organization, the state department of transportation, federal transportation agencies, e.g., Federal Transit Administration and Federal Highway Administration, various local public officials and/or decision makers, and the general public. The significance of these stakeholders' roles and influence depends on local and regional conditions encompassing the bus route/traffic corridor where the bus rapid transit system is to be implemented (5, 6, and 7).

3.1 Integration of Multiple Priorities, Objectives, and System Requirements

The multi-jurisdictional or multi-stakeholder element can make the process of decision-making and implementation more complex as each stakeholder usually brings its own philosophies, priorities, and agendas. In particular, the two primary stakeholders — the transit agency and the highway and traffic department — will have their own ideas on specifying requirements that BRT systems need to satisfy and there may be concurrence as well as differences between these sets of requirements. Achieving consensus, let alone agreement, among all affected stakeholders, whether political jurisdictions or other transportation organizations may at times prove to be a challenging and possibly difficult task. To have a system that works effectively requires the transit agency to achieve agreement with localities and other agencies on infrastructure, operations, and assignment of responsibilities. However, the primary objectives of transit agencies, to provide high-level, high-quality service for their customers at minimum cost, may conflict with the objectives of highway and traffic agencies whose performance is often judged more on enhancing vehicle-moving than people-moving capacity. These often-competing objectives can complicate the implementation of bus rapid transit strategies and may require significant coordination and cooperation if multiple highway and traffic agencies are involved.

3.2 Introduction of New Technologies

Institutionally, there may be concerns over the use of new technologies regarding their complexity and reliability. Moreover, there will need to be coordination on the selection and implementation of new technologies determining whether or not they should be selected to meet the needs of multiple stakeholders and how this could complicate BRT deployment. Insufficient understanding of the "state of the art" of technologies and how they can be used in BRT operations also needs to be recognized and addressed.

3.3 Organizational Adaptation to Bus Rapid Transit Implementation

Implementation issues may arise not only between organizations such as transit agencies, political jurisdictions and traffic operators, but also internally within individual organizations. Concerns over preferences in funding and use of scarce resources, the delegation of additional staff responsibilities could result in intra-organizational resistance and morale issues. Unless there are additional funding sources available, increased spending on one route will usually mean decreased funding on others.

Bus rapid transit systems may require additional resources to support the service offered. Additional operations, new technologies, retrofitted/new vehicles, and new infrastructure will likely require training and maintenance. Achieving agreement on roles and responsibilities may be difficult if employees are merely required to shoulder additional duties and responsibilities for BRT without additional compensation or support.

Many agencies will need additional time to identify and integrate best industry practices for BRT. Even then, identifying and attempting to accommodate an agency's departments' needs may cause internal discord. As new strategies may affect the duties of staff, it is vital that they are consulted and strategies are selected with staff concerns in mind.

3.4 The Political, Legislative, and Regulatory Arena

At each stage in the process of implementing BRT, decision-making stakeholders are involved in a variety of ways that impact the specific deployment path a particular bus rapid transit system will take. The decision-makers are by definition major players in the political arena that govern the local jurisdictions in which the BRT would operate. The commitment to BRT by such major players is of crucial importance to its success.

To establish and sustain a high level of interest and commitment to BRT will likely require a political champion. Whether it is an individual or organizational entity, a political champion would aid in coalition building and sustaining interest in BRT when interest could expand and diminish over time. The strength and capability of a political champion would help determine if the project can withstand voices of opposition arising from various quarters, for example, the local business community or local residents. However, gaining such championing decision-makers often requires proof of the operational and quality-of-service benefits of BRT, but political support is usually required first to perform the testing that could result in the quantifiable benefits. Here we encounter the chicken-or-the-egg dilemma. One way out of this dilemma is to cite BRT benefits arising from several other venues, especially others in the U.S. in communities with similarities to the site in question so that valid comparisons are possible.

Relative to the BRT running way utilized in a particular corridor implementation, managing conflicts with other types of traffic is important to maintain the integrity of any BRT running way. Other vehicles crossing in the path of BRT vehicles or creating congestion in BRT lanes can introduce delays and create safety problems. Enforcing BRT running ways can be done passively through design or active police enforcement. Both types of enforcement require the participation of institutional partners who implement highway design standards and law enforcement agencies (8).

New vehicle models must pass a variety of regulations in order to be approved for operation, including procurement, safety, tail-pipe emissions, and disabled access. The federal Buy America provision requires a certain percentage of the vehicle be produced within the United States. Buses must satisfy regulations that govern safe operations of vehicles; moreover, individual states also place their own standards on vehicle design. Federal, state, and local air quality management districts govern requirements on pollutant emissions. Finally, specific aspects of vehicles such as boarding interface, interior layout, placement of fare systems, use of ITS, and wheelchair securement must satisfy the requirements of the Americans with Disabilities Act (ADA) (8).

3.5 Public Relations and Marketing

The ultimate success of any new product, no matter how good its potential may be, depends largely on how information about it — both benefits and costs — is communicated. To gain support for BRT, it needs to be properly "sold" to many stakeholders including bus passengers, employees, motorists, the general public, as well as decision-makers. However, selling BRT requires setting expectations. Setting high, yet realistic expectations will be crucial for the long-term success of the system. Failure to produce what was proposed could lead to public disappointment and tarnish the sponsoring agency's name and reputation, resulting in BRT being untouchable for some period of time.

One issue that may arise from poorly executed public relations, marketing, and educational campaigns are motorists' complaints and backlash who perceive that transit is getting special, and undeserved, treatment, causing roadway delays and raise "tax-equity" issues upon seeing such a system installed for buses, such as with transit signal priority systems.

It would also be important to educate the public and passing motorists on new interactions they may have with bus rapid transit systems. Moreover, the transit agency needs to take into account its current performance, both actual and perceived by the public. Before taking on the additional responsibilities of a BRT, an agency must ensure its current operations are performing satisfactorily. Otherwise, the agency may face political and public opposition if it is perceived the agency is overextending itself beyond its capabilities.

3.6 Labor and Human Factors

Transit properties must consider the effects of BRT on its staff, especially bus drivers and maintenance workers. BRT may raise concerns over additional work and responsibilities, changing role of drivers, especially without assurances of additional staff, resources, and/or pay, use of Automated Vehicle Location (AVL) systems for monitoring schedule adherence and different responsibilities between BRT and non-BRT routes.

For example, for transit signal priority, bus drivers would have a direct and potentially the closest connection of all agency employees with any new technology implemented as part of a BRT. How would such employees embrace such new systems? Would it mean any change in the definition of their job? The specifics of the bus rapid transit system will determine the extent to which bus drivers need to interact with the system, that is, how much attention drivers must pay to activate and/or monitor the system. With everything the bus driver currently needs to do as part of his/her job, giving the driver additional tasks related to the operation of TSP would likely be problematic leading to a preference for either no or only minimal interaction with the driver.

Finally, drivers will likely need to switch back and forth between TSP and non-TSP routes over the course of relatively short time periods, possibly even the same day. Thus, training for new driving conditions and situations and the ability to smoothly switch between TSP and non-TSP routes could be of concern to drivers as well as transit agency management, especially in the instance where drivers have more than simply minimal interaction with the system.

3.7 Planning and Land Use

Large-scale public transportation projects often influence travel patterns and surrounding land uses. Bus rapid transit, intended to replicate high-level transit service, may raise concerns over how it fits into a region's overall transportation plans and how it will affect local land uses. Many BRT projects intend to strengthen and encourage higher land uses. Project sponsors will need to educate and address public concerns regarding the potential impacts of BRT on the physical environment. The public's fear of change and the "unknown" often leads to resistance and opposition toward many such projects. Finally, a BRT system's inherent flexibility, often a much-touted attribute, may, in fact, be a disadvantage. Potential developers may be reluctant to invest along BRT corridors due to its perceived lack of permanence.

3.8 The Physical Environment

The physical presence of a BRT system may also raise institutional challenges. Many project areas, especially in older city centers, may simply lack the physical space to easily accommodate certain BRT implementation strategies. Bus rapid transit projects may also find themselves competing with other interests for high value real estate, which may not only inflate costs, but also complicate institutional dealings. Thus, availability and acquisition of right-of-way or physical space may be an issue.

Image is also a strong marketing tool for BRT. While station area improvements are a popular BRT strategy, these improvements are typically being inserted into the existing urban design. Organizations may find it a challenge to reach agreement or consensus to develop station improvements that promote a strong image, while being acceptable to numerous local interests.

3.9 Interactions and Tradeoffs

It is essential that a systems approach be taken in the planning for and implementation of bus rapid transit systems. That is what has motivated us to include each of the four topic areas described in this section. Moreover, it is important to integrate these topic areas together to understand how they interact with each other and not think of them in isolation from one another.

In this way, a much more complete and accurate depiction of the system with both its benefits and costs may be derived.

We provide here a few examples to illustrate this point. Design attributes are directly linked with operational and service plans and resulting benefits especially in terms of new ridership. For example, to reduce route travel time along a bus rapid transit corridor, there will be fewer stops/stations than would normally be used if that corridor were used for conventional local bus service. However, the further apart consecutive stops/stations are placed, the further customers would need to walk to access the stop/station. Clearly, a transit agency would plan the location of each stop/station to balance the competing objectives of reducing total travel time and attracting new riders. Having the stops spaced further apart contributes to reducing overall travel time because there would be fewer number of stops for the bus to provide boarding and alighting, however, having to walk further to access the bus may discourage potential riders from using this BRT service. In Los Angeles, MTA's Metro Rapid along Wilshire Boulevard originally sited stations approximately 75% to 80% of a mile apart. Overall travel time along the Wilshire corridor has been reduced by 25% and there has been an increase in ridership by approximately 25% with 33% of these being riders new to transit (9). However, based on public opinion about the Metro Rapid service, MTA is planning on inserting a few additional Metro Rapid stops/stations. The number and location have to be selected carefully as adding stops will attract new riders because of the reduced distance people have to walk to the stop, however, it will increase overall travel time, which itself would be a disincentive to attracting new riders.

Another interaction is among design attributes, service plans, and implementation issues. In order to provide more rail-like level of service, an exclusive or at least near-exclusive right-of-way may be sought. Moreover, at BRT stops/stations the use of queue jumpers and/or bus bulbs may also be considered. The use of these design attributes in order to improve the level of service may, however, collide with concerns of the local business community over its opposition to the removal of or restrictions placed on parking space availability that may be necessary to accommodate such operational and service plans for BRT.

A third example to illustrate the importance of integrating these issues brings together technological aspects, operational plans, and institutional concerns. Again, on Los Angeles' Wilshire Boulevard Metro Rapid service, in 2000 MTA implemented various bus rapid transit features as elements of its Metro Rapid service including transit signal priority along the heavily traveled Wilshire-Whittier Boulevard corridor. This corridor traverses the cities of Santa Monica, Beverly Hills, and Montebello in addition to the city of Los Angeles and each of these municipalities controls signal operation within their respective jurisdictions. Thus for the Wilshire-Whittier corridor, MTA and the four signal operators are the primary stakeholders. Initially, transit signal priority was implemented only within the city of Los Angeles as the other cities wanted demonstrative proof of transit signal priorities' benefits before they relinquished control over the operation of traffic signals in their jurisdictions. To date, transit signal priority still remains implemented only in the city of Los Angeles while negotiations between MTA and the other jurisdictions continue.

4.0 GENERAL ASSESSMENT OF BAY AREA TRANSIT CORRIDORS ON THE STATE HIGHWAY SYSTEM

This section provides a summary of key findings from an earlier part of the project in which the team performed a preliminary assessment of transit corridors in the Bay Area in order to select a single corridor for which a follow-up and more detailed case study assessment would be performed. Complete documentation of this part of the project's work may be found in (10).

In this study we focused on bus transit routes that partially travel on California state routes, whether arterial roadways or freeways. A primary component of this project is to consider the inter-connectivity and regional aspects of bus rapid transit systems deployment in the San Francisco Bay Area region. Considering state routes will help identify more regional opportunities for innovative types of partnerships to help address unmet public transit service needs across jurisdictional boundary lines.

4.1 An Overview of Bus Transit on State Routes in the Bay Area

Initially, we took an inventory of both the state routes and bus routes in the Bay Area. There are approximately 500 bus transit routes in the San Francisco Bay Area and of these, 188 travel a portion of their route along state routes divided among 15 of the more than two-dozen transit agencies in the nine-county Bay Area. These are listed in Table 2.

TABLE 2 Transit Agencies Operating on State Routes

Transit Agency	Number of Bus Routes Traversing State Routes
Alameda-Contra Costa County Transit (AC Transit)	56
County Connection	9
Dumbarton Express	2
Fairfield-Suisun Transit	3
Golden Gate Transit	35
San Mateo County Transit District (SamTrans)	24
San Francisco Municipal Railways (Muni)	2
Santa Clara Valley Transportation Authority (VTA)	21
Sonoma County Transit	7
Tri Delta Transit	5
Union City Transit	1
Vallejo Transit	3
VINE (Napa County)	1
WestCAT	8
WHEELS (LAVTA)	11
Total	**188**

Next, we analyzed these 188 bus transit corridors relative to a set of BRT-related attributes that served as filters that we used to subsequently select a small number of bus transit corridors with a high potential for upgrading to BRT status.

4.2 Selection of Candidate Bus Rapid Transit Corridors

Bus rapid transit systems are generally characterized by the criteria of frequent and all day service based on a substantial volume of passenger demand. Moreover, from the outset, this study has considered bus rapid transit from a regional perspective. We examined the 188 bus routes previously discussed with respect to these criteria on the basis of whether they can sustain bus rapid transit operation and as a result of our examination have selected five bus routes in the Bay Area with a high likelihood of being upgraded to bus rapid transit systems and so warrant further study. The five selected corridors should be suitable for analysis of the impacts of BRT implementation by performing a macroscopic level benefit cost analysis to determine whether bus rapid transit would be beneficial to implement.

Beginning with the 188 bus routes with the above-mentioned objectives in mind, we applied a four-step process based on the above criteria together with the overall regional perspective taken in this study to reduce the field of potential BRT candidate corridors:

Step 1: Length of the bus transit routes that travel on state routes; Based on the project's regional point of view, we believed that only those bus routes traveling above some minimum threshold on state routes should be considered further.

Step 2: Service characteristics related to schedule and route structures based on passenger demand level; external factors.

Step 3: Group bus transit routes that function essentially as one service.

Step 4: Level of passenger demand; Based on the experience of current U.S. transit agencies investigating bus rapid transit systems, we believed that only those bus routes with a ridership level above some minimum threshold in terms of average weekday ridership should be considered further. The examination of passenger ridership is divided into two parts: a preliminary and a more in-depth examination.

Each step in this process is discussed in further detail in the pages that follow. It should be noted that the selection process of bus transit routes for further more in-depth evaluation was not rigidly defined; throughout the process new information contributed to the elimination of routes deemed unsuitable for further evaluation. The process outlined below, however, serves as a good approximation of the logic that was followed in selecting suitable bus transit routes for evaluation as potential BRT systems.

Step 1: Length of Bus Transit Routes that Travel on State Routes

As part of our assignment to focus on existing bus routes traveling on state routes, we assumed that the existing transit system and the state route network adequately serves existing population movements and so there was no need to perform a transit demand evaluation of the Bay Area.

We used information gathered from the Bay Area Transit Information website and from individual Bay Area transit agencies to compile an inventory of all of the bus transit routes that travel on state routes. The 188 of the more than 500 Bay Area bus transit routes travel along some portion of a state route. Consistent with our project objective of focusing on regional aspects and interconnectivity opportunities of bus rapid transit in the Bay Area, we initially considered whether to include each of the 188 bus routes, independent of their lengths that traveled on state routes, i.e., no matter how little on state routes. We ultimately decided to consider further those bus routes whose share on state routes was above some cut-off threshold. Our intention was to be conservative and choose a small value so as not to omit too many bus routes based solely on this factor, yet also remain faithful to the regional service character of this project. We selected a threshold of one mile. While some local bus transit routes operate a short portion of their route along state roadways, most of the bus routes traversing state roadways are more regional in nature; of the 188 bus transit routes traveling along state roadways in the Bay Area, 162 traverse these roadways for more than one mile.

Step 2: Demand Characteristics (Time and Location) and External Factors

A detailed examination of the remaining routes revealed characteristics that made some routes unsuitable for bus rapid transit operation. These characteristics were limited operating hours, such as peak-period only service, night service or weekend service only; low frequency services, such as 1-hour headways with few departures and arrivals; specialized route structures, such as a connection service. The primary reasons for eliminating routes related to schedules and route structures; throughout the process external factors such as discontinued routes also played a role.

Forty bus transit routes were removed from further consideration based on schedule characteristics that were deemed inappropriate for BRT implementation based on current BRT system experience. In contrast, most BRT systems operate with frequent service throughout the day. Several routes were eliminated based on a combination of limited service characteristics, including large headways, limited hours of operation, and a small number of departures. Many of these routes cater to commuters; although they provide an important transit service, they were not considered the best candidates for BRT implementation given their limited operational characteristics.

An additional 11 routes were eliminated based on route characteristics that would not embody a successful BRT system such as specialized shuttle services between activity centers. Also removed from further review were routes with few or no intermediate or local collector stops, which often serve one employment center; such routes do not represent the structure common of successful BRT systems in other cities in which BRT is a corridor service.

Throughout the process of selecting suitable routes for further analysis, external factors and developments also played a role in determining which bus transit routes would be analyzed. Faced with difficult economic circumstances, transit agencies have canceled some bus routes; Additionally, the recent expansion of BART to San Francisco International Airport has led to the cancellation of routes by SamTrans. Finally, the Contra Costa Transportation Authority (CCTA) and BART recently co-led the SR 4 East Corridor Transit Study, whose objective was to determine what transit improvements would be timely and effective measures to provide East County residents and employees with alternatives to auto travel in the short and medium term. Transit options as well as highway improvements were considered including eBART[3], BART extensions, express buses, bus rapid transit, and combinations of these options. The findings from the assessment of alternatives recommended the use of eBART as the locally preferred alternative along the SR 4 corridor using Union Pacific (UP) rail right-of-way. As a follow-up to these recommendations, two Tri Delta routes serving the SR 4 corridor between Pittsburg and Brentwood, could be removed from further consideration. The result of Step 2 was the removal of 57 bus transit routes from further consideration for upgrade to bus rapid transit based on demand characteristics and external factors.

<u>Step 3: Grouping of Bus Transit Routes that Function as a Single Service</u>

[3] eBART is a new non-electrified operation of self-propelled Diesel Multiple Units.

Several bus transit routes were grouped together to represent one service based on similarities in route structures. In particular, AC Transit operates numerous transbay bus routes between San Francisco and various locations in the East Bay, many of which function essentially as one service with minor route variations. From a BRT perspective, these bus transit routes could function effectively as one service running frequently throughout the day, rather than as separate more limited individual services assuming that the trunk line would be serviced by feeder/collector routes from surrounding neighborhoods. A few bus transit routes were listed by multiple transit agencies, and thus duplicates were removed during this step to avoid including these individual routes under multiple agencies. Other routes were consolidated, such as SamTrans' routes 390 and 391, which travel on SR 82 (El Camino Real) and have overlapping alignments for much of their routes. The result of this process was the removal of 27 duplicate routes.

In order to represent multiple bus transit routes that function as one, ridership figures for each of the individual routes were added to represent the total service ridership. For example, while the highest average weekday ridership of each of the AC Transit "N" routes was 800 passengers, the total average weekday ridership for all of the "N" routes was 2,500 passengers; such ridership groupings were an important input into Step 4.

Step 4: Passenger Ridership for BRT (Preliminary Examination)

The enhanced service provided by BRT implementation can potentially have the effect of attracting new riders. However, without an existing demand for transit service, a BRT system is not likely to be successful. In order to ensure that sufficient demand for transit service exists, only bus transit routes with at least a minimum threshold average weekday ridership were selected and we considered ridership on currently existing BRT systems in the U.S. Moreover, our intention was again to be conservative and choose a relatively small value so as not to omit too many bus routes based solely on this factor, yet also remain faithful to the fact that without existing demand, a BRT system is not likely to be successful. We selected a threshold of 1,000 riders for the average weekday ridership. Bus routes with less than 1,000 passengers were removed from further evaluation as potential BRT candidates.

Successfully implemented BRT corridors in the United States typically have average ridership figures significantly greater than 1,000 passengers per weekday. For example in Los Angeles, the Wilshire-Whittier Boulevard corridor carries approximately 40,000 average weekday riders. Average weekday ridership on Pittsburgh's East Busway is approximately 9,000, while Honolulu's CityExpress! Route A carries 11,000 average weekday passengers, and Miami-Dade's South Busway carries about 2,100 average weekday passengers on its Busway Local Route and about 3,500 on its Busway MAX Route. Again, we used these ridership figures only as an approximate guide.

It should be noted that the use of ridership data to select potential BRT candidates could have been done before steps 1-3; however the time involved for individual transit agencies to respond to data requests required that this step be delayed. Ultimately we were able to obtain ridership data for each of the 78 bus transit routes remaining after going through Steps 1 through 3. Ridership data was obtained by route from each transit agency for February 2003 or later; some agencies were unable to provide such data and in these instances the most recently available ridership figures were used. Table 3 shows the distribution of ridership by the volume of bus transit routes from these 78 remaining routes; the 23 bus transit routes that had an average weekday ridership greater than 1,000 passengers are detailed in Table 3 and Figure 1.

TABLE 3 Distribution of Ridership

Average Weekday Ridership	Number of Bus Transit Routes
0 – 249	17
250 – 499	21
500 – 999	17
1,000 – 1,999	10
2,000 – 4,999	8
5,000+	5

These routes represent seven of the previously identified 15 transit agencies (See Table 2) and pass through every Bay Area County except Napa County. Several of theses routes have been established as potential BRT corridors by individual transit agencies. We have highlighted in bold and in italics in Table 4 those four transit agencies and associated state routes, bus routes, and average weekday ridership that are currently undergoing planning for implementation as bus rapid transit systems in the Bay Area. Not surprisingly, they comprise those bus routes with the four largest ridership volumes among the 23 routes remaining after our selection process and include:

- AC Transit's existing San Pablo corridor (Routes 72-72M-72R on SR 123)
- AC Transit's planned for bus rapid transit system (Routes 82-82L along Telegraph Avenue/International Boulevard/14th Street corridor)
- SamTrans signal priority project on El Camino Real (Routes 390/391 on SR 82)
- Santa Clara VTA's signal priority project on El Camino Real (Route 22 on SR 82)

TABLE 4 Characteristics of Top Twenty-Three Bus Routes

Transit Agency	State Route (SR)	Bus Route	Total Length (mi)	Length on SR (mi)	% on SR	Average Weekday Ridership
AC Transit	13/24	64	15.6	6.3	40%	1,069
AC Transit	***123***	***72-72M-72R***	***16.6-16.9***	***9.3-11.0***	***56-65%***	***15,513***
AC Transit	580/80	80	11.3	3.5	31%	1,041
AC Transit	***185***	***82/82L***	***18.5***	***16.0***	***87%***	***22,481***
AC Transit	123/80	L-LA-LB-LB1-LC	15.0-26.7	16.5-18.0	68%+	1,064
AC Transit	80/580	N-NF-NG-NH-NL-NV	17.2-31.6	11.2-16.9	53-65%	2,489
AC Transit	880/80	O-OX-OX1	15.1-19.0	8.6	45-57%	1,968
Golden Gate Transit	101	4	21.2	10.8	51%	1,485
Golden Gate Transit	101	10	24.5	8.0	33%	1,027
Golden Gate Transit	101	20	32.4	13.7	42%	3,757
Golden Gate Transit	1/101	50	41.9	18.3	44%	3,658
Golden Gate Transit	101	70	31.6	23.6	75%	1,117
Golden Gate Transit	101	80	62.1	49.0	79%	3,212
SamTrans	1	110	11.4	6.0	53%	1,179
SamTrans	***82***	***390/391***	***26.7-33.9***	***25.0***	***74%-93%***	***13,224***
SamTrans	101/82	KX	36.2	13.0	36%	2,406
San Francisco Muni	280	14X	10.1	2.6	26%	2,358
San Francisco Muni	101	9X	12.9	3.1	24%	8,340
Santa Clara VTA	***82***	***22***	***27.0***	***15.0***	***55%***	***20,000***
Santa Clara VTA	880/680	180	37.4	12.7	34%	2,000
Santa Clara VTA	82	300	24.2	14.0	57%	2,871
Vallejo Transit	80	80	21.5	14.4	67%	1,400
WestCAT	4/80/123	J	14.5	6.3	44%	1,570

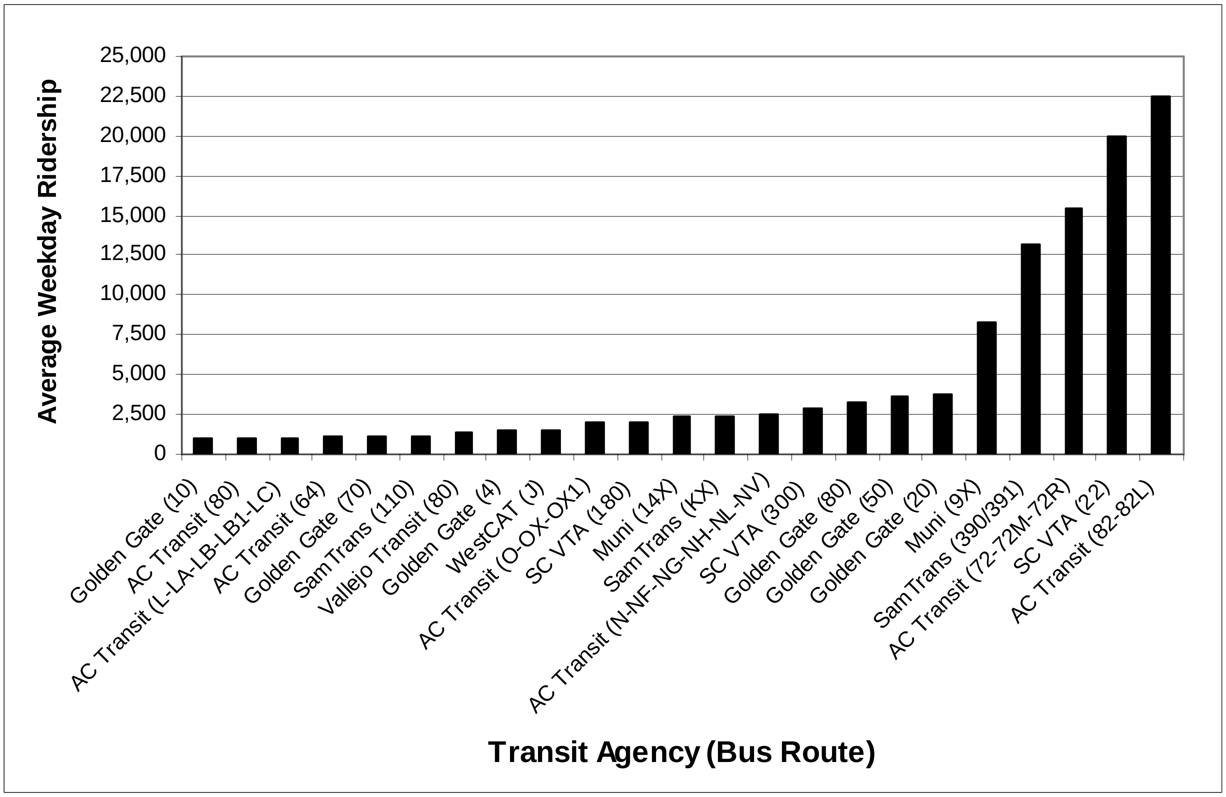


FIGURE 1 Average Weekday Ridership for Top Twenty-Three Bus Routes

The bus route with the fifth largest ridership is Muni's route 9X that travels on US 101. Route 9X appears in three of Muni's 13 corridors as part of its vision for rapid transit in San Francisco (3), one of which is under planning consideration for implementation of bus rapid transit[4].

Step 4: Passenger Ridership for BRT (In-depth Investigation)

In this final step, we examined in more detail these 23 bus routes, again in terms of their ridership to better understand what level of ridership is needed to sustain a successful BRT service. Recall that we purposely were conservative in our selection of 1000 passengers as the cut-off value for minimum average weekday ridership needed for bus rapid transit systems. From Table 3 and more obviously from Figure 1, there is a distinct and clearly defined division between 18 of the bus route corridors and the remaining five. These 18 routes' average weekday

[4] The three 9X corridors are 1. Chinatown-North Beach-Marina, 2. Geneva-Ocean, and 3. Potrero-San Bruno. Numbers 1. and 2. are being considered for LRT and #3 for BRT.

ridership ranges from a minimum of 1,027 to a maximum of 3,757. In this step we investigated more closely those currently implemented BRT corridors with the smallest average weekday ridership. We identified these corridors from the recently completed TCRP A-23 Project Report (9) and began with the corridor with the smallest ridership. Our objective in this step is to search for the BRT system with the lowest ridership and use that ridership as a lower bound in our current project to more narrowly focus onto the best potential BRT candidates.

The results of this analysis showed that the West Busway in Pittsburgh is the BRT system with the lowest documented ridership. For our current research we used its ridership as the minimum weekday ridership for a successful BRT system. Hence we have identified our 5 best candidates for BRT in the Bay Area (Table 5).

TABLE 5 Five Top Candidate Corridors for Bus Rapid Transit in San Francisco Bay Area

Transit Agency	State Route (SR)	Bus Route	Average Weekday Ridership (Number of Passengers)
AC Transit	185 (Telegraph Ave/International Bl/14th St.	82/82L	22,481
Santa Clara VTA	82 (El Camino Real)	22	20,000
AC Transit	123 (San Pablo Ave.)	72-72M-72R	15,513
SamTrans	82 (El Camino Real)	390/391	13,224
San Francisco Muni	101 (San Bruno)	9X	8,340

It is noteworthy that these five top candidate corridors closely match ongoing bus rapid transit corridor activities in the San Francisco Bay Area that are currently under study, though at different stages of development, to be upgraded to bus rapid transit on these corridors. This finding helps support the validity of the more non-traditional and top-down approach taken in this project to initially focus on state routes to identify potential bus rapid transit corridors. We also note that the different approach taken in this project to identify bus route corridors on state routes with a high potential to be upgraded to BRT systems has led us to the same corridors that have already been selected by the more traditional and customary approach taken directly by transit agencies.

Since the objective of the project was to identify transit routes that could support a BRT service, at this point in the project we solicited input from Caltrans to prioritize this list of five corridors and make a final selection of a single corridor on which further in-depth analysis was performed.

We considered several criteria to make the final bus route corridor selection including the route corridor 1) with the highest average weekday ridership in order to benefit the most riders possible, 2) with two transit agencies operating on it thus bringing together additional opportunities for organizational collaboration and coordination, 3) with a bus rapid transit system that is already in operation, and 4) that is currently only at the initial stage of being considered for bus rapid transit system operation.

Furthermore, we note that even if a full BRT service cannot yet be implemented, there are potential interim solutions (such as express routes or HOV lanes) that could improve the quality of service on these routes and potentially improve the service on the other 18 routes whose average weekday ridership is between 1,000 and 4,000 passengers.

4.3 Final Selection of Case Study Corridor(s)

Recall that the five corridors consist of:

1. AC Transit routes 82-82L on SR 185 (Telegraph Av/International Blvd./E. 14th St)
2. AC Transit routes 72-72M-72R on SR 123 (San Pablo Avenue)
3. Sam Trans routes 390 & 391 on SR 82 (El Camino Real)
4. Santa Clara VTA route 22 on SR 82 (El Camino Real)
5. SF Muni's route 9X on US 101 (San Bruno Express)

Number 1 has the highest average weekday ridership of any of the five routes and this could benefit the most riders possible, however, AC Transit is already committed to this corridor for BRT implementation as the MIS and EIR are already complete and under preparation, respectively and so AC Transit has studied this corridor a lot already; Number 2 is already in revenue service so many of the questions AC Transit may have had (and we could have studied) have likely been answered by the availability of data that can be collected from the corridor. Number 5 above is just at the very beginning of being considered for BRT implementation as this corridor was included in Muni's 2002 Vision Document for the future. Moreover, the corridor lies within the city and county of San Francisco and so does not encompass cross-jurisdictional issues. Numbers 3 and 4, however, involve two bus routes on the same roadway, includes not only multi-jurisdictional issues by including two counties and numerous local cities, but also includes two transit properties. These attributes make the selection of these two bus route corridors uniquely qualified and very faithful to Caltrans' mandate to consider inter-connectivity and regional aspects of bus rapid transit systems deployment in the Bay Area and to identify more regional opportunities for innovative types of partnerships to help address unmet public transit service needs across jurisdictional boundary lines. It was for these reasons that we selected as our case study corridor, the union of VTA's Line 22 and SamTrans' Lines 390/391 along CA 82 ─ El Camino Real on the western and southern portions of San Francisco Bay.

5.0 CASE STUDY: CALIFORNIA STATE ROUTE 82 ─ EL CAMINO REAL

In this section, we document our investigation into the potential for bus rapid transit along the two-county jurisdictional region along the western and southern portions of the San Francisco Bay.

5.1 The Case Study Corridor and Its Transportation Setting

California State Highway 82 traverses Santa Clara and San Mateo Counties with a northern terminus just at the southern outskirts of San Francisco. In the south, it begins in the proximity of Gilroy near US 101 and CA 152. For much of its route between San Jose and the southern outskirts of San Francisco, it is also known as El Camino Real and forms an alternative to US 101 and I-280 between San Jose and San Francisco. The total length is approximately 52 miles and it traverses two counties: Santa Clara and San Mateo.

The case study corridor comprises the primary portion of the urbanized areas of San Mateo and Santa Clara Counties, that is, the bayshore parts of the peninsula. VTA's Line 22 is 27 miles long of which 15 miles ─ approximately 55% ─ is situated on California State Route 82. Line 22's northern and southern termini are, respectively, the Menlo Park Caltrain Station (in San Mateo County) and the Eastridge Transit Center in the city of San Jose (Figure 2). SamTrans's Lines 390 and 391 range from approximately 27 to 34 miles in length, respectively, of which 25 miles ─ approximately 74% to 93% ─ is situated on SR 82 Bus Route 390 encompasses the corridor from the Palo Alto Caltrain Station in the south (Santa Clara County) to Daly City in the north while bus route 391 traverses the corridor from the Redwood City Caltrain Station in the south to San Francisco in the north (Figure 3).

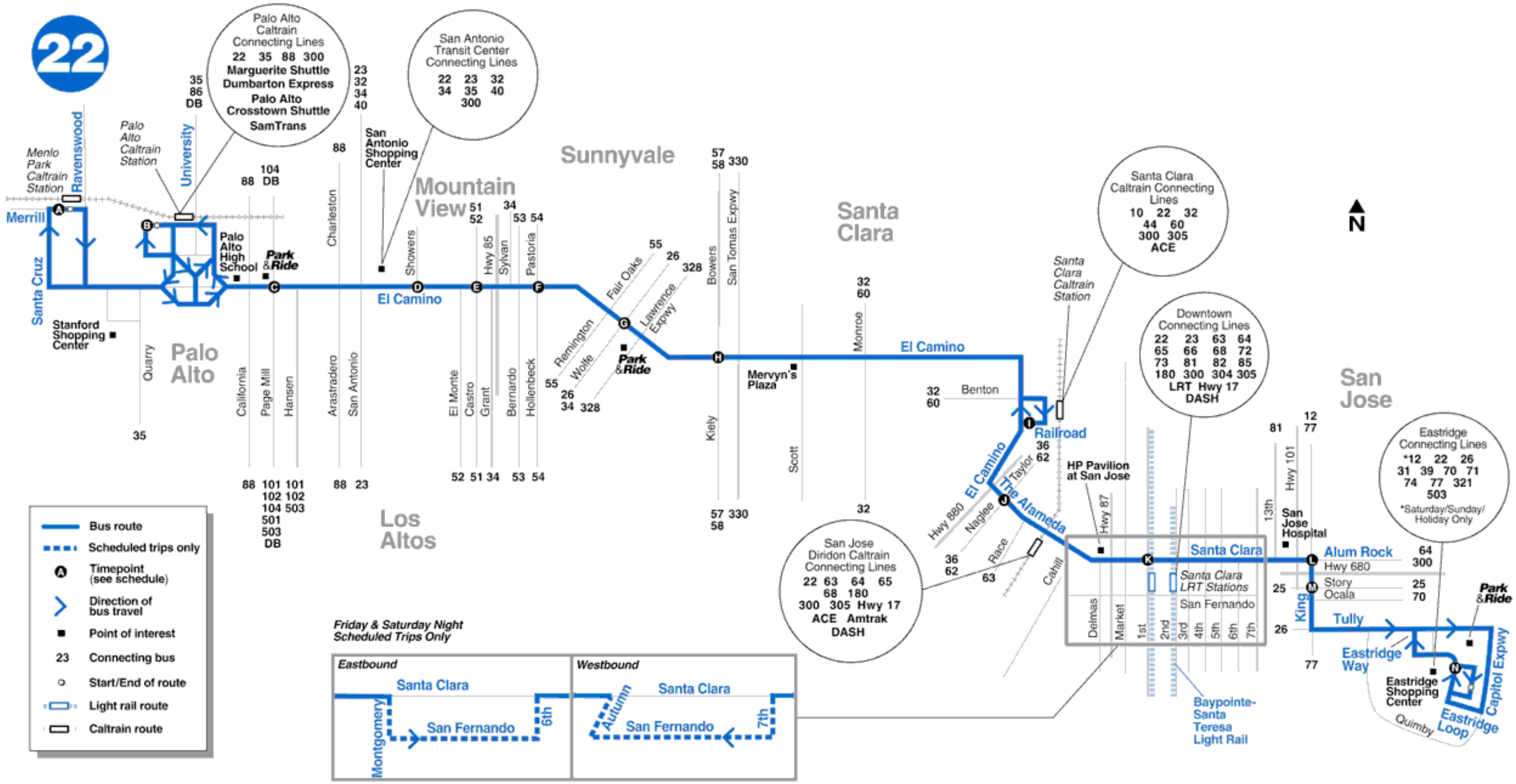


FIGURE 2 VTA Bus Route 22

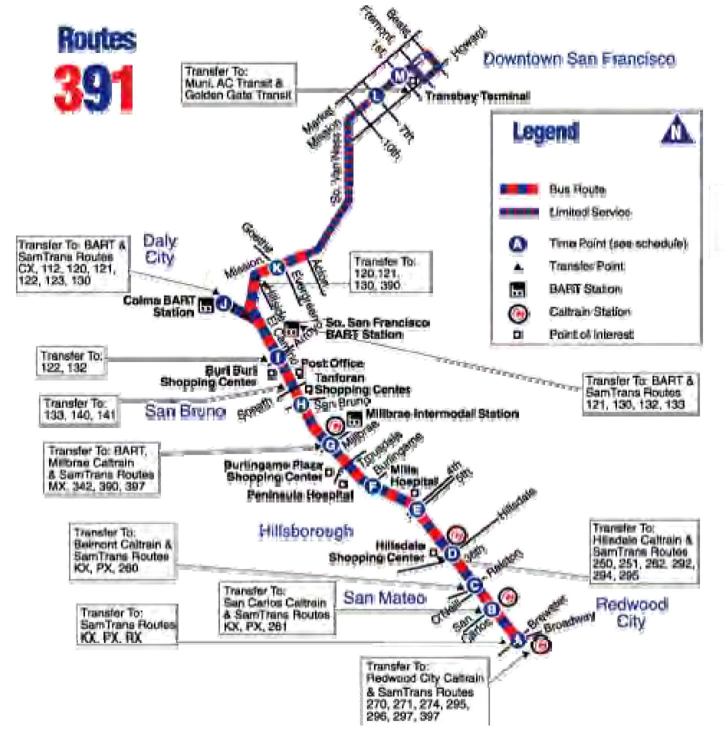


FIGURE 3 SamTrans Bus Routes 390 and 391

5.1.1 Infrastructure Assets along the Transportation Corridor

Along portions, if not all, of the corridor length lie additional assets of the Bay Area's metropolitan transportation system that provide alternative travel modes and/or routes and play roles, ranging from central to secondary, in understanding the opportunities for bus rapid transit system along this corridor (Figure 4). The highlighted assets in Figure 4 include roadway and rail assets:

- Roadway Assets
  - U.S. Highway 101 (US-101)
  - Interstate 280 (I-280)
- Rail Assets
  - Altamont Commuter Express (ACE)
  - Bay Area Rapid Transit District (BART)
  - Caltrain
  - VTA's Light Rail Transit Line

U.S. Highway 101 and Interstate 280 each run the entire length of the corridor though US-101 is located in the densely urbanized portions of the corridor while I-280 is located more on the western fringe of the urbanized part of the corridor. Of the four rail assets on the corridor, only Caltrain runs the entire length of the Peninsula; it parallels SR 82 from San Bruno south. Caltrain is the commuter rail service provider on the peninsula of the San Francisco Bay Area and is a tri-county partnership of San Francisco Municipal Railway, San Mateo County Transit District and Santa Clara Valley Transportation Authority. It is owned and operated by the Peninsula Corridor Joint Powers Board (JPB), which consists of three members from each of the JPB partners: San Francisco, San Mateo, and Santa Clara counties. The San Mateo County Transit District (SamTrans) is the managing agency that includes oversight of Amtrak, the contract operator. It is useful to note this institutional arrangement for Caltrain along the corridor as it offers an institutional model to

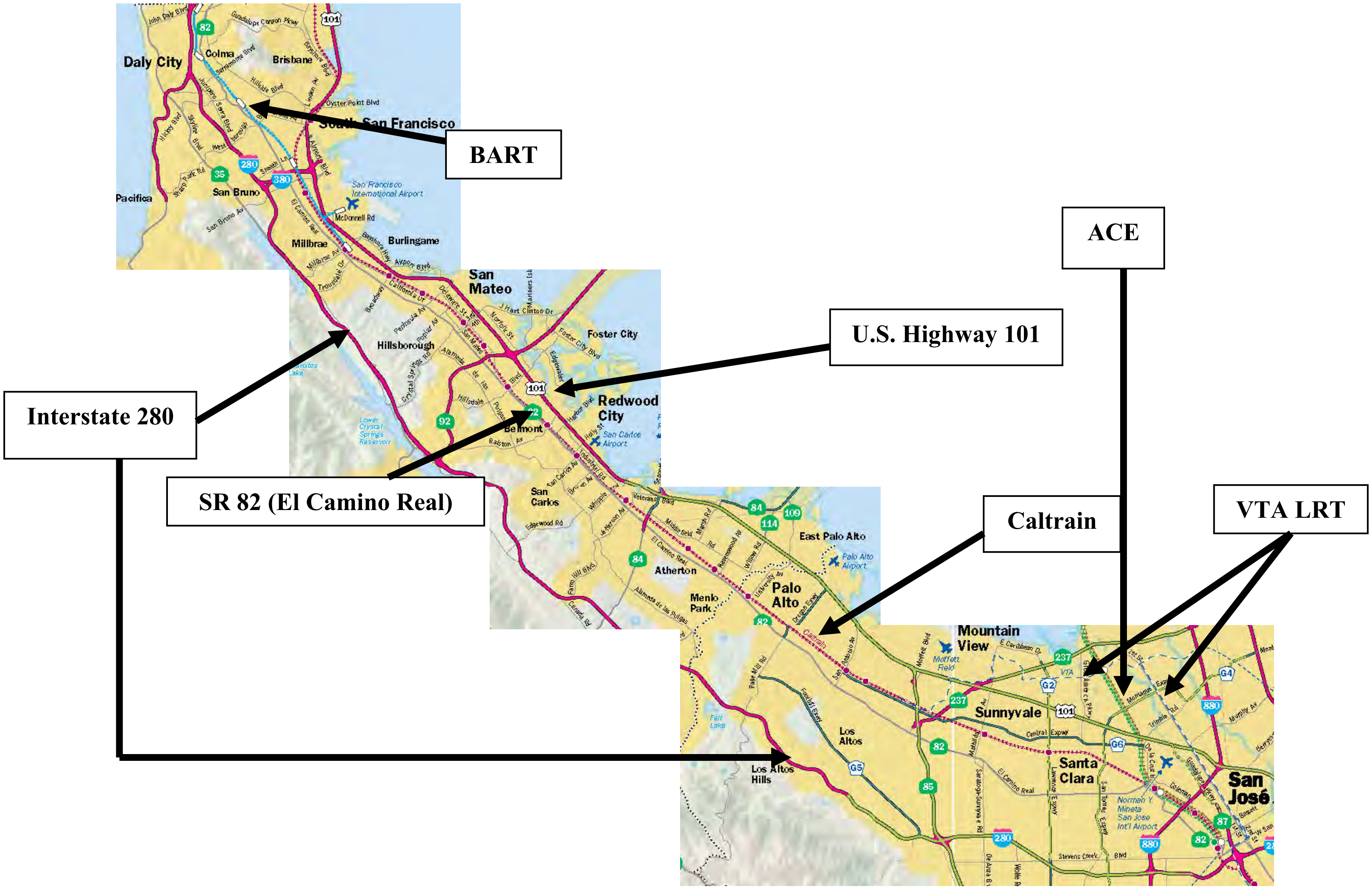


FIGURE 4 SR 82 Corridor and Adjacent Transportation Assets

consider for a possible corridor-wide bus rapid transit system involving SamTrans and VTA. A system map of Caltrain is shown in Figure B-3 of Appendix B of this report.

The other three rail assets ─ Altamont Commuter Express (ACE), Bay Area Rapid Transit District (BART), and VTA's Light Rail Transit span either northern or southern portions of the SR 82 corridor.

- ACE: North-west Santa Clara County as far south as San Jose
- BART: Northern San Mateo County as far south as Millbrae
- VTA LRT: North-west portion of Santa Clara County from Mountain View through San Jose

There are various cross-system connections among pairs of these rail assets:

- ACE and VTA LRT connect at the Great America Station
- VTA and Caltrain connect at the Mountain View and Tamien Stations
- Caltrain and ACE connect at the San Jose Diridon Station
- BART and Caltrain connect at the Milbrae Station

System route maps for ACE, BART, and VTA's LRT are shown in Figures B-1, B-2, and B-4, respectively, of Appendix B of this report.

5.1.2 Regional Express Bus Services

SamTrans currently has five express bus services that span part to all of San Mateo County, continue into San Francisco and Palo Alto with from one-third to one-half their length on SR 82. Four of these express services are described in Table 6. Detailed route maps for these four services are depicted in Appendix C. The fifth regional express bus service is a new service that is described in Section 4.2.1 and an element of the recently implemented Regional Express Bus Service Program in the Bay Area. While VTA also has express and limited bus service routes, all except route 300 ─ a limited service similar to route 22 ─ traverse only about 4-5 blocks in length on SR 82. Detailed route maps for VTA's express bus services depicted in Appendix D.

TABLE 6 SamTrans' Express Bus Services

Route Number	Termini	Intermediate Stops
KX	Palo Alto and SF Transbay Terminal*	Menlo Park, Atherton, Redwood City, San Carlos, Belmont, SFO, SF CBD
MX	San Mateo and SF Transbay Terminal	Burlingame, Millbrae, San Bruno, SF CBD
PX	Redwood City and SF Transbay Terminal	San Carlos, Belmont, San Mateo, SF CBD
RX	Palo Alto and SF Transbay Terminal*	Menlo Park, Atherton, Redwood City, SF CBD

*These termini are the same; however there are differences in the intermediate stops and the portion of the route traversing SR 82.

5.2 New Corridor Activities

There are several other corridor activities that should be noted and examined when taking in the full measure of opportunities for implementing bus rapid transit along the SR 82 Corridor. These include the following, which are described in the remainder of this section:

1. Regional Express Bus Service Program and Rapid Bus Proposal
2. Silicon Valley Rapid Transit Project: BART Extension to San Jose
3. El Camino Real Grand Boulevard Initiative
4. Caltrain's Baby Bullet Express trains

5.2.1 Bay Area System Plan for Regional Express Bus Service and its Rapid Bus Proposal

In the Bay Area, the Metropolitan Transportation Commission has promoted express buses for several decades. As part of the 2001 Regional Transportation Plan, MTC approved a resolution ─ Resolution 3434 ─ to expand transit services in the Bay Area over the next several years. Included in Resolution 3434 is a description of an express bus route along SR 82 (11, 12, and 13). MTC has also conducted a number of studies that identify and evaluate possible improvements to the HOV system; a number of these improvements have been incorporated into both the 20-year Regional Transportation Plan (RTP) (14) and the Bay Area Blueprint for the 21st Century, a planning effort that parallels the RTP, focuses on near-term congestion relief, and includes additional express bus and HOV projects that should be supported if additional funds can be secured (15, 16, and 17).

MTC's most recent update, the *2002 HOV Lane Master Plan (18),* includes HOV lane demand forecasts for 2010 and 2025, a survey of public attitudes toward HOV lanes, recommendations for HOV lane system expansion, and recommendations for further development of MTC's Regional Express Bus Program.

Freeway HOV lanes and express bus services are complementary. However, additional markets for express buses may exist along arterial routes in some parts of the region. For example, the San Francisco County Transportation Authority and Muni are considering priority treatment and express operations for several cross-town routes from residential districts to downtown. AC Transit is completing two major studies of BRT on routes that parallel congested freeways. Additional services that provide "feeders" to rail systems - ACE, BART, Caltrain - are also possible, as are interregional services. Furthermore, express bus services may be considered as a high quality alternative to new rail investments or major upgrades, as they generally can be implemented sooner and at a fraction of the cost. Such potential cost savings are especially appropriate in the current fiscal climate, where rail projects may have to be delayed because of funding shortfalls, but even in good economic times the cost per new rider comparisons make express bus services attractive.

A recently completed project has built upon this prior work and extended the work done for the regional HOV lane and rapid bus plans. This project was conducted by the University of California Transportation Center (UCTC) under the sponsorship of and partnership with Caltrans District 4, the Metropolitan Transportation Commission, several Bay Area transit properties, and other regional stakeholders. The project developed a Bay Area Regional Express Bus System Plan whereby express buses on the region's HOV lanes as well as specifically selected major arterial routes will be implemented.

The UCTC team worked with Caltrans and other regional stakeholders to develop a strategy for improvements in the system network to accommodate both intra-and inter-regional trips in the Bay Area. Both existing and proposed HOV lanes and priority treatments on all major corridors were examined as well as both existing and new express bus services that are in place or being proposed. The team reviewed the performance of proposed investments, with the aim of helping

Caltrans prioritize projects for inclusion in District 4 plans, programs and budgets. The proposed investments were weighed against the plan's overall objectives: to relieve congestion on the freeways, increase transit ridership, facilitate accessibility to intermodal hubs and activity centers, accommodate interregional express bus trips, validate that regional express bus service and smart-growth are mutually supportive, and identify and prioritize cost-effective HOV lane extensions, gap closures, and other improvements to support express bus services. In keeping with policies set forth in the California State Transportation Plan, community acceptance, environmental justice, environmental protection and enhancement, and economic development issues were also considered to the extent possible in evaluating the proposed actions.

While building upon the recommendations of express bus and HOV studies that are underway in the region, this study focused on and identified physical and operational improvements that can and should be made to the State highway system to support express bus services. It also proposed ways to integrate local transit providers' existing and planned express bus routes and Bus Rapid Transit services on local streets and arterials with those on the region's freeway system, making connections to the region's BART and commuter rail systems and other transit projects, especially Regional Express Bus Service (19).

The project was carried out in three phases:

In the first phase, the project team 1) reviewed existing express bus and HOV plans and needs assessments, 2) identified needed Caltrans actions, 3) worked with Caltrans and other stakeholders to prioritize corridors and action items within those corridors, and 4) developed an integrated, overall strategy for deploying regional express bus service (20, 21, and 22).

In the second phase of the project the team analyzed a few high priority corridors to assist Caltrans and its partners develop improvement plans, operational strategies, institutional arrangements, and financing approaches for the management, operation, and maintenance of express bus services selected from among Interstates 880, 80, and parallel State Routes (SR 123 and 185) and U.S. 101 and Interstate 280 (and SR 82).

In the third phase of the study, the study team developed a detailed work program for a pilot project for a portion or portions of the REB plan in high priority corridors.

As part of the Metropolitan Transportation Commission's (MTC) *Transportation Blueprint for the 21st Century*, a Bay Area Rapid Bus Proposal was developed. In particular, for the Peninsula Corridor and the Santa Clara Valley, such proposals were developed. For the Peninsula Corridor, BRT would be implemented on I-280 along its High Occupancy Vehicle (HOV) lanes between South Central San Mateo County to Colma BART Station in the north and Silicon Valley in the south. The main infrastructure needed would be additional park and ride lot development along I-280. For the Santa Clara Valley, the rapid bus concept would focus on expanding service on the Valley's already existing extensive system of freeway and expressway HOV lanes. Support facilities include freeway HOV-to-HOV connectors on SR 85, in San Jose, and in Mountain View.

As a result of this project, a Regional Express Bus Service Program Pilot Project was implemented by MTC in 2004 in San Mateo County along the 101 corridor. The project is called REX and is receiving federal and state grants, supplemented with local funding for operating expenses derived from the passage in 2004 of Regional Measure 2 that raised Bay Area bridge tolls from $2 to $3. Figure 5 depicts the route map for the REX express bus service.

The SamTrans Express Bus routes described in Section 4.1.2, that is, routes KX, MX, PX, and RX are currently scheduled to continue and there are no plans for any service cuts at this time in these routes; however, this situation could change given the state of the economy. At the current time while there have been ongoing discussions at SamTrans to implement a regional express bus along SR 82, there are no operational plans in the short term to have this as a component of the REB Program.

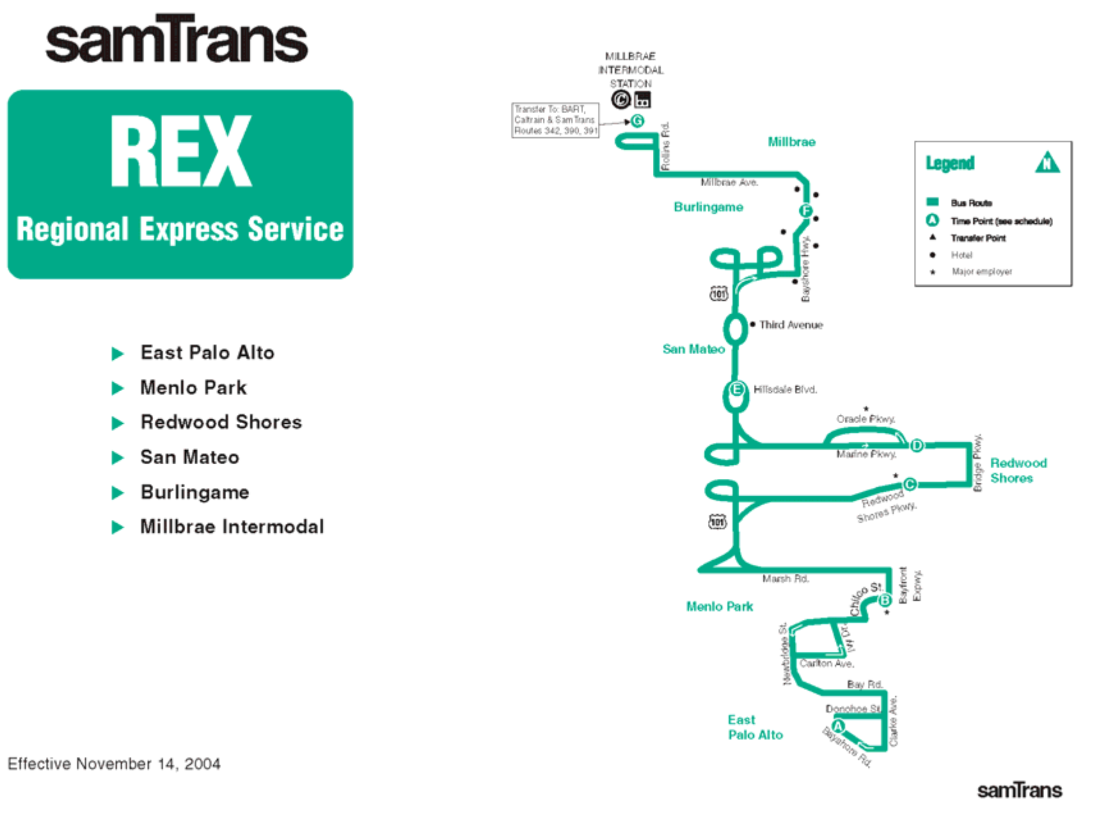


FIGURE 5 SamTrans Regional Express Bus Service REX

5.2.2 Silicon Valley Rapid Transit Corridor: BART Extension to San Jose

The Santa Clara Valley Transportation Authority (VTA) has been conducting studies to extend BART from the proposed Warm Springs BART Station in Alameda County into Santa Clara County, a 16.3 mile extension. BART has been a partner on the Silicon Valley Rapid Transit Project (BART to Santa Clara County) study, and has supported and monitored VTA's efforts. Measure A, a sales tax measure sponsored by VTA, passed in November, 2000 and dedicated $2 billion toward this project. VTA is the lead agency and will work in cooperation with BART.

The Silicon Valley Rapid Transit Corridor study area, which is located in the southern part of the San Francisco Bay Area, falls within portions of Alameda and Santa Clara counties. The corridor stretches over 20 miles from Union City to the cities of Fremont, Milpitas, San Jose, and Santa Clara. Major highways include Interstate 880 and Interstate 680 running north and south, Interstate 280 and Highway 237 crossing east to west and Highway 101 intersecting the corridor.

In addition, three existing rail lines fall within the corridor: Alviso, former Southern Pacific and Union Pacific. Existing transit services in the study area include VTA light rail, VTA and Alameda County Transit express and local buses and Caltrain, Altamont Commuter Express (ACE), Capitol Corridor Intercity, and Amtrak rail services.

The Silicon Valley Rapid Transit Corridor is primarily traveled by residents living in the East Bay and beyond who work in Santa Clara County. Residential development in the East Bay coupled with significant job growth in the corridor cities has led to very high and increasing levels of traffic congestion. Stretching over 20 miles from the City of Union City to the Cities of Fremont, Milpitas, San Jose and Santa Clara, California the corridor presents a "missing link" in the regional rail transportation network. Filling this gap with transportation improvements is key to improving regional mobility and alleviating traffic congestion.

The Santa Clara Valley Transportation Authority (VTA) has completed a Major Investment Study (MIS) to identify a Preferred Investment Strategy for the Silicon Valley Rapid Transit Corridor. The proposed BART Extension to Milpitas, San Jose, and Santa Clara was selected following completion of the Silicon Valley Rapid Transit Corridor Major Investment Study (MIS) in November 2001. The MIS evaluated 11 alternatives representing various modes of travel (express bus, bus rapid transit, commuter rail, diesel and electric light rail, and BART) and various alignments and stations located in the Cities of Fremont, Milpitas, San Jose, and Santa Clara, California. The BART Extension will be further refined during the conceptual design phase of the project and carried forward in the Environmental Impact Statement/Environmental Impact Report (EIS/EIR).

Improved transit in the corridor, filling this gap, has been a long-standing goal in the Bay Area. The BART Extension will enhance regional connectivity through expanded, interconnected rapid transit services between San Francisco Bay Area Rapid Transit in Alameda County and light rail and commuter rail in Silicon Valley.

In December 2004, VTA certified the Final Environmental Impact Report for the proposed BART Extension to Milpitas, San Jose and Santa Clara. The study presents alternatives for improving transit services and discloses the environmental impacts of those alternatives. It describes the project alternatives, existing environmental setting, impacts from construction and operation, best practices and design requirements integrated into the project, and mitigation measures to reduce or eliminate impacts. The Final EIR presents information on the refinement of the Locally Preferred Alternative, documents agency and public comments on the proposed project, provides VTA responses to those comments, and indicates revisions and corrections to the draft document as a result of responses to comments and updated information.

This EIR was initially written as a combined federal/state document (Environmental Impact Statement/Environmental Impact Report [EIS/EIR]) in accordance with the requirements of the National Environmental Policy Act and CEQA. However, subsequent to the public review period for the Draft EIS/EIR, VTA has chosen to pursue federal funding and state environmental clearance of the project on independent paths. The Final EIS, to be completed at a later date, will require federal review and approval.

The BART Extension will offer connections to the core BART system, Altamont Commuter Express (ACE), Caltrain, Capitol Corridor Intercity Rail, Amtrak, VTA light rail and bus, the San Jose International Airport, and the California High-Speed Rail system. Intermodal stations will be designed to provide the most efficient and convenient transfers for passengers. The next steps include preliminary engineering, final design, construction, procurement of vehicles, testing, and implementation of new service. Overall project completion is targeted for 2015.

5.2.3 El Camino Real Grand Boulevard Plan / Enhanced Bus Service

As part of developing its Short Range Transit Plan (FY 2003/04) and its 20-Year Strategic Plan, SamTrans has identified several system-wide objectives. In particular, one is the El Camino Grand Boulevard Initiative, in which SamTrans and its local municipal partners will assess El Camino Real from Daly City in the north to the Stanford Shopping Center in the south just across the Santa Clara county line to create a corridor initiative and related service plan to identify opportunities to

- Increase housing and employment densities within ½ mile of the roadway

- Improve the infrastructure and streetscape to make transit service as attractive and convenient as possible
- Improve amenities to make the streetscape safer and more attractive to pedestrians
- Reduce traffic congestion

As part of the El Camino Grand Boulevard plan as well as being an element of the Strategic Plan is the El Camino Corridor Enhanced Bus Service plan, which is in early planning phases. The proposed service enhancements will offer faster running times and higher quality amenities than the local bus service (Routes 390 and 391) that currently operates along CA SR 82. However, current plans do not include a dedicated bus right-of-way. For the proposed Enhanced Bus Service along El Camino Real, new standard low-floor buses, transit signal priority, and a bus-stop identity and improvement program are under consideration.

The voters in San Mateo County voted overwhelmingly in favor of County Measure A in the November 2004 election (75% yes, 25% no, with 2/3 majority required) to continue the existing one half of one percent sales tax for an additional 25 years through December 2034. The proceeds will be used for highway and transit improvements as set forth in the County's Transportation Expenditure Plan. Measure A, both existing and the reauthorization beginning in 2008, does not fund El Camino Real improvements through SamTrans; however, the cities and county could, if they so choose, use their street and road allocations to fund roadway improvements on El Camino Real. At the same time, the San Mateo County Economic Development Association (SAMCEDA) and Joint Venture: Silicon Valley Network are working with municipalities and local agencies in San Mateo County to increase housing, retail, and transportation options (23, 24, 25, and 26).

Components of Phase I include the following:

- Create of Grand Boulevard Policy Committee and Technical Advisory Committee
- Conduct transportation and circulation assessments and develop design guidelines
- Establish a long range Transit, Housing, and Economic Improvement Plan, including incentives for private sector participation

- Develop financing mechanisms and policies to attract mixed-use, transit-supportive housing development
- Provide technical assistance to individual cities
- Secure Demonstration Project funding and long-term funding
- Complete detailed planning and preliminary design and engineering for Demonstration Projects

Currently, plans for five Demonstration Projects are under development including plans for

- Daly City
- Colma
- Belmont
- San Carlos
- Redwood City

5.2.4 Caltrain's Baby Bullet Express Service

Caltrain expanded upon ongoing schedule integration practices in June 2004 by adding to Caltrain's Peninsula train service with the debut of the new Baby Bullet express service in which travel time between San Francisco and San Jose was decreased 40% from 96 minutes on the local train to just under one hour on the Baby Bullet. Travel times are decreased primarily because the Baby Bullet stops at only the seven most heavily patronized stations[5] of Caltrain's 34 stations and bypassing slower local trains made possible by the construction of additional tracks. Higher speed also contributes to the improved travel times as the Baby Bullet travels at approximately 80 mph, whereas some local trains currently reach a maximum of about 60 mph. Moreover, low floors and additional doors help expedite passenger boarding and alighting and so also contribute to further reducing travel time. There are five Baby Bullet trains in the morning and in the afternoon/evening peak periods.

Caltrain has revamped its entire schedule to provide what it hopes is a more efficient and timely mix of local, limited-stop and express train services during the week. Caltrain continues to work closely with BART to enhance the already existing interagency schedule coordination between

[5] San Francisco (at 4th/King Streets and at 22nd Street), Millbrae, Hillsdale, Palo Alto, Mountain View, and San Jose (Diridon).

these two rail service providers especially at the new Millbrae intermodal station ─ an example of an infrastructure integration practice ─ where improved connections between BART and Caltrain's Baby Bullet have been possible since the latter's debut in June 2004. These schedule and infrastructure integration practices have worked together to improve customer level of service. Since its debut one year ago, the Baby Bullet has experienced a 17% increase in ridership, totaling more than 31,000 average weekday riders (27).

5.3 Linkages Between VTA and SamTrans: Collaboration and Coordination of Activities

Along El Camino Real, VTA's Line 22's northern and southern termini are, respectively, the Menlo Park Caltrain Station (in San Mateo County) and the Eastridge Transit Center in the city of San Jose. SamTrans' Line 390 encompasses the corridor from the Palo Alto Caltrain Station in the south (Santa Clara County) to Daly City in the north while bus route 391 traverses the corridor from the Redwood City Caltrain Station in the south to San Francisco in the north.

Not all Line 22's go all the way up to Menlo Park in San Mateo County. However, Line 22 and Line 390 buses all do meet at the Palo Alto Transit Center. Currently it is configured as a bus stop island so people can walk from bus stop to bus stop even during the remodeling period. The Palo Alto Transit Center (the Caltrain Station) located at the Stanford Shopping Center is the primary interface between Line 22 and Line 390 and it is currently undergoing remodeling that is scheduled to complete in summer 2005.

The last shared bus stop between 22 and 390 is actually on El Camino Real (SR 82) and Ravenswood/Menlo Aves. The Menlo Park station is off El Camino Real. Lines 22 and 390 share a total of 4 stations; in addition to Ravenswood/Menlo Aves. and the Palo Alto Transit Center, there are two stops in between at Cambridge and Middle Avenues.

There is schedule coordination between VTA and SamTrans, for 22 and 390 mainly during the off-peak periods when the headways can be up to an hour and someone who's 5 minutes late would have to wait around 55 minutes for his/her connection. Instead of saying off-peak, it's better to say when headways are big, say late evening. Thus, if there is going to be a schedule change then each agency will inform the other so their "own" folks who transfer can be notified.

The level of fare coordination between the two agencies consists of the SamTrans Monthly Pass accepted as local fare at shared stops by VTA. Likewise, VTA Day and Monthly Passes are also accepted as local fare at shared stops.

An important aspect of ongoing linkages between VTA and SamTrans is the extent of transfer volume activity between VTA's Line 22 and SamTrans' Line 390. While it is believed that the amount of such transfer activity is not insignificant, it has not yet been quantified by SamTrans or VTA. To have this information would require special studies that have not yet been performed.

From VTA's web site, a user cannot be connected to SamTrans' web site. From SamTrans' web site you can directly connect to VTA's web site. Each agency exchanges with the other their schedules for overlapping bus routes, however, such schedules may not be the most current and each agency recommends that callers contact the other agency directly (28).

5.4 Current State of Bus Rapid Transit Development

This section describes the current state of development toward implementation of bus rapid transit systems in Santa Clara and San Mateo Counties. The Santa Clara County Valley Transportation Authority is currently in the construction phase of implementing their BRT along SR 82, while San Mateo County Transit District is at a considerably earlier stage of BRT development along SR 82.

5.4.1 Santa Clara County Valley Transportation Authority

The El Camino/Santa Clara Street/Alum Rock Avenue corridor is the backbone of the Santa Clara Valley Transportation Authority (VTA) bus network, providing service along the east-west length of Santa Clara County between the Eastridge Shopping Center in San Jose and the Caltrain Station in Menlo Park. The corridor is 27 miles long and includes the cities of San Jose, Santa Clara, Sunnyvale, Mountain View, Los Altos, Palo Alto, and Menlo Park. This bus corridor, now served by VTA's Line 22 is VTA's most popular, carrying approximately 20,000 riders per day, or 20% of VTA's total bus ridership. The line operates near capacity with many buses operating with room only for standees. Line 22 is supplemented by Line 300, a limited stop express service along generally the same corridor. Lines 22/300 connect with regional rail services as well as 55 VTA bus lines. A major connection occurs in downtown San Jose, where Line 22 intersects the north-south Guadalupe Light Rail Line.

VTA's Line 522 will replace Limited Stop Line 300 and supplement Line 22, providing faster, more frequent, and more direct service between Eastridge in San Jose and the Palo Alto Transit Center (Figure 6). The service will combine state-of-the-art technology and service enhancements. In comparison to current Line 300 and Line 22 schedules, travel times may be reduced between 10 and 25 percent. VTA's vision for Lines 22/300 is that they operate as an integrated Bus Rapid Transit Corridor. To achieve this vision, VTA is implementing a variety of improvements by providing the following features (29):

Project Features

- Faster, more reliable service
- Better passenger information and security at stops
- Queue jump lanes at congested locations
- Advanced communication system
- Signal prioritization for buses to reduce delay
- Improved passenger facilities at stops
- High capacity, easy-access, and cleaner buses
- More frequent and direct service

<u>Transit Signal Priority (TSP)</u> ─ Provides an advantage for buses when traveling through intersections, by extending green traffic signals or reducing the red phase of traffic signals when a bus is approaching. The TSP system along El Camino Real from Palo Alto to Race Street in San Jose was developed and installed by the California Department of Transportation (Caltrans) in collaboration with VTA. TSP will be installed at additional intersections in San Jose in 2005.

Limited Stops — Stops (30 in each direction) will be spaced approximately one-half to one-mile apart compared to stops spaced approximately a quarter-mile apart for local bus service.

Frequent Service (Weekdays and Saturdays) — Frequent service linking VTA's Eastridge, Santa Clara and Palo Alto Transit Centers and bus and light rail lines to businesses and residential areas. Initial service will operate every 15 minutes between 5 a.m. and 9 p.m. on weekdays and 6 a.m. and 8 p.m. on Saturdays. Line 522 will not operate on Sundays.

Headway-Based Schedules — Buses will serve each bus stop approximately every 15 minutes. However, unlike all other VTA Bus lines, Line 522 buses will travel as fast as traffic and signals allow, meaning buses will not sit idle at bus stops when ahead of published time-schedules.

Queue-Jump Lanes — These special lanes will allow buses to bypass traffic at congested intersections, by making use of an exclusive right-turn lane and a "receiving" lane across the intersection. Initial queue-jump lanes are located at the Page Mill Road and Arastradero intersections in Palo Alto.

All Low-Floor Buses — These buses will allow for quick and easy passenger boarding and exiting.

Fully Accessible — Line 522 service will be fully accessible in accordance with the Americans with Disabilities Act (ADA).

Project Schedule & Costs

Phase One (Line 522) — Improved service in the El Camino/Santa Clara Street/Alum Rock Avenue corridor will include Transit Signal Priority, limited stops, frequent service, headway-based schedules, queue jump lanes and near-level boarding. Service is anticipated to begin in July 2005.

The budget for the first phase of Line 522 service is $3.5 million. This includes $1.6 million in funding from the Bay Area Air Quality Management District's Transportation Fund for Clean Air for queue-jump lanes and Transit Signal Priority implementation.

<u>Next Phase</u> ─ Line 522 service is the pre-curser to Bus Rapid Transit (BRT) service in Santa Clara County. The 2000 Measure A includes $30 million to design and construct BRT corridors in Santa Clara County. Future improvements will include permanent rail-like stations, more intersections with Bus Signal Priority, real-time station display information, new higher capacity vehicles, exclusive bus lanes, and off-vehicle fare payment. Along with the El Camino/Santa Clara Street/Alum Rock Avenue corridor, Stevens Creek Boulevard and Monterey Highway have been identified as potential BRT corridors.

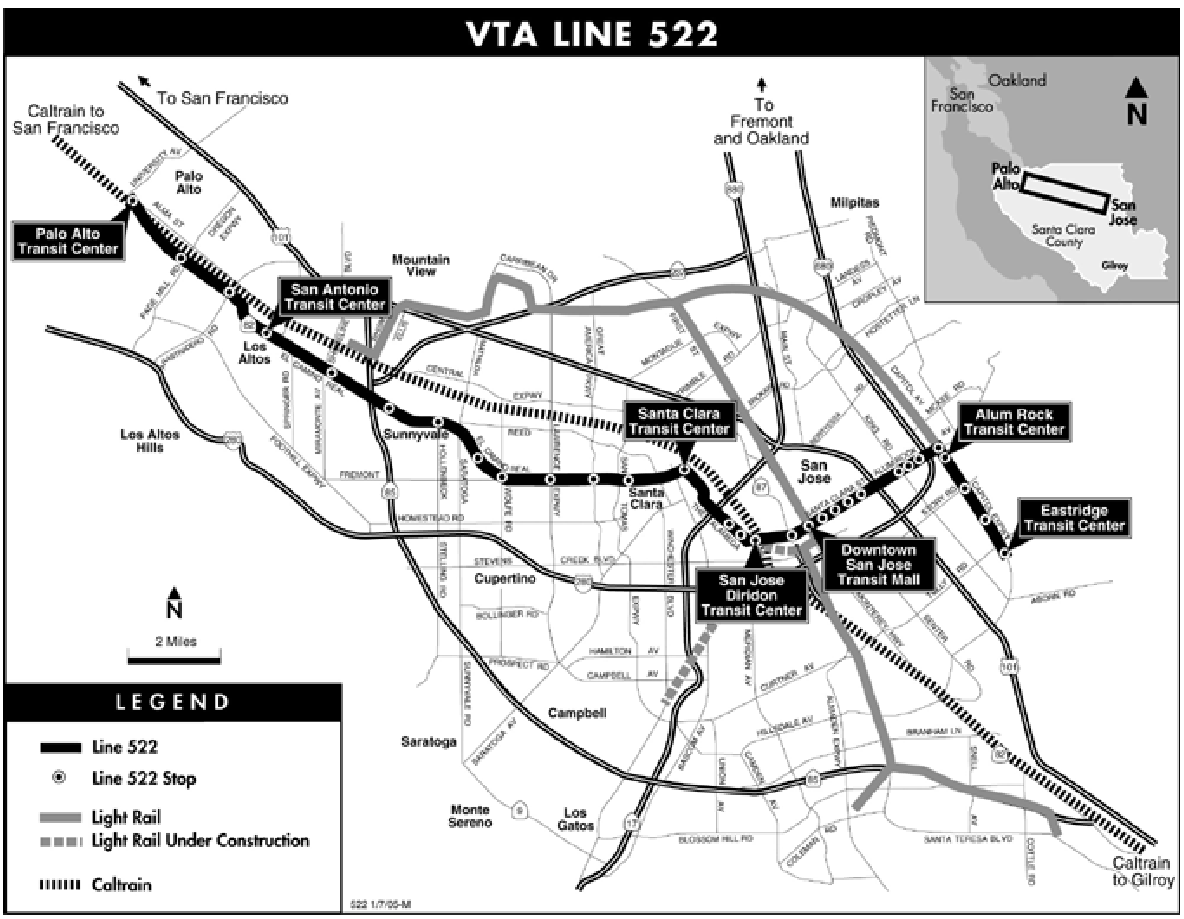


FIGURE 6 Santa Clara Valley Transportation Authority Line 522

5.4.2 San Mateo County Transit District

San Mateo County Transit District (SamTrans) is currently studying the potential impacts of transit signal priority systems along routes 390 and 391 on SR 82. It is also in the early planning stages for its Enhanced Bus Network Service. A brief discussion is provided in Section 5.2.3 with a more complete description in (26).

5.5 Demand for Bus Rapid Transit on the SR 82 Corridor

It has been previously noted that the average weekday ridership for SamTrans Line 390 and VTA's Line 22 are, respectively, 13.2 K and 20.0 K. Both San Mateo and Santa Clara counties are each individually moving toward implementing enhanced bus transit services along SR 82 (Sections 5.2.3 and 5.4). In Santa Clara County, such services are referred to as bus rapid transit and are substantively more comprehensive, definitive, and nearer-term than plans under development by SamTrans. Nonetheless, there is momentum toward bus rapid transit along the SR 82 corridor in San Mateo County as well. It is implicit from these individual developments that there is sufficient demand to implement bus rapid transit systems on SR 82 within each of these two counties. Development plans for bus rapid transit by VTA and SamTrans have proceeded fairly independently of each another. Currently, the only development area of overlap for VTA and SamTrans is consideration of transit signal priority.

5.5.1 Examining the Level of Inter- and Intra-County Travel

Because VTA and SamTrans are each separately determining their own bus rapid transit systems/enhanced bus service operations, the question of demand for bus rapid transit along the SR 82 corridor essentially reduces to examining the level of inter-county versus intra-county travel along the peninsula on SR 82 to determine whether a single inter-county bus rapid transit system is warranted traversing San Francisco, San Mateo and Santa Clara Counties. That is, to what degree does there exist an unmet public transit service need across jurisdictional boundary lines on the peninsula of the San Francisco Bay Area? Two approaches can be used for this examination: microscopic and macroscopic.

At the more microscopic level, we would require information dealing with the level of transfer activity between SamTrans' Line 390 and VTA's Line 22, in particular, at the Stanford Transit Center, which is the primary transfer point for these two transit lines. While surveys have been conducted on-board both Line 390 and 22 buses, the level of transfer activity has not been documented. There is anecdotal information indicating that such levels are not insignificant, yet such data has not been quantified. This would require special studies that have not yet been performed (give a reference here indicating conversations with SamTrans and VTA).

At the more macroscopic level, we considered the level of inter-county travel for San Francisco, San Mateo, and Santa Clara Counties. Various measures of travel were compiled and are shown in Tables 7 through 14. We observe in Tables 7 and 8 that in terms of the number of commuters traveling between their county of residence and county of work, between approximately 60% and 90% of such commuters live and work in the same Peninsula County (San Francisco, San Mateo, or Santa Clara). The Year 2000 was used as a Base Year while data for all other years was forecasted by the Metropolitan Transportation Commission.

TABLE 7 County-to-County Commuters in San Francisco Bay Area Peninsula Counties 2000-2030 (in 1000s)

County of Residence	County of Work	2000	2010	2020	2030
San Francisco	San Francisco	*321.9*	*328.6*	*362.0*	*402.8*
San Francisco	San Mateo	43.3	46.3	50.9	57.1
San Francisco	Santa Clara	15.9	18.0	16.1	16.3
San Mateo	San Francisco	71.7	72.6	83.4	87.5
San Mateo	San Mateo	*206.1*	*218.9*	*252.6*	*267.7*
San Mateo	Santa Clara	55.5	61.7	61.9	61.9
Santa Clara	San Francisco	7.9	7.3	10.7	12.5
Santa Clara	San Mateo	40.7	39.5	53.3	60.9
Santa Clara	Santa Clara	*727.9*	*762.4*	*932.3*	*1,031.2*

Source: "Commuter Forecasts for the San Francisco Bay Area 1990-2030", Planning Section of Metropolitan Transportation Commission, May 2004 (30).

TABLE 8 Share of Commuters Living and Working in County-of –Residence in San Francisco Bay Area Peninsula Counties 2000-2030

County of Residence	2000	2010	2020	2030
San Francisco	77.5%	77.2%	77.9%	77.7%
San Mateo	58.5%	58.9%	60.3%	60.8%
Santa Clara	88.2%	89.2%	87.9%	87.4%

Source: "Commuter Forecasts for the San Francisco Bay Area 1990-2030", Planning Section of Metropolitan Transportation Commission, May 2004 (30).

More detailed and consistent findings are shown in Tables 9 and 10, which depict the level of home-based work trips by mode for peninsula counties again for Base Year 2000 and two forecasted years (2015 and 2030). Once again, intra-county home-based work trips far exceed inter-county home-based work trips across each travel mode. Of particular importance are the entries for the Drive Alone mode.

TABLE 9 Intra-County Home-Based Work Trips by Mode for Peninsula Counties for 2000 Base Year and for 2015 and 2030 Forecast Years (in 1000s)

County (Production-Attraction)	Year	Drive Alone	Shared Ride 2-Person	Shared Ride 3 or more	Transit	Bicycle	Walk	Total
SF-SF	2000	180.3	42.8	13.1	193.4	13.8	67.1	510.6
SF-SF	2015	186.9	46.5	14.1	219.5	15.3	71.0	553.3
SF-SF	2030	222.2	57.3	16.8	263.1	19.8	86.8	666.0
SM-SM	2000	265.5	31.8	9.5	7.3	3.0	12.0	329.2
SM-SM	2015	284.8	33.9	9.8	8.2	3.5	12.5	352.8
SM-SM	2030	338.6	41.8	11.7	10.6	4.7	16.6	424.0
SC-SC	2000	949.1	120.4	29.5	46.3	16.7	21.7	1,183.8
SC-SC	2015	1,122.8	149.7	35.1	62.8	21.3	26.3	1,418.0
SC-SC	2030	1,348.6	191.5	43.2	83.6	29.3	35.4	1,731.6

SF = San Francisco
SM = San Mateo
SC = Santa Clara

Source: "Travel Forecasts for the San Francisco Bay Area 1990 – 2030 Data Summary", Planning Section of Metropolitan Transportation Commission, January 2005 (31).

TABLE 10 Inter-County Home-Based Work Trips by Mode for Peninsula Counties for 2000 Base Year and for 2015 and 2030 Forecast Years (in 1000s)

County (Production-Attraction)	Year	Drive Alone	Shared Ride 2-Person	Shared Ride 3 or more	Transit	Bicycle	Walk	Total
SF-to-SM	2000	56.5	7.6	2.3	4.7	0.4	0.5	72.1
SF-to-SM	2015	56.3	7.6	2.2	6.5	0.5	0.6	73.6
SF-to-SM	2030	56.0	8.0	2.1	6.9	0.7	0.8	74.4
SM-to-SF	2000	64.3	13.3	5.5	40.9	0.2	0.4	124.6
SM-to-SF	2015	61.6	13.5	5.8	44.8	0.3	0.5	126.4
SM-to-SF	2030	72.4	16.0	6.7	48.0	0.4	0.6	144.1
SF-to-SC	2000	18.4	3.4	1.6	2.1	0.0	0.1	25.5
SF-to-SC	2015	13.2	2.1	0.9	3.8	0.0	0.0	20.0
SF-to-SC	2030	12.3	2.2	0.9	4.1	0.0	0.0	19.6
SC-to-SF	2000	8.3	1.5	0.7	3.3	0.0	0.0	13.9
SC-to-SF	2015	5.8	0.9	0.4	4.9	0.0	0.0	12.0
SC-to-SF	2030	7.3	1.3	0.6	7.6	0.0	0.0	16.9
SC-SM	2000	51.1	7.0	0.9	2.8	0.6	0.2	62.6
SC-SM	2015	64.6	9.3	1.3	5.1	0.7	0.2	81.2
SC-SM	2030	80.5	12.7	1.7	7.5	1.1	0.3	103.8
SM-SC	2000	89.4	9.8	2.1	4.5	1.5	0.6	107.8
SM-SC	2015	89.6	9.9	2.0	5.0	1.6	0.5	108.6
SM-SC	2030	97.1	11.2	2.3	5.8	2.2	0.6	119.1

Source: "Travel Forecasts for the San Francisco Bay Area 1990 – 2030 Data Summary", Planning Section of Metropolitan Transportation Commission, January 2005 (31).

Additional information is shown in Tables 11 and 12, which depict the level of total person trips (work and non-work) trips by mode for peninsula counties again for Base Year 2000 and forecasted years 2015 and 2030. Once again, the number of total intra-county personal trips far exceeds such inter-county trips across each travel mode. Of particular importance are the entries for the Drive Alone mode.

TABLE 11 Intra-County Total Personal Trips (Work + Non-Work) by Mode for Peninsula Counties 2000 Base Year and for 2015 and 2030 Forecast Years (in 1000s)

County (Production-Attraction)	Year	Vehicle Driver	Auto (Persons in Vehicles)	Transit	Bicycle	Walk	Total
SF-SF	2000	706.5	910.6	515.0	29.5	674.8	2,130.0
SF-SF	2015	785.3	1,036.6	615.6	35.8	817.3	2,505.3
SF-SF	2030	899.1	1,170.4	688.3	40.4	907.7	2,806.8
SM-SM	2000	1,157.6	1,548.6	18.4	26.7	174.2	1,767.9
SM-SM	2015	1,354.7	1,804.8	16.7	29.4	206.2	2,057.1
SM-SM	2030	1,522.5	2,007.0	20.1	30.5	227.2	2,284.8
SC-SC	2000	3,559.5	4,783.8	147.1	97.6	303.1	5,331.6
SC-SC	2015	4,191.2	5,651.8	185.1	113.9	364.2	6,315.1
SC-SC	2030	4,865.4	6,501.6	235.6	128.8	415.9	7,281.9

Source: "Travel Forecasts for the San Francisco Bay Area 1990 – 2030 Data Summary", Planning Section of Metropolitan Transportation Commission, January 2005 (31).

TABLE 12 Inter-County Total Personal Trips (Work + Non-Work) by Mode for Peninsula Counties for 2000 Base Year and for 2015 and 2030 Forecast Years (in 1000s)

County (Production-Attraction)	Year	Vehicle Driver	Auto (Persons in Vehicles)	Transit	Bicycle	Walk	Total
SF-to-SM	2000	184.0	229.4	11.5	2.1	3.9	246.9
SF-to-SM	2015	172.4	214.8	12.1	2.0	4.5	233.4
SF-to-SM	2030	176.1	219.9	13.0	2.2	5.1	240.3
SM-to-SF	2000	231.0	294.2	50.2	5.1	2.6	352.1
SM-to-SF	2015	253.9	327.9	56.0	6.0	2.9	392.7
SM-to-SF	2030	280.0	360.3	60.4	6.6	3.2	430.5
SF-to-SC	2000	34.0	39.7	2.1	0.0	0.2	42.0
SF-to-SC	2015	21.1	24.7	4.0	0.0	0.0	28.8
SF-to-SC	2030	20.0	23.6	4.2	0.0	0.0	27.9
SC-to-SF	2000	20.1	25.6	3.3	0.0	0.0	29.0
SC-to-SF	2015	27.1	36.4	6.6	0.0	0.0	43.0
SC-to-SF	2030	29.6	39.7	9.9	0.0	0.0	49.6
SC-SM	2000	152.4	190.1	5.1	1.5	1.1	197.8
SC-SM	2015	197.8	248.7	7.1	1.9	1.3	259.0
SC-SM	2030	241.1	304.4	10.2	2.4	1.5	318.5
SM-SC	2000	196.1	234.7	5.2	3.6	4.1	247.6
SM-SC	2015	194.1	233.1	5.7	3.9	4.5	247.2
SM-SC	2030	206.0	246.4	6.6	4.4	4.7	262.1

Source: "Travel Forecasts for the San Francisco Bay Area 1990 – 2030 Data Summary", Planning Section of Metropolitan Transportation Commission, January 2005 (31).

Thus, because cross-county travel is such a small fraction of total travel among the three counties, it appears as though inter-county travel demand may not be sufficiently great to warrant a single integrated bus rapid transit line traversing the Bay Area's peninsula counties without additional investigation at the corridor level, which, in terms of specific levels of transfer activity between SamTrans' Line 390 and VTA's Line 22, has not yet been performed by SamTrans or VTA.

Another macroscopic indicator of the level of inter-county travel is average trip length. In Tables 13 and 14 the average trip lengths are shown for home-based work trips for different areas of residence and areas of work, respectively, in San Francisco, San Mateo, and Santa Clara Counties. Factoring in the size of each of three peninsula counties, these average trip lengths are consistent with data shown in earlier tables indicating that the volume of intra-county travel far outweighs its inter-county counterpart.

TABLE 13 Average Trip Length for Home-Based Work Trips by Areas-of –Residence in San Francisco Bay Area Peninsula Counties 2000-2030 (miles)

Superdistrict of Residence (County)	2000	2015	2030
San Francisco CBD (SF)	3.9	3.6	4.8
Richmond District (SF)	6.6	6.1	6.0
Mission District (SF)	8.1	7.2	6.9
Sunset District (SF)	8.6	7.8	7.5
Daly City/San Bruno (SM)	10.8	10.1	10.0
San Mateo/Burlingame (SM)	11.6	11.1	11.7
Redwood City/Menlo Park (SM)	9.8	9.6	9.6
Palo Alto/Los Altos (SC)	7.5	7.3	7.4
Sunnyvale/Mountain View (SC)	7.6	7.4	7.5
Saratoga/Cupertino (SC)	10.0	9.7	9.7
Central San Jose (SC)	8.4	8.1	8.0
Milpitas/East San Jose (SC)	10.5	10.3	10.1
South San Jose/Almaden (SC)	12.2	11.9	11.6

Source: "Travel Forecasts for the San Francisco Bay Area 1990 – 2030 Data Summary", Planning Section of Metropolitan Transportation Commission, January 2005 (31).

TABLE 14 Average Trip Length for Home-Based Work Trips by Areas-of–Work in San Francisco Bay Area Peninsula Counties 2000-2030 (miles)

Superdistrict of Work (County)	2000	2015	2030
San Francisco CBD (SF)	15.1	15.8	16.0
Richmond District (SF)	7.3	8.4	7.4
Mission District (SF)	9.6	10.5	9.7
Sunset District (SF)	6.9	7.1	6.2
Daly City/San Bruno (SM)	13.6	16.0	21.2
San Mateo/Burlingame (SM)	11.6	14.0	15.1
Redwood City/Menlo Park (SM)	13.1	15.0	14.3
Palo Alto/Los Altos (SC)	12.2	13.9	13.7
Sunnyvale/Mountain View (SC)	12.4	13.5	13.2
Saratoga/Cupertino (SC)	10.2	10.9	11.0
Central San Jose (SC)	9.3	10.2	10.0
Milpitas/East San Jose (SC)	10.4	10.9	10.2
South San Jose/Almaden (SC)	10.9	11.5	11.3

Source: "Travel Forecasts for the San Francisco Bay Area 1990 – 2030 Data Summary", Planning Section of Metropolitan Transportation Commission, January 2005 (31).

5.5.2 The Interface Between SamTrans and VTA: The Palo Alto Intermodal Transit Center

VTA's new BRT, Line 522, will range between Eastridge Transit Center in San Jose and the Palo Alto Transit Center in the northern part of the county. For SamTrans, its new Enhanced Bus Service will range from Daly City in the north to the Palo Alto Transit Center in the south just across the Santa Clara county line. Thus the Palo Alto Transit Center is at the crux of where the two separate county BRT efforts would overlap; it is already the primary transfer point between VTA (Line 22) and SamTrans (Line 390) and would likely continue in this role.

Even if the level of existing and potential cross-county demand warranted consideration of a corridor-wide bus rapid transit system, it could be implemented by 1) establishing a single integrated system or 2) maintaining already existing separate services including the transfer. The former would likely bring into play numerous institutional stakeholders along the corridor with a diverse and potentially conflicting set of priorities that would have to be reconciled. The latter would necessitate a continued focus on the transfer process to make it as seamless as possible in order to minimize adverse travel behavior due to penalties associated with various actions required of passengers during the transfer process, such as out-of-vehicle waiting time.

Based on peninsula-area transportation developments over the past five years, there is consensus to continue maintaining separate county-wide enhanced bus transit services along SR 82 coupled with redevelopment plans to transform the Palo Alto Transit Center/Caltrain Station into a major intermodal transportation hub on the peninsula with the objective of increasing train, bus, bicycle, and pedestrian interconnectivity. With an estimated improvement cost of approximately $200 million of which $50 million have been allocated from Santa Clara County Measure A funds, the plan would involve numerous stakeholders including rail operators, bus operators, the City of Palo Alto, Stanford University, and private property owners. If fully implemented, it has the potential to greatly contribute to providing a seamless connection among the various transit alternatives that converge at the Palo Alto Transit Center, in particular, between the VTA and SamTrans bus rapid transit systems (32).

Work began in late 2004 on the near-term improvements to reconstruct the Palo Alto Caltrain Transit Center and is expected to be complete by summer 2005. The reconstruction will improve links between Caltrain and bus service, as well as accommodate additional buses operated by VTA, SamTrans, and the Dumbarton Express, and provide more convenient connections with Stanford's Marguerite shuttle and Palo Alto's local shuttle system. The project adds two new bus bays for Line 22's new articulated buses and provides improved passenger shelters. Project elements include the reconstruction of the University Avenue bridge connecting with Palm Drive, reconstruction and expansion of the Caltrain bridge over University Avenue to include four tracks to allow express train service, and roadway improvements.

5.5.3 Challenges to Implementing Bus Rapid Transit Along the SR 82 Corridor

The primary challenges to implementing bus rapid transit along the El Camino Real corridor in San Mateo and Santa Clara Counties deal with funding issues and institutional coordination. As a result of each county's separate development efforts in addition to plans for redevelopment of the Palo Alto Transit Center, a bus rapid transit system along the El Camino Real corridor in San Mateo and Santa Clara counties is, de facto, being implemented. Each county's efforts are being built in an incremental and step-by-step fashion. While plans have been developed for these separate systems as well as for their primary interface at the Palo Alto Intermodal Transit Center, all funding sources have not been identified and so full funding has not yet been secured for these projects. Part of the funding derives from monies raised through county and regional ballot measures approved by the voters such as sales tax increases and bridge toll increases (Santa Clara County Measure A in 2000 and Regional Measure 2 in 2004). The amount of money raised through such means is also dependent on the overall state of the economy in the Bay Area, which has experienced a downturn over the last few years.

As we previously discussed in Section 5.3, SamTrans and VTA currently do engage in some schedule coordination between Lines 390 and 22, respectively, especially during off-peak periods when bus headways are longer and the penalty for missing a connecting bus is greater. To help increase the likelihood that inter-county bus rapid transit service will be successful, focus will have to be placed on making the connection between SamTrans' and VTA's BRT service at the Palo Alto Transit Center as seamless as possible and making the entire trip as close to a single-seat-trip as possible. Schedule coordination will likely have to be enhanced and fare coordination should be considered as well to foster the trip's seamlessness.

5.6 Findings and Recommendations

Our objective in conducting this case study has been to explore the prospects of a bus rapid transit system being implemented along SR 82 in San Mateo and Santa Clara Counties of the San Francisco Bay Area. SamTrans and VTA are each moving forward with development plans to implement enhanced bus transit services within the jurisdictional boundaries of their respective counties primarily along El Camino Real. In Santa Clara County, VTA's bus rapid transit system is already under construction while in San Mateo County, SamTrans' plans for enhanced bus transit services along El Camino Real, are in the planning stages only. Nonetheless, there is momentum toward bus rapid transit along the SR 82 corridor in San Mateo County as well. While VTA and SamTrans have each individually determined that there is sufficiently great demand for bus rapid transit along the El Camino Real corridor within each of their counties, the question remains as to whether a single integrated corridor-wide bus rapid transit system spanning Santa Clara and San Mateo Counties is justified, that is, is there sufficient demand across the county line to modify the existing setup of two separate county-wide systems? From a macroscopic point of view, it appears as though there is not sufficient demand between San Mateo and Santa Clara counties to justify such a single integrated system, that is, a single-seat system with no transfer between VTA and SamTrans; it would take additional and more microscopic analyses to be conducted to more accurately answer this question that were beyond the scope of this investigation. It is recommended that such analyses, if performed, consider, at a minimum, the following tasks:

- Origin-Destination survey of passengers on board VTA's Line 22 and SamTrans' Line 390 to learn where passengers board and alight the buses; this data will also allow bus passenger trip lengths and the exact nature of transfer activity between Line 22 and Line 390 to be determined.
- Peninsula-wide broad area survey (home-based) to capture data from general population as to the public's usage and non-usage of public transportation along the peninsula, origin-to-destination trip length and locations.
- Peninsula-wide survey of US 101 drivers inquiring as to why drivers do not take Caltrain, an already existing public transportation mode along the peninsula; or some other form of public transportation or if they have taken it, why not anymore?
- At the level of travel analysis zone data available from MTC, an origin-to-destination analysis to determine more microscopically the volume of inter and intra-county travel and trip length.
- Impact assessment of Caltrain's Baby Bullet Service over time to determine the degree people are giving up their SOVs (or HOVs) on US 101 to take the new service.

If a single bus rapid transit system is truly not justified, then the current environment would remain unchanged with two separate systems implemented; focus would then be placed on the Palo Alto Transit Center/Caltrain Station, currently, the primary transfer point between Line 22 and Line 390. Redevelopment plans already exist to transform the Palo Alto Transit Center/Caltrain Station into a major intermodal transportation hub on the peninsula. The more conservative approach would be to perform additional analyses to more accurately understand the level of cross-county passenger demand and eventually evaluate the performance of the system consisting of the two separate county BRT systems joined in as seamless a way as possible by means of the Palo Alto Intermodal Transit Center.

5.7 Partnering Opportunities and Role of Caltrans to Build and Operate Bus Rapid Transit on SR 82

The case study analysis has shown that there are two primary alternatives for implementing bus rapid transit along the El Camino Real corridor of SR 82: 1) Two-system solution joined as seamlessly as possible at the Palo Alto Intermodal Transit Center and 2) A single integrated system. When planning for the implementation of bus rapid transit in either of these two contexts, the two transit agencies ─ VTA and SamTrans ─ and Caltrans will, at a minimum, play primary roles.

In the first option, VTA and SamTrans would each work with Caltrans (Headquarters and District 4) as well as local/municipal departments of traffic whose political jurisdictions SR 82 passes through, in particular, to implement transit signal priority. At the Palo Alto Intermodal Transit Center, which is located in Santa Clara County, Caltrain would participate as another major player. Currently at the Palo Alto Transit Center/Caltrain Station, there are other participants, including Stanford Marguerite Shuttle, Dumbarton Express, and the Palo Alto Cross-town Shuttle. If fully implemented, the Palo Alto Intermodal Transit Center would involve these stakeholders as well as the City of Palo Alto, Stanford University, and private property owners. At this point it is unclear whether it would be necessary to have one of the three partners take the lead role, and, if so, which of the two transit agencies or Caltrain would be the lead. However, as previously noted in Section 5.1.1, Caltrain is a tri-county partnership of San Francisco Municipal Railway, SamTrans, and VTA owned and operated by the Peninsula Corridor Joint Powers Board (JPB), itself a partnership of San Francisco, San Mateo, and Santa Clara counties with management oversight provide by SamTrans. Therefore, essentially SamTrans and VTA are the core participants, even if Caltrain continues to take a lead role at the intermodal transit center.

In the second option, an institutional arrangement different than currently exists between SamTrans and VTA would likely be necessary. In this case, the arrangement for Caltrain along the corridor could offer an institutional model to consider for a possible corridor-wide bus rapid transit system involving SamTrans and VTA (See Section 5.1.1 for a description of this institutional model). However, in this case, Caltrans District 4 would likely take on a major participatory role with the transit agencies.

6.0 EXPLORING BUS RAPID TRANSIT AND LIGHT RAIL TRANSIT

Bus rapid transit has been successfully implemented in many cities around the world including the United States as well as in California (See Table 1 for a list of these systems and Appendix A for a description of their current state). The selection of bus rapid transit as the locally preferred alternative in these various municipalities has normally, though not always, been the result of an analysis of modal alternatives by means of a Major Investment Study in the transportation planning process. It should be noted however that it is not the case that each modal alternative is always considered as a competing candidate in the MIS process and BRT, when considered as a feasible choice, may in some instances be competing directly with a rail alternative while in other instances competing against only non-rail alternatives, depending on the local circumstances that exist (33). Nevertheless, there has not been any lack of discussion of and comparison between BRT and LRT because, for example, "in most North American urban corridor applications, the BRT service pattern that appears to work best features all-stop 'LRT-type' service at all times of day, complemented by an overlaid integrated local/express services for specific markets during peak periods." The authors in (33) continue to say that a comparison of BRT with LRT is most appropriate in the setting in which buses operate in combinations of exclusive rights-of-way, median reservations, bus lanes, and arterial streets.

Bus rapid transit and light rail transit may be compared from many different perspectives including measures that are readily quantifiable and others that allow primarily qualitative comparisons.

In 2001, the General Accounting Office (GAO) performed a comparative analysis of bus rapid transit with light rail transit primarily based on an assessment of their *capital* and *operating* costs, yet also examining other characteristics of these two transit modes including flexibility, ease with which it could be phased in to service, stimulus for community economic development, and environmental aspects (34). A total of 38 BRT systems in the U.S. including demonstration projects and operational systems were examined. The analysis performed in the GAO study was based on a conceptual framework that classified bus rapid transit systems in terms of their running ways, that is, whether a BRT system operated on 1) surface streets in mixed traffic, 2) dedicated lanes, 3) high-occupancy vehicle lanes or 4) grade-separated busways. Findings from the GAO report states that the average capital cost per mile of LRT ranges from 1.5 to 50 greater than the equivalent cost of BRT, depending on the degree of implementation of BRT elements (Table 15).

TABLE 15 Bus Rapid Transit and Light Rail Transit Capital Costs per Mile ($2001)

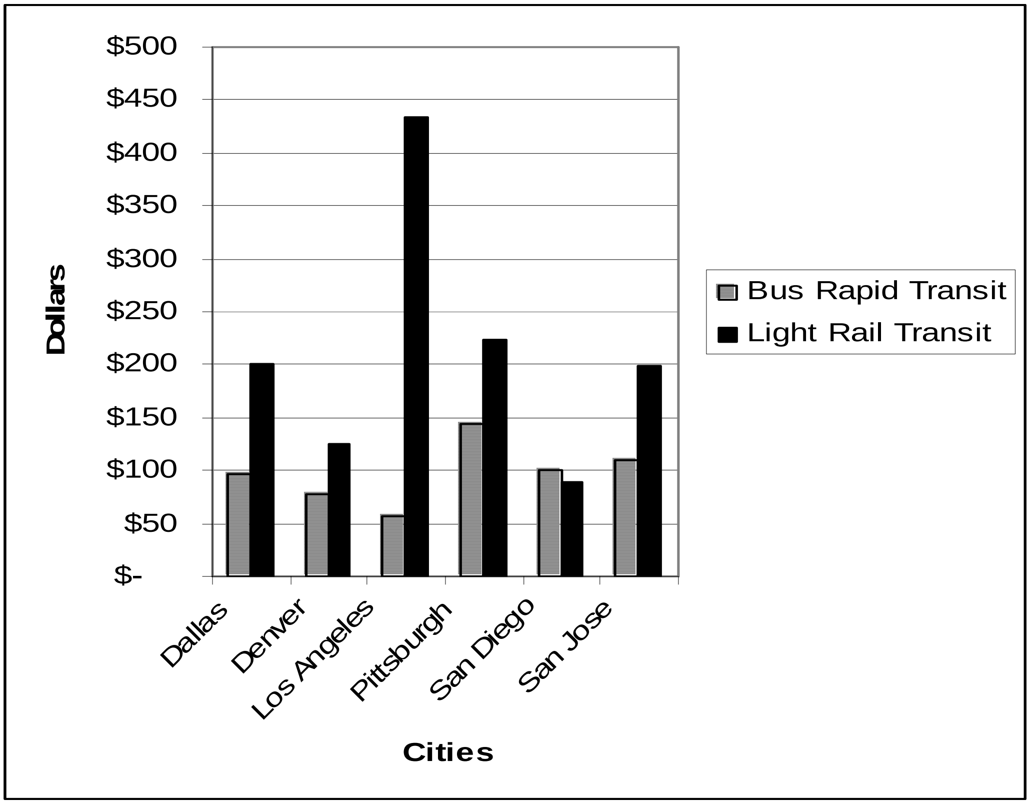
Travel Mode	Number of Facilities	Range of Costs	Average Cost
Bus Rapid Transit			
Arterial Streets	3	$0.2 M - $9.6 M	$0.68 M
HOV Lanes	8	$1.8 M - $37.6 M	$9.0 M
Busways	9	$7.0 M - $55.0 M	$13.5 M
Light Rail Transit	18	$12.4 M - $118.8 M	$34.8 M

Source: "Mass Transit Bus Rapid Transit Shows Promise", U.S. General Accounting Office, GAO-01-984, September 2001 (34).

For operating costs, results were somewhat more mixed and varied due at least in part to the fact that the BRT systems that the GAO studied operate in different ways. For the analysis of operating costs, the GAO considered six cities in which both bus rapid transit and light rail transit are operational including Dallas, Denver, Los Angeles, Pittsburgh, San Diego, and San Jose. The performance measures used included:

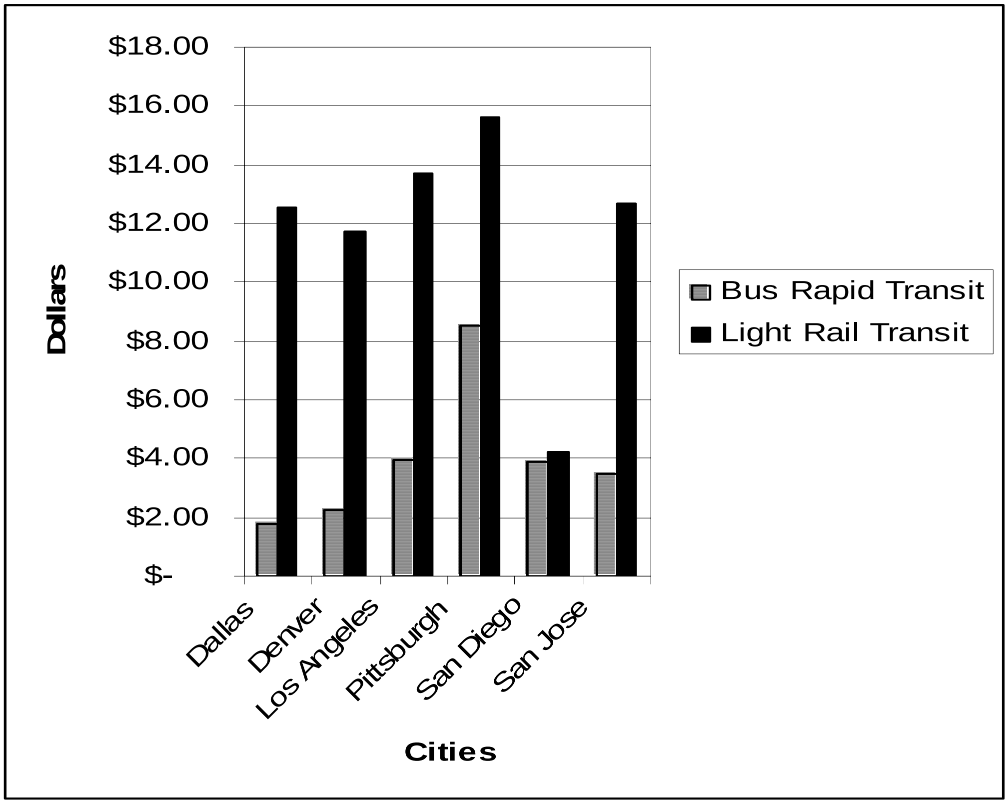
- Operating cost per vehicle hour
- Operating cost per revenue mile
- Operating cost per passenger trip

The following three figures (Figure 7 -9) show the varied results from comparing operating costs for bus rapid transit and light rail transit.



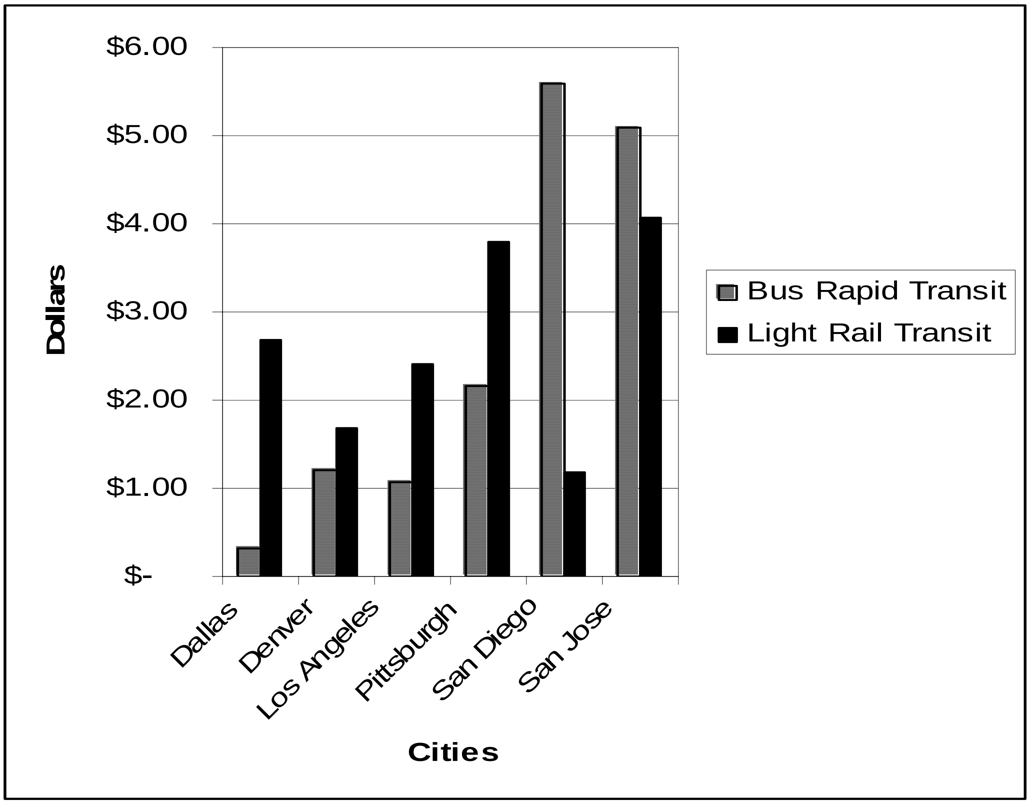
Source: "Mass Transit Bus Rapid Transit Shows Promise", U.S. General Accounting Office, GAO-01-984, September 2001 (34).

FIGURE 7 Operating Cost per Vehicle Revenue Hour (1999)



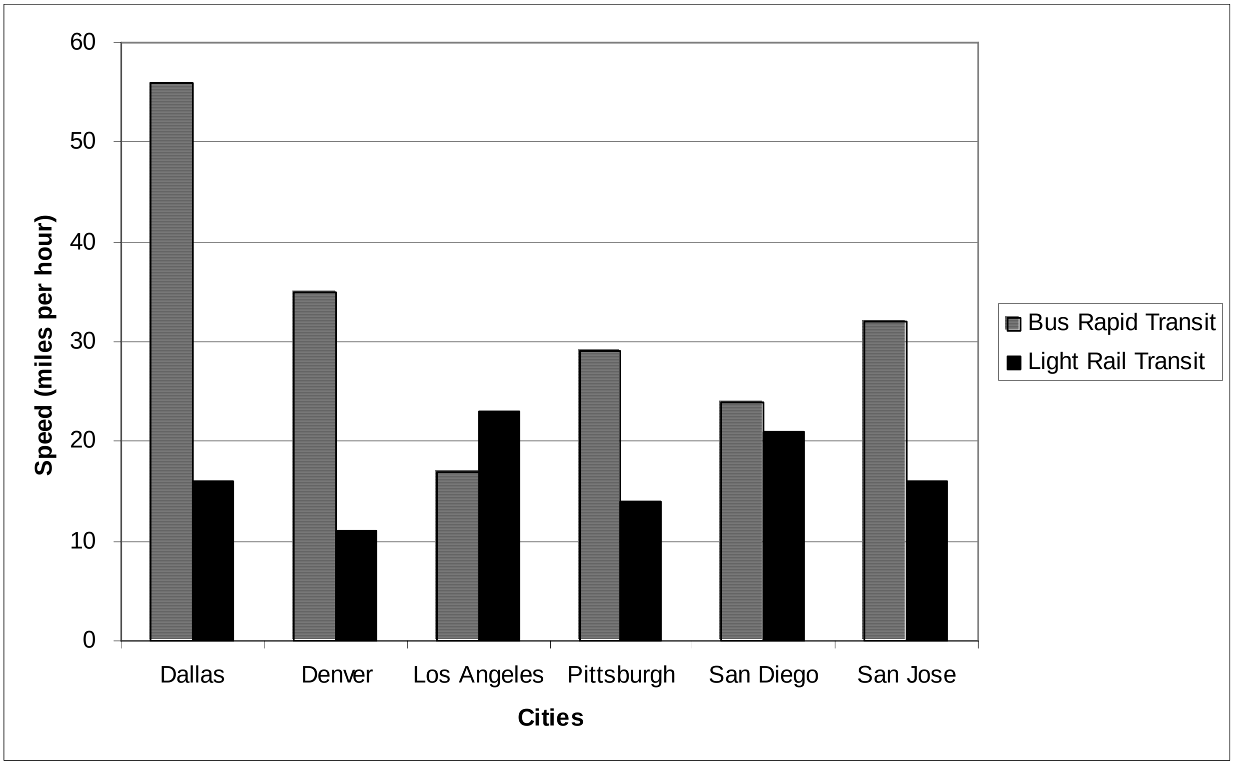
Source: "Mass Transit Bus Rapid Transit Shows Promise", U.S. General Accounting Office, GAO-01-984, September 2001 (34).

FIGURE 8 Operating Cost per Vehicle Revenue Mile (1999)



Source: "Mass Transit Bus Rapid Transit Shows Promise", U.S. General Accounting Office, GAO-01-984, September 2001 (34).

FIGURE 9 Operating Cost per Unlinked Passenger Trip (1999)



Source: "Mass Transit Bus Rapid Transit Shows Promise", U.S. General Accounting Office, GAO-01-984, September 2001 (34).

FIGURE 10 Average Speed of Bus Rapid Transit and Light Rail Transit Services (1999)

Other high-level findings from the GAO Report on a comparison between bus rapid transit and light rail transit include:

- BRT generally has advantages
  - Having more flexibility than LRT
  - Being able to phase in service rather than having to wait for an entire system to be built
  - Being used as an interim system until light rail is built, if desired.
- BRT has disadvantages
  - Dealing with the negative image potential riders attach to buses regarding their noise, pollution, and quality of ride
- LRT has advantages
  - Increased economic development and improved community image
- LRT has disadvantages
  - Tendency to provide a bias toward building future rail lines

There are passionate advocates on each side of this modal debate. In fact, just in terms of the flexibility attribute associated with bus rapid transit, the author in (35) states that

"On one end of the spectrum, some planners have become BRT advocates, saying that it is always superior to LRT. BRT uses vehicles that have rubber tires and can be steered, thus providing implementation, operating and passenger service flexibility unachievable with LRT. At the other end of the spectrum, there are planners that denigrate BRT, saying that it is always a second choice for precisely the same reasons; it is so flexible that it is difficult to assure the permanently high quality of service that both potential passengers and real estate developers demand."

As the author continues to state, "The fact is that no single type of rapid transit investment will be ideal in all situations. Each potential rapid transit application should be planned on a case-by-case basis, with an unbiased, objective and comprehensive analysis of all reasonable and feasible options both rail-bound and flexible rubber-tired, for the given corridor or sub-area situation. The criteria used to compare rapid transit investments should reflect the investment goals and objectives held by decision makers and the public. Criteria will, of course, include capital, operating and maintenance costs, direct impacts and transportation system performance".

Consistent with these views, we see from the authors in (36) that

"Reviewing bus and rail rapid transit attributes provides an opportunity to explore the continuum available in terms of technology and its application. With regard to BRT, it need not ─ and should not ─ be perceived as a low-cost alternative to LRT. Rather, the services offered by the transit industry should be a reflection of the travel desires of the public and the financial capacity to sustain operation. Adopting a context-sensitive design approach for transit investments is more meaningful with BRT in the short list of options."

Thus, even though comparisons between BRT and LRT have been and will likely continue to be made and it appears as though BRT is considerably less expensive than LRT capital costs wise, it is not a forgone conclusion that operating and maintenance costs also favor BRT. Moreover, even under the conditions in which both BRT and LRT are among the short-listed feasible alternatives, other criteria enter into the equation as well such as flexibility, actual and perceived level of permanence; so, it is important to take a holistic and systems approach based on site-specific conditions when performing such a comparative analysis in the context of the transportation planning process. For each corridor all feasible rapid transit alternatives need to be developed and evaluated as objectively as possible since both BRT and LRT system characteristics, performance level, capital and operations and maintenance costs, public support can vary greatly given local circumstances.

7.0 CONCLUSIONS

There are numerous opportunities for bus rapid transit in the San Francisco Bay Area in the context of bus corridors that travel at least part of their routes on the state highway system. Our examination of bus routes that overlap with the state highway system revealed that the routes with the five largest average weekday ridership volumes closely match those corridors for which bus rapid transit initiatives have been taken, ranging from being under preliminary consideration as part of a vision document to being in revenue operation. Current bus rapid transit opportunities lie throughout the Bay Area except in the North Bay counties due mainly to relatively low ridership volumes in this sub-area compared with San Francisco, the East Bay, and the Peninsula/South Bay.

The selection and study of the SR 82 corridor on the Bay Area's peninsula has shown that bus rapid transit activities are in progress on this corridor, though in the context of two distinct systems corresponding to VTA's plans for the new route 522 in Santa Clara County and SamTrans' plans for enhancement to transit service for its Route 390 in San Mateo County. Based on the macroscopic examination (Section 5.5.1), it appears that the level of cross-county travel ─ both current and forecasted ─ does not warrant development of a single and integrated BRT corridor between Santa Clara and San Mateo counties and into San Francisco County. Nonetheless, whether a single integrated corridor or two-system solution is eventually selected to satisfy levels of service needs, institutional cooperation and coordination is needed. It is recommended that the simpler and more conservative approach be taken and maintain the two-system solution, while simultaneously conducting a thorough evaluation to fully understand the tradeoffs between these two alternatives coupled with more accurately determining the level of inter-county demand.

In addition to these bus rapid transit initiatives overlapping with the state highway system, other bus rapid transit initiatives not part of the state highway system are being taken in the Bay Area, primarily studies in San Francisco for BRT along Geary Boulevard and Van Ness and Potrero Avenues. These are being managed under the sponsorship of Muni and the San Francisco Transportation Authority.

In the context of rail transportation in the Bay Area, multi-county regional partnerships have been established and successfully maintained to help satisfy previously unmet transit service needs. Examples include BART, ACE Train, and Caltrain. While Caltrans is not part of BART or Caltrain, Caltrans District 10 does have a voice on the ACE Train's Board of Directors as an ex-officio member. These partnerships have established a precedent for institutional arrangements that may be considered for use in the case of regional/express bus transport along the SR 82 corridor as well as along other corridors. Tradeoffs must also be recognized and expected among the number of participating organizations/stakeholders and the extent of customer benefits and complexity of institutional issues.

This research focused on opportunities for bus rapid transit on the state highway system in the San Francisco Bay Area. Outside the Bay Area, there are currently only a few bus rapid transit systems/busways on the state highway system and each of them is in Los Angeles County under Metro's (formerly Metropolitan Transportation Authority) Metro Rapid system and other bus/transitways along L.A. county freeways. Metro Rapid has one line ─ bus route 761 ─ that is currently operational serving Van Nuys Boulevard between Westwood at UCLA and Lake View Terrace in the San Fernando Valley. Metro Rapid route 761 travels part of its bus route on Interstate 405 with two Metro Rapid stops along the corridor segment on the 405 freeway. The other Metro Rapid route, part of Metro's phased implementation of nearly 20 Metro Rapid routes throughout the county, will be on SR 2 (Santa Monica Boulevard) from the city of Santa Monica to downtown Los Angeles. It is scheduled to be put into revenue service in June 2006 (37). There are two transitways on the state highway system: The El Monte Busway on Interstate 10 runs 12 miles east from downtown Los Angeles and the Harbor Transitway on Interstate 110 runs south for 11 miles from downtown L.A. Complete details on each of these busways may be found in (1). Based on this project's investigation, promising and valuable follow-on research could consist of a statewide investigation of the opportunities of implementing bus rapid transit on the state highway system, particularly the Sacramento, San Diego, and greater metropolitan Los Angeles areas.

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APPENDIX A: STATUS OF CALIFORNIA BUS RAPID TRANSIT SYSTEM ENTERPRISES

Alameda and Contra-Costa Counties

San Pablo Corridor

In June 2003 AC Transit put into revenue service its first bus rapid transit line primarily along the San Pablo Corridor of California Route 123 in the East Bay portion of the San Francisco Bay Area. The BRT line is 14 miles long running through seven cities traveling on a State Highway under Caltrans jurisdiction. AC Transit has named this BRT service the “Rapid” and each Rapid bus stop/shelter and bus is adorned with the same “Rapid” red branding and logo to enhance the visibility of this service. Buses are new 40-footers with low floors and equipped with three doors. Each Rapid Bus stop/shelter is also equipped with a NextBus bus arrival information system. Transit signal priority has also been implemented along the San Pablo Corridor. There are a limited number of stops ─ 26 stops over the 14 mile corridor ─ spaced approximately ½ mile apart. Stops have been moved to the far side of the intersection. There are also queue bypass lanes to allow buses to bypass extensive queues at intersections.

Telegraph Avenue ─ International Boulevard Corridor

AC Transit is planning to implement its second bus rapid transit system along the Telegraph – International Boulevard corridor in the East Bay of the San Francisco Bay Area. Bus Rapid Transit was chosen as the locally preferred alternative as a result of a Major Investment Study that AC Transit conducted along this alignment. The corridor is 18 miles long with a plan for 33 BRT stops at an average stop spacing of approximately 0.55 miles. AC Transit currently estimates that while “most” of the 18-mile alignment will have an exclusive transit lane only 1.5 miles are definitely off-limits because of its potential impact on traffic circulation. More definitive data must wait until the completion of an ongoing Environmental Impact Report for the corridor.

Los Angeles County

Wilshire-Whittier Corridor/Wilshire BRT

After a visit by officials from the Los Angeles County Metropolitan Transportation Authority (MTA) to Curitiba, Brazil to view its bus rapid transit system, MTA commissioned a study to assess the feasibility of BRT in Los Angeles. The study's findings, which initiated the Metro Rapid Program in 1999, recommended that MTA, in partnership with the City of Los Angeles Department of Transportation (LADOT), conduct a demonstration along two to three major arterials that had strong ridership and favorable characteristics for BRT development. In June 2000, MTA and LADOT began the demonstration of its new bus rapid transit service, called Metro Rapid, along two of the city's most heavily traveled urban-suburban corridors in terms of ridership: Wilshire-Whittier Boulevards and Ventura Boulevard corridors. MTA conducted a survey of riders along these corridors to assess riders' points of view about service. Survey findings provided MTA input to develop its goals for service improvement.

MTA's implementation of Metro Rapid along the 27-mile long Wilshire-Whittier corridor was planned for two phases with Phase I consisting of the following elements (modeled after Curitiba's BRT system) operating in mixed traffic:

- Low floor buses fueled by compressed natural gas
- Transit signal priority
- Stops equipped with *Next Bus* message information signs
- Reduced the number of stops from 135 to 30
- Implemented a new operation policies:
    - Faster buses can and are even encouraged to pass slower buses
    - Passengers are encouraged to alight the bus from the backdoor
- Stops placed on the far side of intersections
- Reduced headway to 2.5 minutes during peak periods (7-10 AM, 4-7 PM).
- Introduced prepaid fare payment

- Color-coded Metro Rapid buses and stops/stations using red and white with "Metro Rapid" designated on each bus. Use of this design and colors on vehicles and stations help to promote and instill a unique identity of the service in passengers' minds.

In terms of the level of Metro Rapid's staged deployment, some of the key attributes that MTA wanted to deploy could not be immediately implemented to their full extent due to budgetary and/or institutional constraints. However, MTA wanted to package together and deploy as many BRT attributes as possible as soon as possible in order to make a substantive and positive impression with the public, especially current passengers. This led MTA to reject an FTA suggestion to implement each BRT element separately to more readily determine each element's individual impacts. MTA's concern was that implementing each element separately, instead of making a big splash with the public, would provide benefits in drips and drabs and that this would not be a good marketing strategy. MTA correctly assessed the situation as the Metro Rapid Bus Phase I was hugely successful and contributed to MTA not only receiving a green light for Phase II but also getting the go-ahead for an expansion of the Metro Rapid Program to more than two dozen Metro Rapid Lines throughout the county by 2009. While these Lines will not be configured in exactly the same manner, there is a core set of BRT elements that each will be implemented with.

The entire 27-mile length of Metro Rapid's Wilshire-Whittier corridor was implemented in Phase I however, even within Phase I, additional sub-phases were necessary as not all other BRT elements were deployed along the entire corridor length. For example, signal priority was deployed along the corridor only in the City of Los Angeles, which comprised approximately half the corridor length. Other corridor cities, e.g., Santa Monica, Beverly Hills, initially refused to implement signal priority until they were convinced of demonstrable benefits from it that outweighed relinquishing jurisdictional control over their traffic signals. Instead of requiring an all-or-nothing deployment of signal priority along the whole corridor to accommodate early institutional constraints and thus potentially contributing to many years' delay of the technology, MTA and LADOT opted for full technical deployment though partial institutional deployment. The benefits of transit signal priority have been demonstrated and are being used to convince the other cities to agree to implement signal priority along the entire corridor.

The Phase I Demonstration program has increased speeds, improved reliability, and attracted new riders. However, several areas emerged where additional refinements are desirable:

- Continue to improve bus operating speeds by completing the transit signal priority installation along the corridor outside Los Angeles.
- Introduce exclusive bus lanes where feasible and give priority to arterial segments with chronic, debilitating, traffic congestion delay.
- Provide more passenger capacity by introducing larger vehicles during peak periods rather than increasing service frequency.
- Reduce station dwell times by testing and introducing off-vehicle fare collection systems such as "proof of payment" and introducing high-capacity buses to manage standees within standards and avoid gross aisle congestion delays.

In June 2001, MTA adopted bus rapid transit for the western half of the Wilshire-Whittier corridor, called the Wilshire BRT, as the Locally Preferred Alternative. The MTA completed environmental clearance for this portion of the corridor in August 2002 with construction bids accepted in 2003 and completion by late 2005. This portion of the corridor comprises Phase II of Metro Rapid's implementation. Phase II will add the following elements:

- Peak period exclusive bus lanes in city of Los Angeles by means of a three-stage demonstration (field test & evaluation) of dedicated bus lane segments during peak periods
    - Stage I: Between Centinela and Federal Avenue, no curbside traffic diversion though loss of peak period parking; currently in operation and under evaluation
    - Stage II: Between La Brea and San Vicente, curbside traffic diversion
    - Stage III: Between Western and La Brea, curbside lanes narrower than transit lane standard; demonstration of electronic guidance integrated into demonstration
- Smoother ride on rebuilt concrete lanes
- Smartcard fare payment read by on-board validators at each door
- Ticket vending machines at bus stops to reduce boarding time

- Upgrade/enhance existing stops/shelters with amenities and add "gates" that will align where passengers wait with doors of stopped bus for faster boarding.
- Expanded use of transit signal priority system (outside city of L.A.) requiring agreements with neighboring cities (Beverly Hills and Santa Monica)
- Articulated 3-door buses to increase bus capacity and reduce peak-period crowding
- Multiple-door entry and exit
- New bus interior designs for greater passenger comfort
- Maintains all existing landscaped medians and left turn pockets

MTA has proposed following capital projects to address specific jurisdiction-by-jurisdiction concerns along the Wilshire BRT:

1. Curb lane repair and reconstruction within city of Los Angeles
2. New stations along corridor outside city of L.A.
3. New station at VA Hospital
4. Demonstration Program for each transit lane
5. Bus Storage and Maintenance Facility in Los Angeles CBD
6. Park-&-Ride facilities on MTA-owned land

Orange County

The Orange County Transportation Authority (OCTA) decided in February 2005 to proceed with considering options for rapid transit even though federal funding for FY 2004-2005 would not be forthcoming for the previously planned CenterLine LRT project, a 9.3-mile starter segment from the Depot at Santa Ana to John Wayne Airport. The LRT project is on hold while OCTA explores other mass-transit solutions including bus rapid transit systems.

The 1990 passage of a one half-cent sales tax earmarked for transportation projects included funding for a rapid-transit system. Originally, OCTA selected LRT as the preferred alternative for this corridor. The project secured approximately 50 percent of the required funding and preliminary engineering for the project was completed, however, the project did not receive federal funding this year, resulting in OCTA's decision to study other options.

OCTA is also developing a process to insure consistency between future work on the rapid-transit master plan in conjunction with recently begun efforts to revise OCTA's long-range transportation plan. Next steps, in terms of consideration of alternative rapid transit options, are expected to be announced in June 2005.

Riverside,

In 2002 the Riverside Transit Agency (RTA) began planning for bus rapid transit by establishing an ad hoc committee to study the BRT option. RTA engaged the University of California (Berkeley, Los Angeles, and Riverside campuses) to perform a two-year feasibility planning study to implement bus rapid transit in Riverside County, which is a low density sprawling area yet is very fast growing. It has minimal transit use by transit dependent communities. RTA was looking for a cost-effective public transit mode with the potential to increase ridership. The most intensely urbanized zone of the County lies between Riverside and Corona. Centered around Magnolia Avenue, this nearly 15-mile stretch in the western part of the county includes many of the older neighborhoods, traditional and more modern activity centers found in Riverside County, as well as the traditional government and large-office center of Downtown Riverside. This corridor is the most transit-friendly one in the County, and is the one that generates the highest current transit ridership.

In this two-year study, travel patterns were examined by all modes in the county and projected growth was forecasted over a twenty-year time horizon. A range of transit improvements were analyzed and recommendations were subjected to focus group review by the public, current bus riders, and homeowners. The ‘Rapidlink’ concept was developed that included the following features: skip-stop configuration, automatic vehicle location systems, full bus shelters at stops, bus arrival information signs, maximum of fifteen minute headways, low-floor buses powered by compressed natural gas, transit signal priority, transit merge priority at stations, and a Rapidlink design features (logo, name, color). Rapidlink would be implemented in stages over twelve to fifteen years.

Sacramento Metropolitan Area

In January 2004 Sacramento Regional Transit (RT) implemented the first of its bus rapid transit systems, called the 'Enhanced Bus' or 'EBus' on the Stockton Blvd. corridor of bus route 50 between Florin Mall and the Sacramento Central Business District. Three additional EBus corridors were identified by RT as part of its 20-year Vision Plan and include: Watt Avenue, Sunrise Blvd., and Florin Road. The Stockton Blvd. EBus is approximately nine miles long with stations approximately one-half mile apart that operates in mixed traffic and offers weekday service with 15-minute headways between 5:30AM and 7:30PM. The buses are low-floor and CNG-powered and along with the shelters, are designed with a blue and yellow color scheme with the 'E' logo. The EBus offers transit signal priority and queue jumpers at 'E' shelters. Information is provided to passengers on-board the buses. The 'EBus' is a partnership among RT, the city of Sacramento (Public Works Department), Sacramento County (Department of Transportation), and the Sacramento Area Council of Governments.

San Bernardino

Omnitrans, the primary public transportation service provider in the San Bernardino Valley (SBV), has begun planning to improve its transportation services to address expected growth in population, jobs, and travel demand over the next twenty years. The 'E' Street Corridor, in particular, is the focus of much investigation. This corridor study area is approximately 14 miles long, generally from California State University San Bernardino on the north through downtown San Bernardino, then southeast to Loma Linda University generally following Omnitrans' current bus route 2. It runs through a variety of land uses, from low-density residential development in the north to commercial development along 'E' Street. The San Bernardino CBD has some of the highest concentrations of office and public facilities in the Omnitrans service area. The southern end of the corridor contains significant public, educational and medical facilities.

The corridor supports about 120,000 people and more than 70,000 jobs with the highest job density in the SBV. The corridor contains a sizable number of transit-dependent residents living within a quarter of a mile from a current bus stop who are of low income and/or have no automobile. The corridor also contains a sizable population of residents under 18 and over 65 –

another indicator of transit dependency, as over half the population is college age or younger and eight percent is over 65 years of age.

The area is well served by transit. Just over 75 percent of corridor residents and about 77 percent of the jobs lie within one quarter mile of a bus stop. The corridor has about 24,000 daily riders, the largest number in the SBV. About 3.4 percent of residents use public transit, also the highest percentage in the SBV.

However, transit travel times in the corridor do not compete well with the speed attained by private automobiles. Currently, buses travel in mixed flow with other traffic and stop every few blocks. Many passengers experience long wait times transferring between routes. As a result, travel times on buses are typically two to three times those for autos, and can add 20 to 40 minutes to a trip. Slow buses result in limited mobility for the many people in the corridor dependent on transit for their travel and deters more people who may live and work in the corridor from at least occasionally using transit. Depressed economic conditions exist in the central corridor. Portions of the corridor are viewed as unsafe. Parking capacity is a problem at major corridor activity centers. Traffic conditions create wide variation in travel times for existing buses, particularly near the I-10 freeway where bottlenecks occur often. These variations create scheduling problems and often result in longer travel times for riders.

As a result of these corridor-wide problems, Omnitrans together with the region's metropolitan planning organization, the San Bernardino Associated Governments (SANBAG) and other public agencies are currently studying conceptual alternatives as part of its normal transportation planning process in order to identify their locally preferred alternative for the 'E' Street corridor.

The conceptual alternatives include

- No Action, which would include only existing and already programmed projects and services

- Transportation Systems Management, which would include existing and programmed projects, and the most recent Omnitrans Short Range Transit Plan and other non-capital improvements
- BRT
- LRT

Major milestones of the alternatives analysis include:

- February 2004: Project Initiation and Scoping
- August 2004: Conceptual Alternatives Analysis
- December 2004: Detailed Alternatives Analysis
- June 2005: Selection of Locally Preferred Alternative and Transition to Preliminary Engineering Study

San Diego

In October 2000, the Metropolitan Transit Development Board (MTDB) adopted the Transit First strategy, a strategic plan to define the future role of transit in the region. MTDB determined that a bus rapid transit Showcase Project to demonstrate the Transit First strategy should be pursued and the Downtown San Diego to San Diego State University (SDSU) corridor was selected. MTDB has completed a preliminary planning study of the Showcase Project that identified the route and general station locations. A more detailed study, now underway, is assessing transit signal technology that would be used and is performing an engineering design for the transit lanes and stations.

The Downtown San Diego — SDSU Corridor is 9.9 miles long. Currently, plans call for there to be 17 BRT stops/stations in each direction. The new BRT service is intended to replace at least parts of currently existing lines that cover portions of the new route. Of the 9.9 mile corridor, approximately 3.5 miles will be a transit-only lane. Buses will be able to use the general purpose lanes when needing to pass. There will be a reserved mostly curb-side bus lane in each direction, so passing will only be needed to get around slower buses or right-turning vehicles or cars accessing the on-street parking. The operating plan has not yet been developed and depends on funding availability, however, preliminary planning calls for 10-minute and 15-minute headways during peak and off-peak periods, respectively.

San Francisco

The Municipal Railway of San Francisco (Muni) began initial consideration of bus rapid transit in the city in 2002 when it produced its 2002 Vision Document. This was followed up in 2004 with the San Francisco Countywide Transportation Plan and implementation of San Francisco's Transit First Policy to develop the city's network of Transit Preferential Streets by means of bus rapid transit. Three corridors were initially selected for further consideration of BRT: Van Ness Avenue, Geary Boulevard, and Potrero Avenue. Also in 2004 was the initiation of the Van Ness Avenue Bus Rapid Transit Study that conducted an assessment of existing conditions and needs for the corridor and development of bus rapid transit alternatives. Currently Muni and the San Francisco Transportation Authority (SFTA) have commissioned an analysis of BRT conceptual alternatives (center or side alignments) in conjunction with an implementation strategy and that is scheduled to be complete in summer 2005. While it is premature to identify with any certainty what combination of elements will be deployed along the Van Ness corridor, Muni and SFTA are examining dedicated transit lanes that are physically separated from other traffic, distinctive stations and boarding areas, provision of bus arrival information to passengers at stations, transit signal priority, and streetscape improvements and other amenities.

San Mateo

San Mateo County Transit District (SamTrans) is currently studying the potential impacts of transit signal priority systems along routes 390 and 391 on SR 82. It is also in the early planning stages for its Enhanced Bus Network Service. A brief discussion is provided in Section 4.2.3 with a more complete description in http://www.samtrans.org/stratplan.html Strategic Plan/Short Range Transit Plan.

Santa Clara

The Santa Clara Valley Transportation Authority (VTA) is currently implementing its vision of bus rapid transit along its Line 22 corridor, which provides service along the east-west length of Santa Clara County between the Eastridge Shopping & Transit Center in San Jose to the Caltrain station in Menlo Park. Line 22 is twenty-seven miles long and runs every 10 minutes during weekdays, primarily along El Camino Real (California State Route 82) serving the cities of San Jose, Santa Clara, Sunnyvale, Mountain View, Los Altos, Palo Alto, and Menlo Park. It is VTA's most heavily used line, carrying over 23,000 riders daily and representing 16% of VTA's total bus ridership. The line operates near capacity with many buses at standing room only. Line 22 is supplemented by Line 300, a limited stop express service along generally the same corridor. Lines 22/300 connect with regional rail services as well as 55 VTA bus lines. A major connection occurs in downtown San Jose, where Line 22 intersects the north-south Guadalupe Light Rail Line.

VTA is implementing BRT along Line 22 in two phases over the next four years. VTA's new Line 522 will replace Limited Stop Line 300 and supplement Line 22, providing faster, more frequent, and more direct service between Eastridge in San Jose and the Palo Alto Transit Center. In comparison to current Line 300 and Line 22 schedules, travel times may be reduced between 10 and 25 percent. A package of changes will be utilized to transform Line 22 into a BRT corridor. This package will include a combination of the following features:

Phase I (Line 522), currently under construction, will consist of transit signal priority, limited stops with station spacing approximately one mile, headway-based schedules, queue jump lanes, near-level boarding, low-floor buses and far side stops. Service is anticipated to begin in July 2005.

Future improvements under Phase II will include permanent rail-like stations, more intersections with transit signal priority, real-time station display information, new higher capacity vehicles, exclusive bus lanes, and off-vehicle fare payment. Along with the El Camino/Santa Clara Street/Alum Rock Avenue corridor, Stevens Creek Boulevard and Monterey Highway have also been identified as potential BRT corridors.

Santa Monica

The City of Santa Monica, in Los Angeles County, will add a new “express style” BRT service to its Big Blue Bus service lines. It will travel on Lincoln Boulevard, a densely-populated and heavily-traveled corridor between Downtown Santa Monica on the north to the Los Angeles International Airport and the Metro Green Line (LRT) on the south through the municipalities of Venice, Playa Vista, Marina Del Rey, and Santa Monica. It will be eight miles long and connect at its northern terminus with L.A. County's Wilshire Metro Rapid Line. It is expected that corridor travel time will be reduced up to 30% over current times.

The new "Metro Blue" buses will be a darker blue than Big Blue Buses current fleet. The new buses will follow the same logo as that used by MTA's Metro Rapid, only in blue not red. These buses will be operational during morning and afternoon peak periods beginning in June 2005 equipped with the following features:

- Newly designed buses with lower floors, allowing passengers to load and unload quickly
- Easy-to-reach luggage racks and reading lights
- Transit signal priority system as is used by Los Angeles County MTA along its Metro Rapid routes
- Limited number of stops to reduce overall commuting time
- New logo and branding on buses and bus shelters to maximize visibility and recognition
- Cleaner burning and less polluting natural gas fuel

Bus-only lanes are being considered for future implementation.

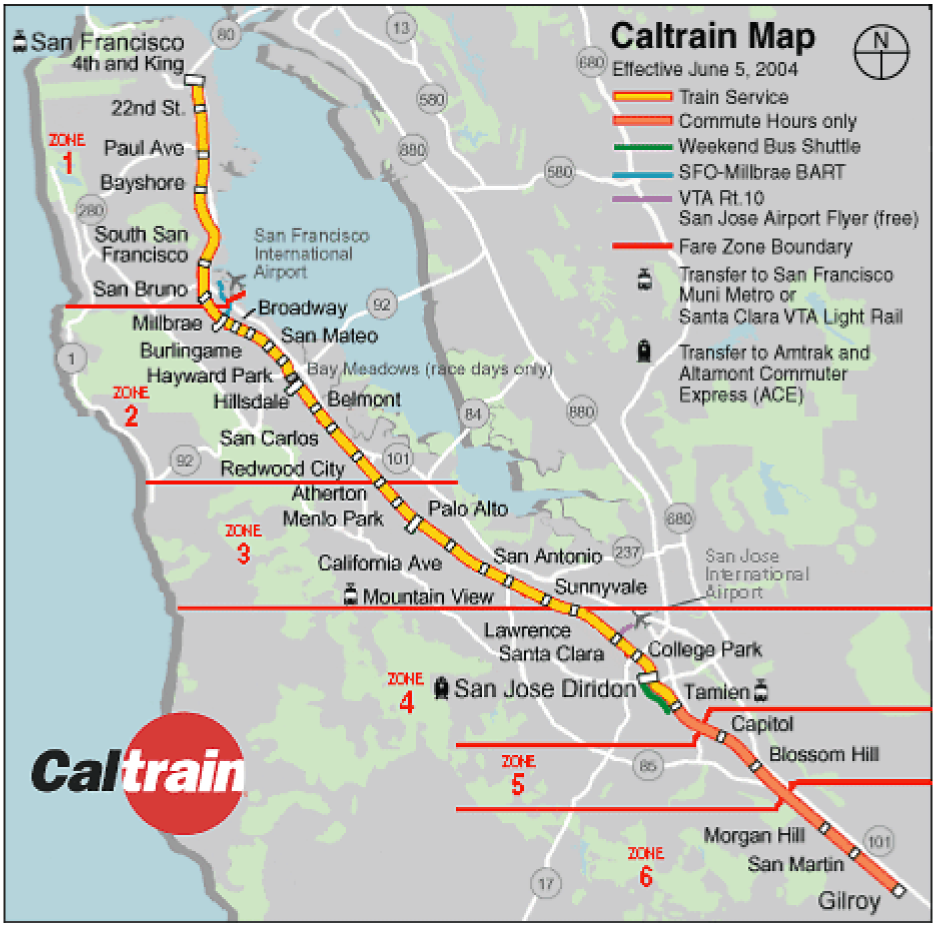
APPENDIX B: ROUTE MAPS FOR RAIL SYSTEMS IN SAN MATEO AND SANTA CLARA COUNTIES

Source: http://www.acerail.com/main/acerail.htm

FIGURE B-1 Altamont Commuter Express System Route Map

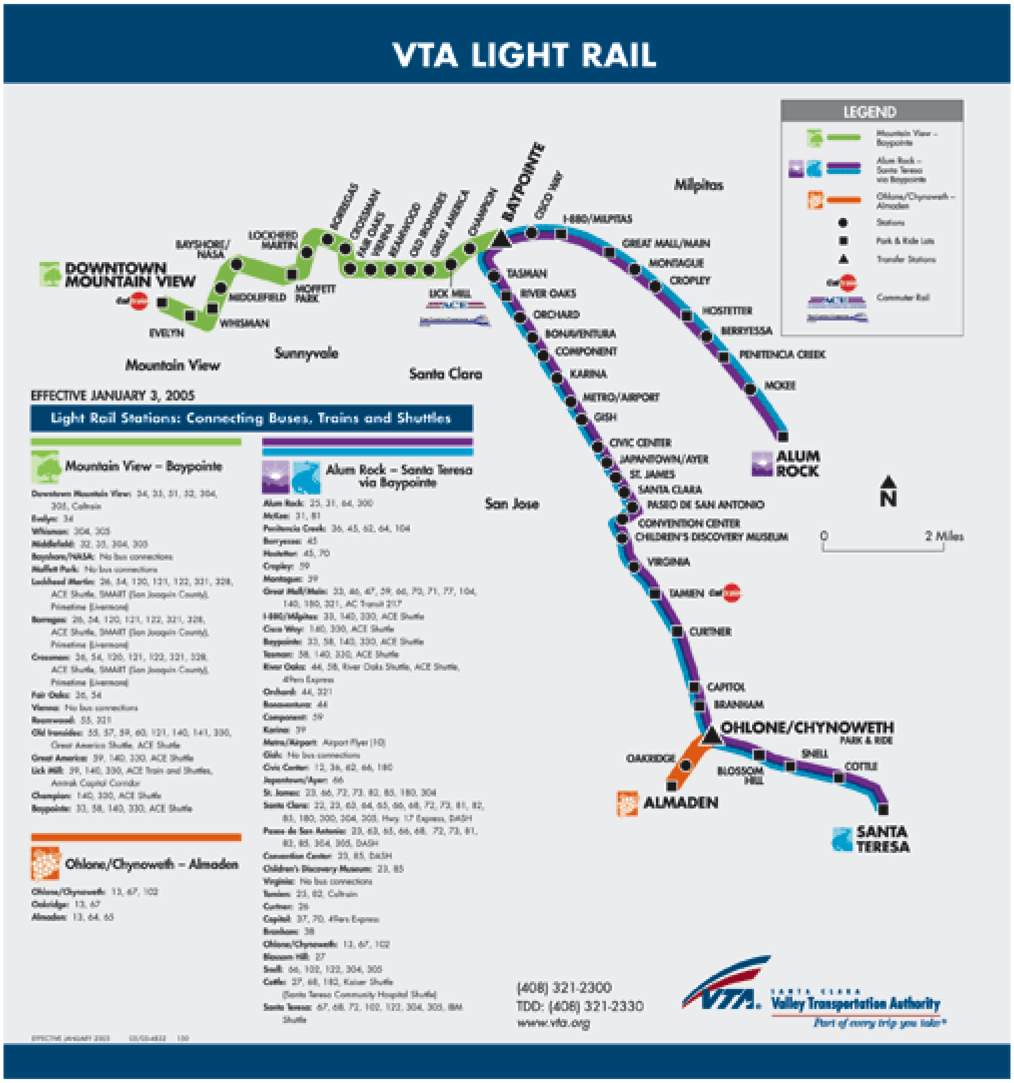
Source: http://www.bart.gov/stations/map/systemMap.asp

FIGURE B-2 Bay Area Rapid Transit (BART) System Route Map



Source: http://www.caltrain.org/caltrain_map.html

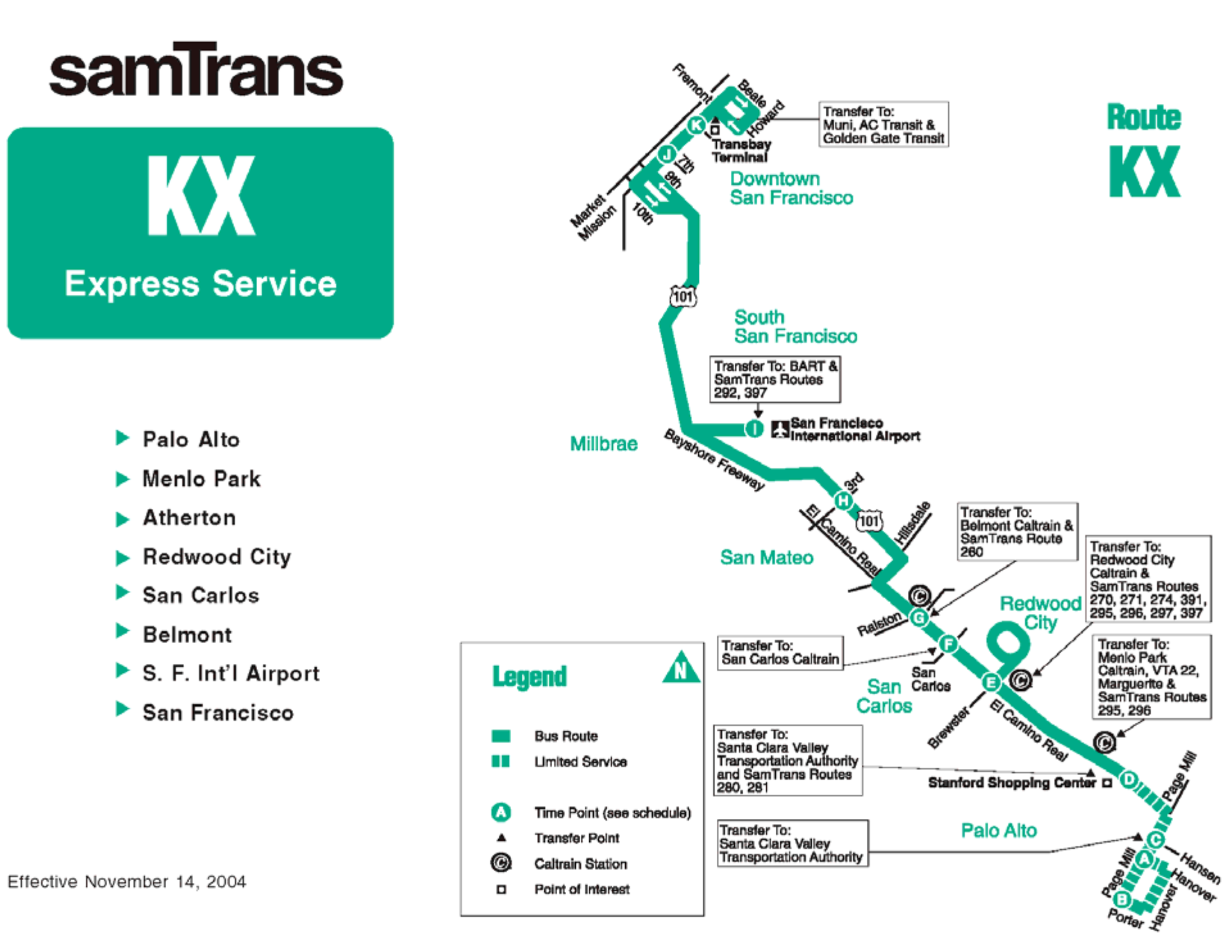
FIGURE B-3 Caltrain System Route Map



Source: http://www.vta.org/schedules/SC_LRT_MAP.GIF

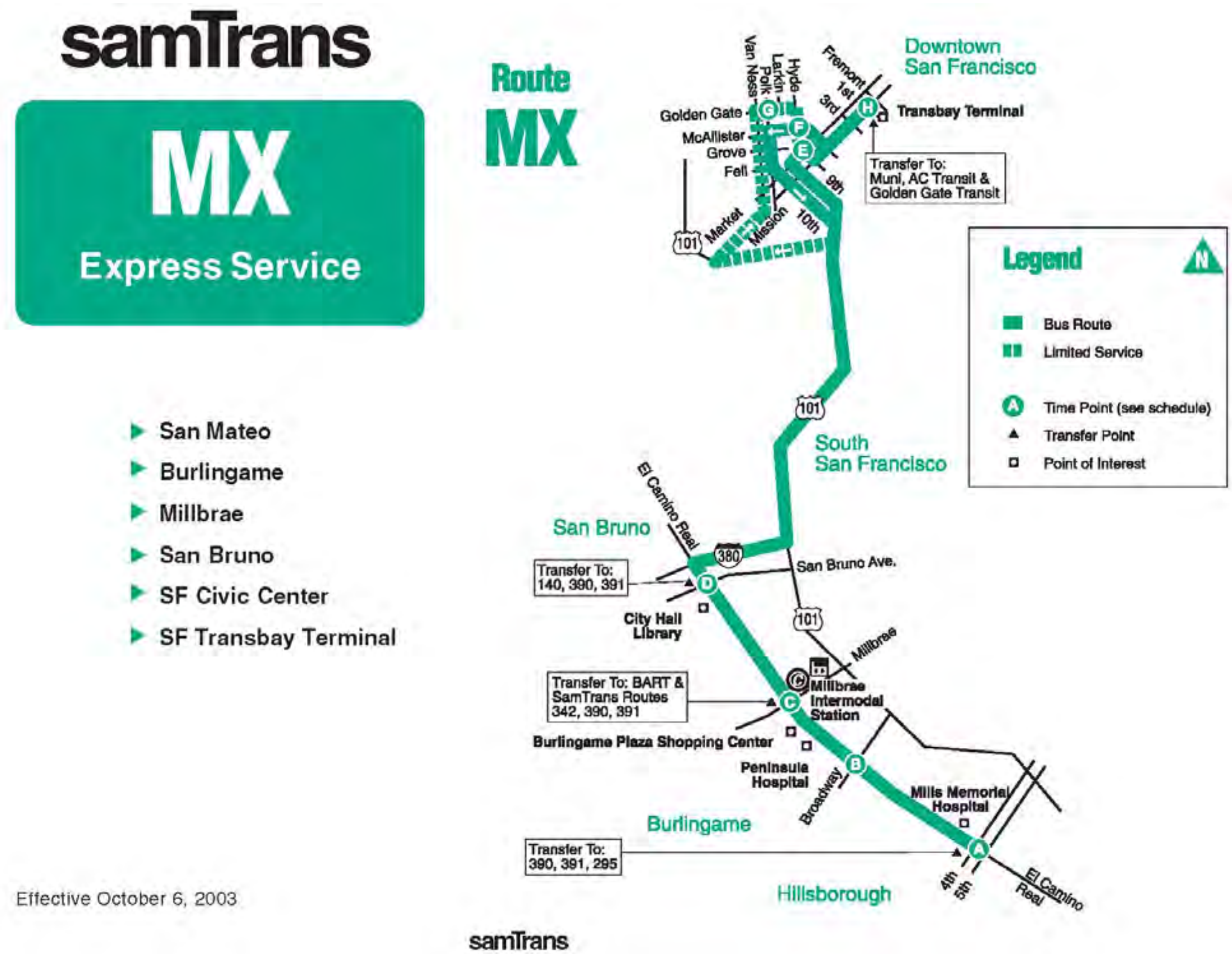
FIGURE B-4 Valley Transportation Authority System Route Map

APPENDIX C: CURRENT SAMTRANS EXPRESS BUS ROUTES TRAVERSING SR 82



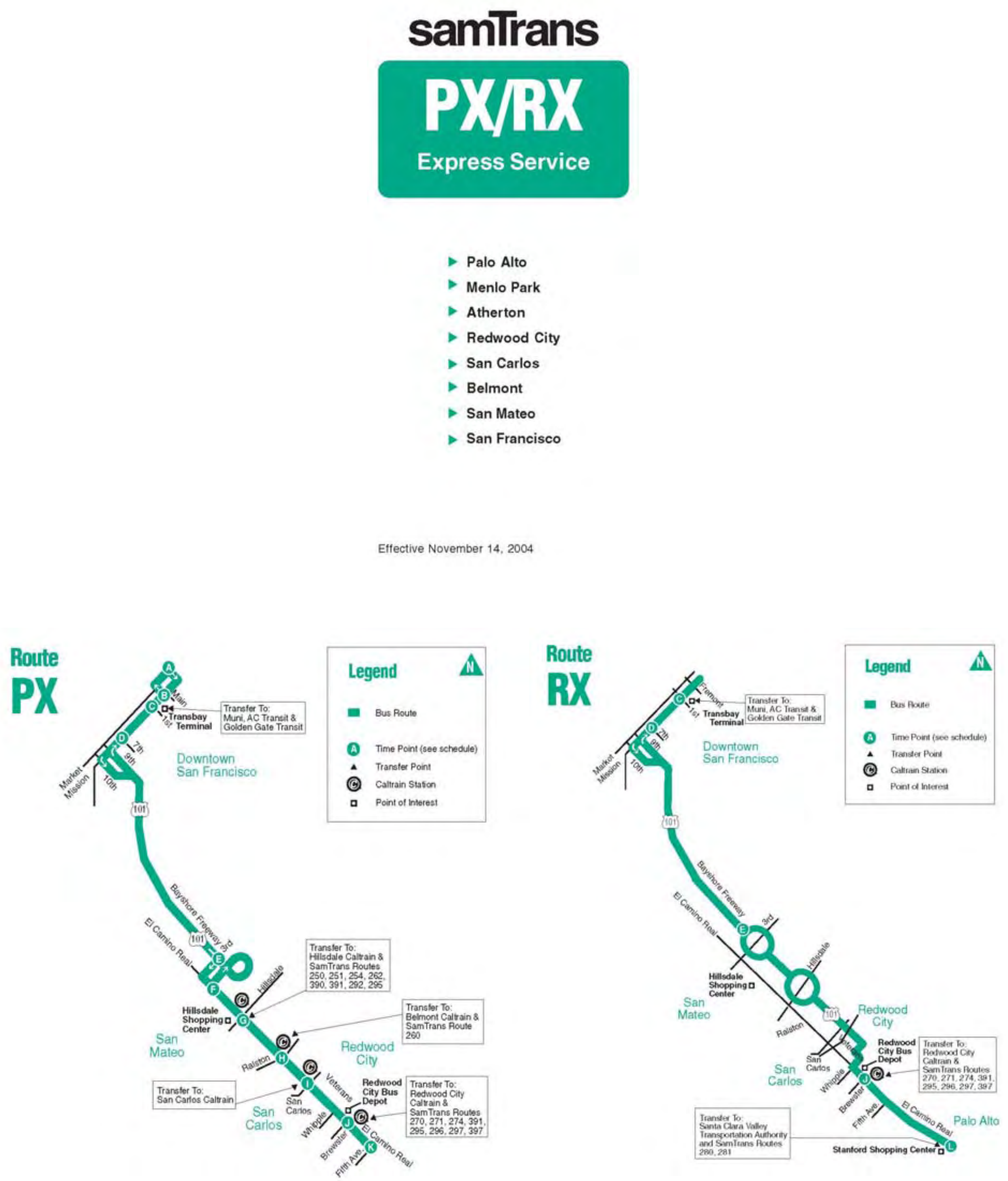
Source: www.samtrans.com

FIGURE C-1 SamTrans Express Bus Route KX



Source: www.samtrans.com

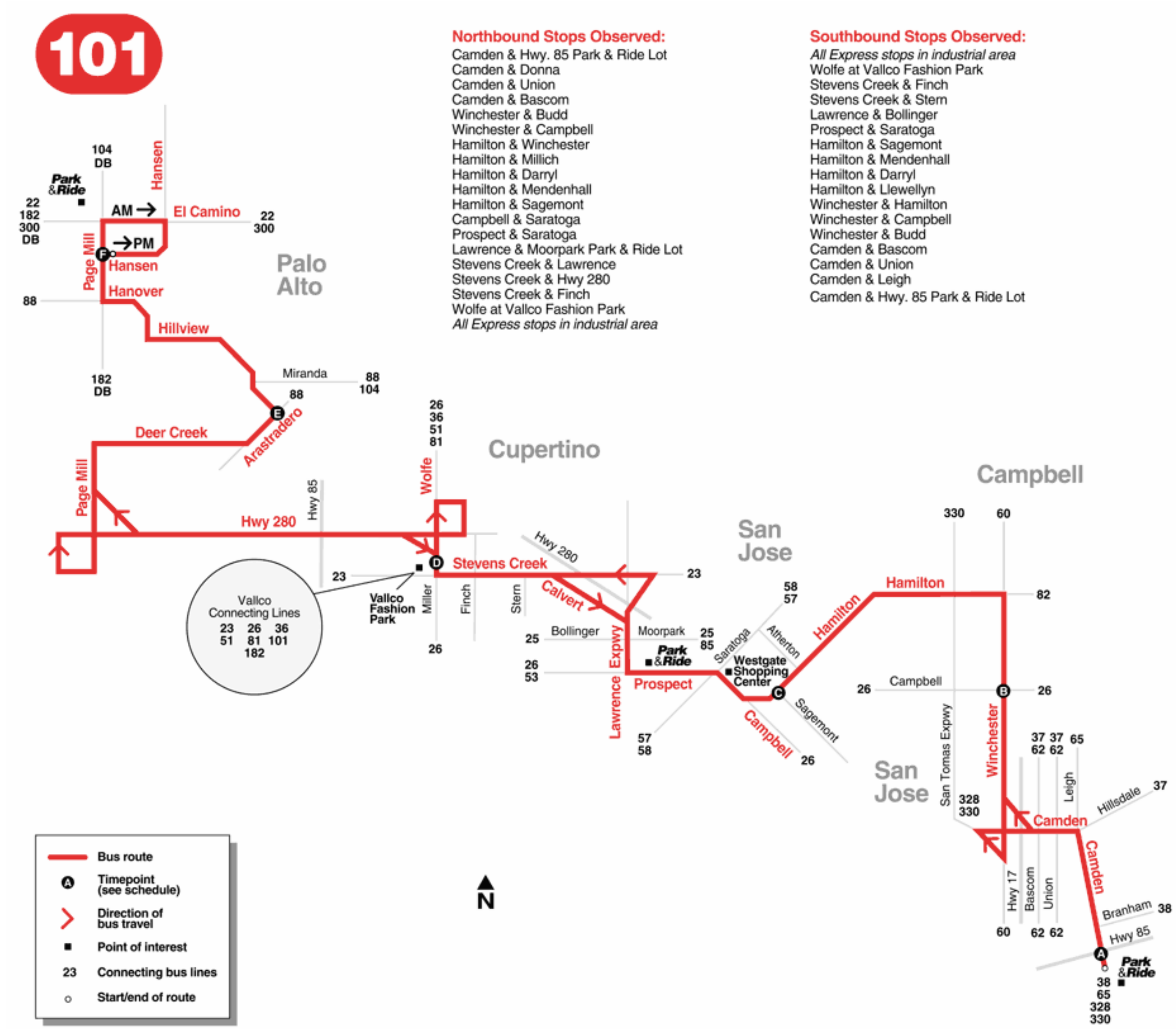
FIGURE C-2 SamTrans Express Bus Route MX



Source: www.samtrans.com

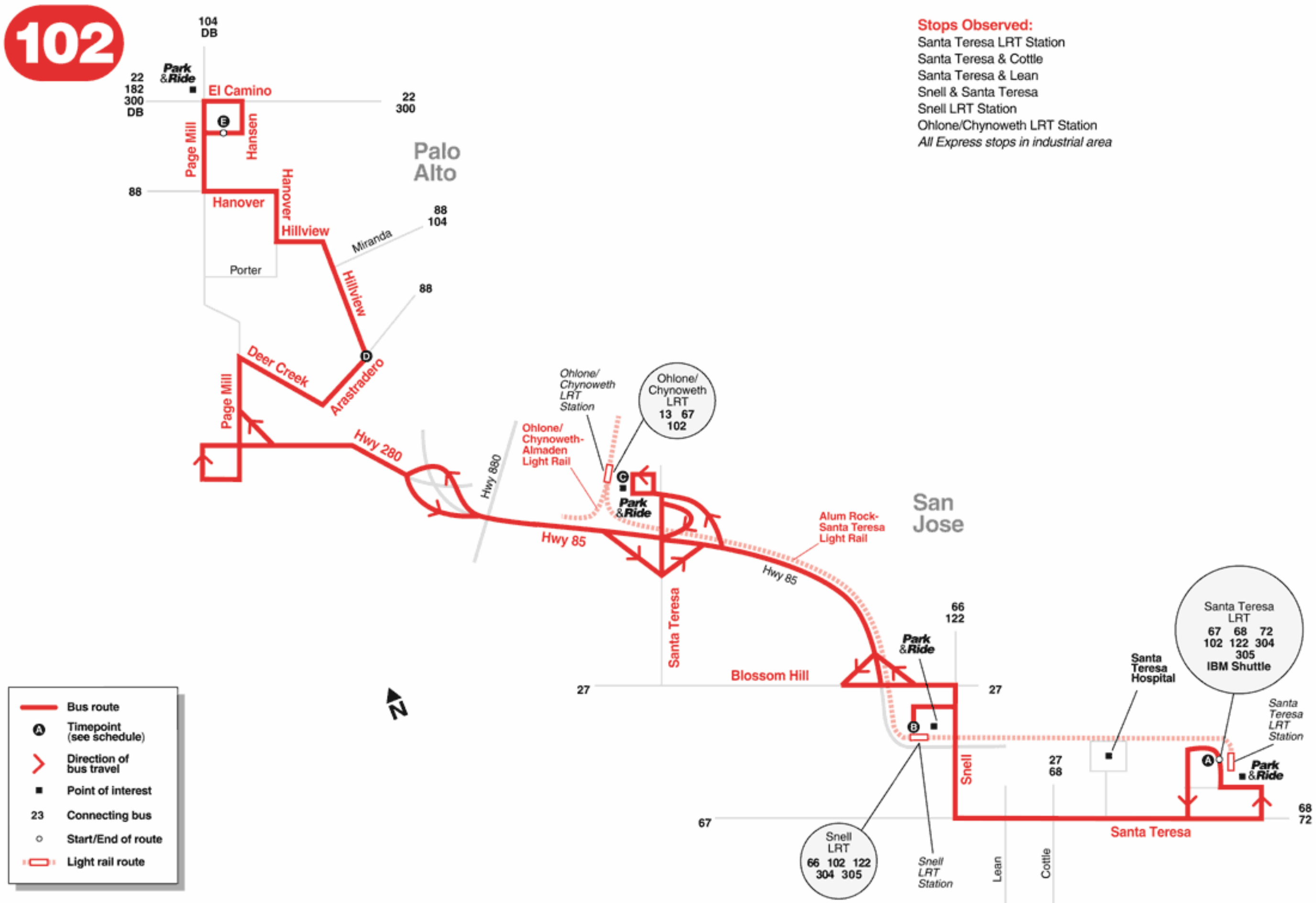
FIGURE C-3 SamTrans Express Bus Routes PX and RX

APPENDIX D: CURRENT VTA EXPRESS BUS ROUTES TRAVERSING SR 82



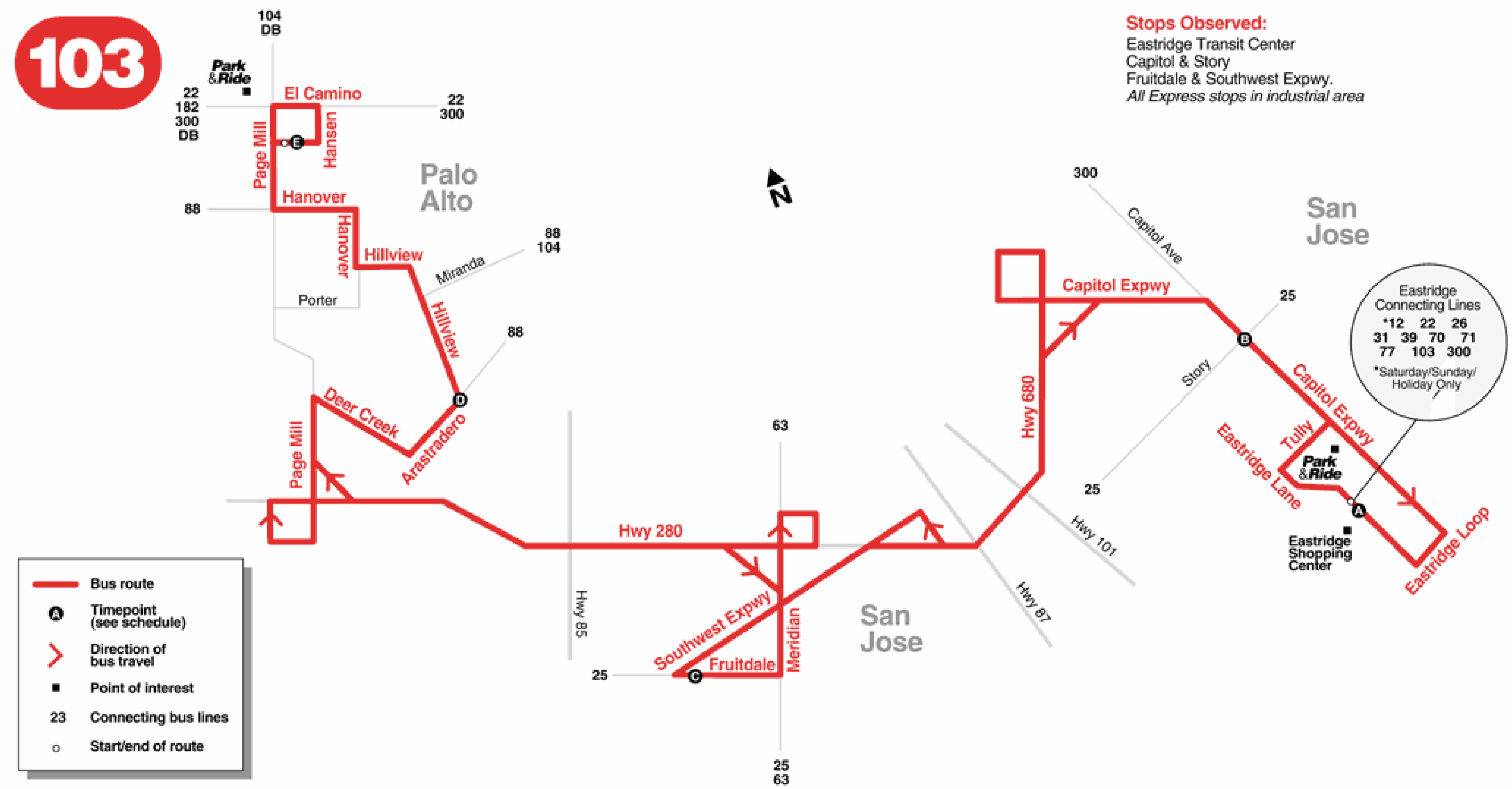
Source: www.vta.org

FIGURE D-1 VTA Express Bus Route 101



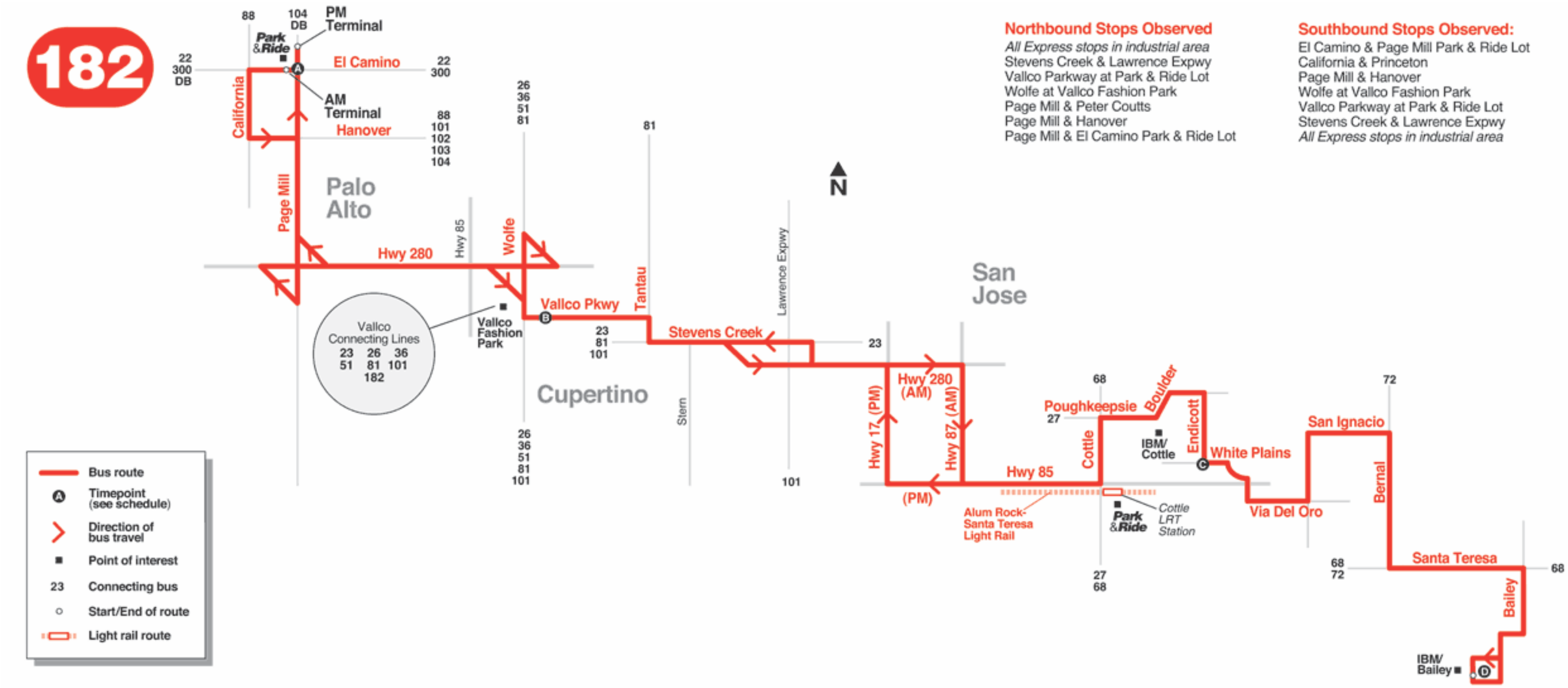
Source: www.vta.org

FIGURE D-2 VTA Express Bus Route 102



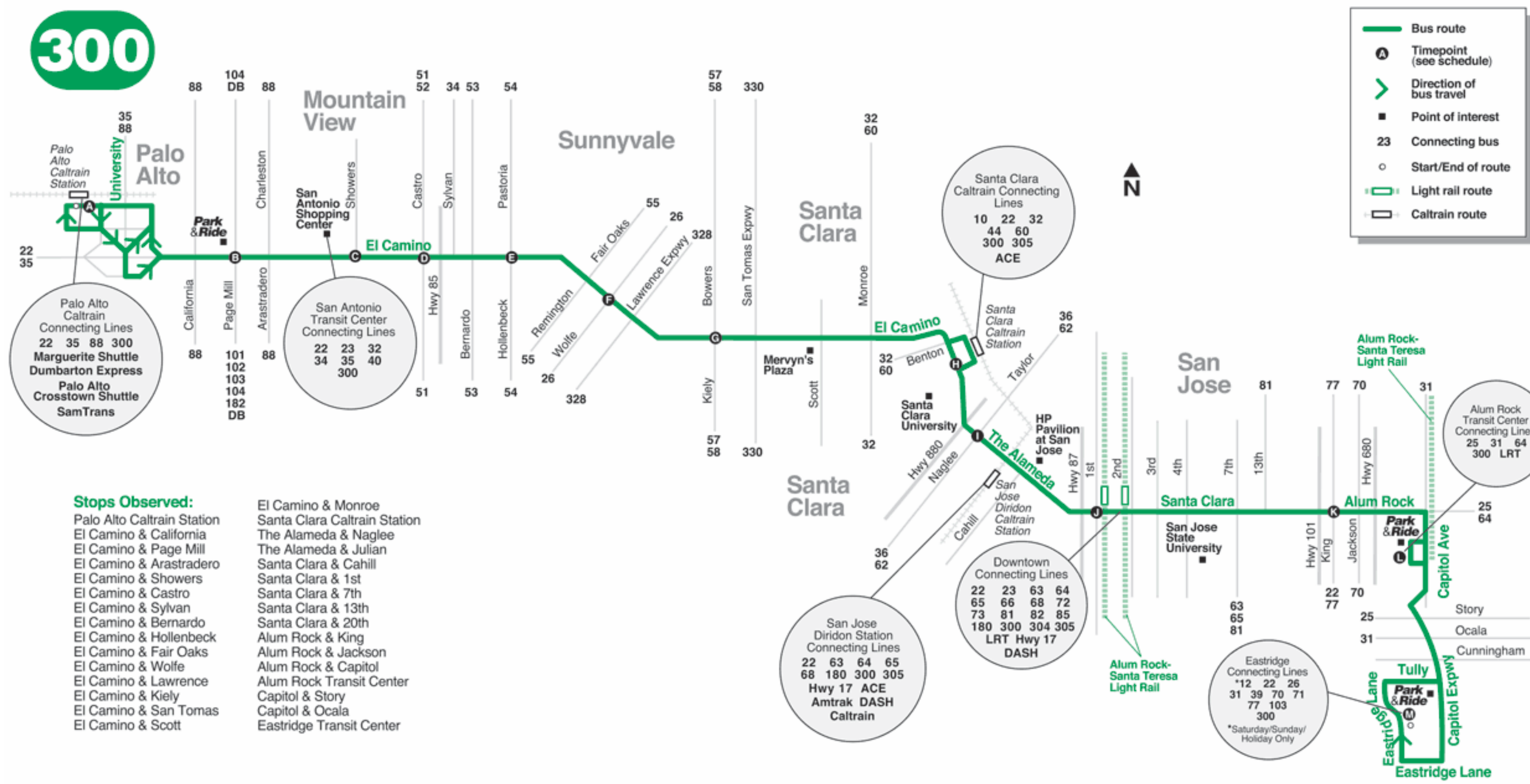
Source: www.vta.org

FIGURE D-3 VTA Express Bus Route 103



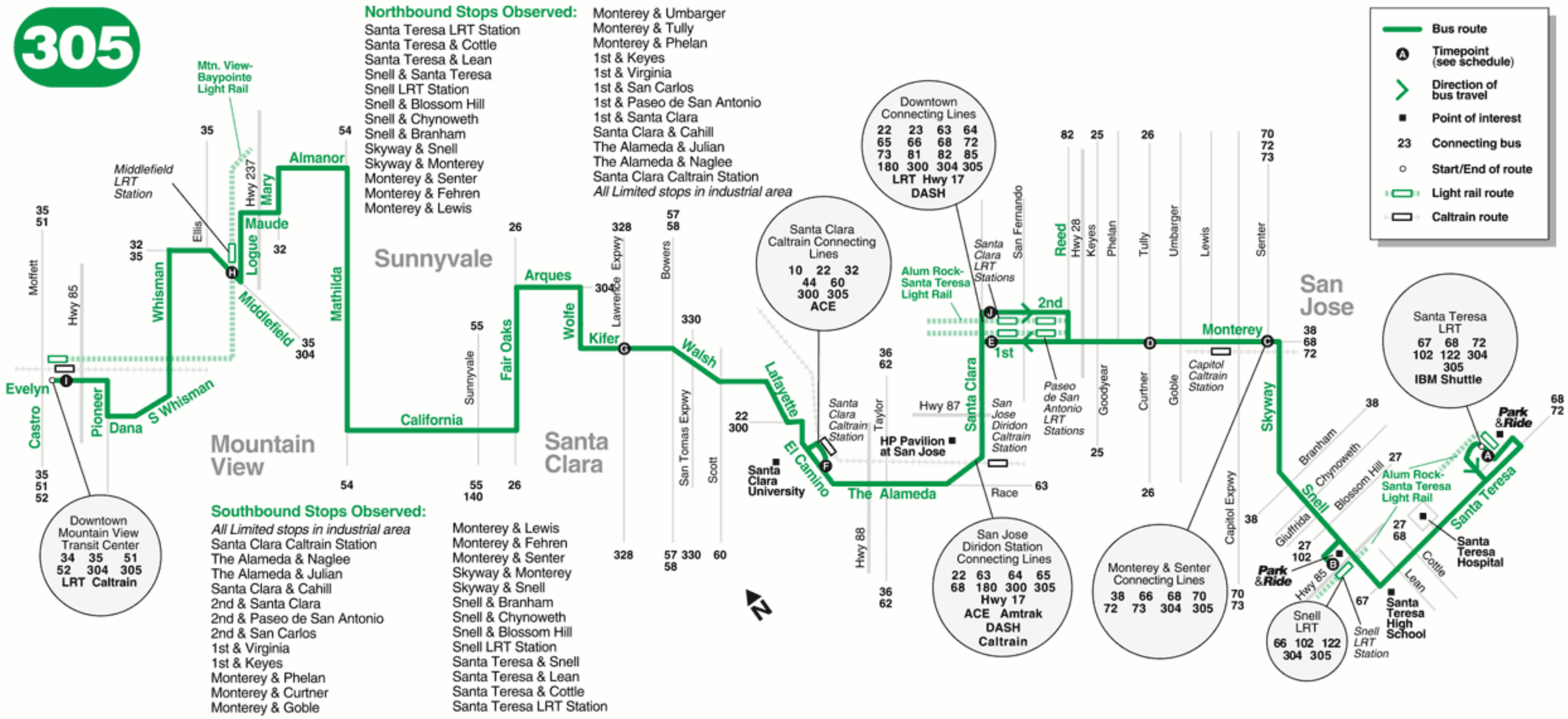
Source: www.vta.org

FIGURE D-4 VTA Express Bus Route 182



Source: www.vta.org

FIGURE D-5 VTA Express Bus Route 300



Source: www.vta.org

FIGURE D-6 VTA Express Bus Route 305