Bay Area Transit Triathlon

An Empirical Study of Public Transportation in the San Francisco Bay Area*

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Abstract

As an empirical test of the numerous public transportation agencies serving the San Jose-San Francisco-Oakland Combined Statistical Area, the author proposes the Bay Area Transit Triathlon Challenge: Using only regularly scheduled transit, travel among all three major San Francisco Bay Area airports in as short as time as possible. Public transportation service proves effective if the journey's time is at most twice the time to drive in a private vehicle.

In a circuit completed 2004 Oct 09 by the author, the public transportation journey required 268% of the time but cost only 44% of a comparable private vehicle journey (5:50:20 hours and $19.90 versus 2:10:30 hours and $44.95).

We describe several needed improvements including a need to modify the public transportation system so vehicles travel through an integrated transportation network rather than requiring passengers to switch vehicles when switching transit systems. Other needed improvements include the need for easier and uniform payment options, the need for more transit information especially non-English materials, and the need for greater operator courtesy.

Contents

1 Introduction

Despite the service of over three dozen public transportation agencies in the San Jose-San Francisco-Oakland Combined Statistical Area, less than seven percent of Bay Area weekday journeys use public transportation for at least one link [TC05].

As an empirical test of these public transportation services, the author participated in the first annual Bay Area Transit Triathlon, journeying among the three major Bay Area airports exclusively using public transportation. Timings, costs, and experiences were compared and contrasted with the same journey traveled exclusively by private vehicle. The author considers the public transportation service a success under these easy standards:

- The time for the public transportation journey was at most twice the time for the journey via private automobile.
- The cost of the public transportation journey was at most half of the cost for the journey via private automobile.

Additional auxiliary criteria collected during the journey included:

- the availability of schedules, maps, and other information in boarding areas and inside transit vehicles,
- the required number of individual travel segments,
- the ease of paying for each travel segment, e.g., what methods of payment are accepted and whether exact change is required, and
- the friendliness of transit agency employees if any were present.

His two circuits, completed 2004 Oct 09 using only public transit and again only using a private automobile, indicated that using public transit required 268% the time but cost only 44% of a comparable private automobile journey. Public transit failed to provide timely transportation compared with using a private automobile. Furthermore, driving the circuit provided to be much less stressful than taking transit. Using this experience, the author presents ideas how to improve public transit in the San Jose-San Francisco-Oakland Combined Statistical Area.

2 The Bay Area Transit Triathlon Challenge

As a test of the effectiveness of public transit, the author issues the Bay Area Transit Triathlon Challenge:

> Using only regularly scheduled transit, travel among all three major San Francisco Bay Area airports in as short as time as possible.

The journey can occur at any time but must use only regularly scheduled public transit available to members of the general public. It can be supplemented by non-motorized means such as walking, running, or cycling. If two journeys have equal times, the lower cost journey wins. Complete rules appear in Section C.

The Secondary Bay Area Transit Triathlon Challenge compares the effectiveness of public transit with any ground-based transportation:

> Complete the Bay Area Transit Triathlon Challenge in at most twice the time to complete a comparable journey using any ground-based transportation.

The secondary challenge contrasts the most relevant measure of any transportation means: a journey's travel time.

The three major San Jose-San Francisco-Oakland Combined Statistical Area airports are each located in a different county. Since each county chooses to organize almost of all its public transit in one individual county-wide transit organization, the journey both tests three separate transit systems and also their interconnections.

Airports are both major employment centers and major one-way journey origins and destinations so they are ideally suited to have good public transit service. Many people who never otherwise use public transit will use public transit to travel to or from an airport so they can avoid paying to park a private vehicle. Passengers traveling to an airport also usually have a fixed arrival deadline so timely public transit service is greatly desired. Furthermore, both San Francisco and San Jose Airports have recently encouraged more use of public transit. For a while, the Santa Clara Valley Transportation Authority previously offered free transport to the San Jose Airport, and it also currently operates a free bus connecting its light-rail line, the airport, and the multi-county CalTrain passenger rail line. San Francisco

Airport regularly advertises the numerous ways to reach the airport via public transit including two rail lines, scheduled local bus service, and numerous long-distance bus and shuttle services. For all these reasons, public transit to these airports should be as efficient as any in the San Jose-San Francisco-Oakland Combined Statistical Area system.

3 The Transit Journey

The author used public transportation to journey from San Jose Airport (SJC) to Oakland Airport (OAK) to San Francisco International Airport (SFO) back to SJC. Walking (and running) supplemented riding busses and trains operated by six different transit agencies. The entire journey required 5:50:20 hours and $19.90. Section A contains journey details including observations of vehicle operator friendliness and available transportation information. Below, we describe the author's choice of the particular circuit and schedule, present a summary of the journey, and describe the user friendliness of the various systems used.

Since the author works on weekdays, the author chose to complete the journey on Saturday, 2004 Oct 09. Daylight hours were chosen because more public transportation services are available then. The San Francisco Bay Area `511.org` website contains links to schedules and maps and fares for many of the public transportation agencies serving the San Jose-San Francisco-Oakland Combined Statistical Area as well as a journey planner. This particular journey has too many travel segments for the online 511 TakeTransit™ Trip Planner [MTC02], but the author used the planner to explore transportation possibilities for various travel segments, e.g., SJC to OAK, choosing the maximum one mile walking distance between transfers. He also used individual agencies' information to produce a final schedule. In his planning, he arbitrarily chose a starting time of 09:00, which was then shifted to the actual starting time of 09:06:10. The shorter counter-clockwise journey's schedule was chosen over the clockwise journey.

United Airlines and Continental Airlines serve all three airports. The latter's ticket counters were chosen as the airport terminal destinations.

Table 1 contains a summary of the journey. Six different transportation agencies were involved; see Table 2. VTA and SamTrans are primarily intra-county transportation agencies serving Santa Clara and San Mateo counties, respectively. AirBART is a shuttle service serving the Oakland Airport.

Table 1: Times, transit, costs, and comments for the transit journey SJC to OAK to SFO to SJC. "SJ" abbreviates "San Jose," and "SF" abbreviates "San Francisco." "N", "E", "S", and "W" abbreviate "north," "east,", "south," and "west."

Location	Time	Transit	Cost	Comments
SJC	09:06:10			start
SJC	09:06:20	walk		
SJC bus stop	09:13:50	VTA 10 bus east	$0.00	depart 5 min. late, arrive 2 min. late
SJ 1st St at Metro	09:19:40	VTA 901 train S	$1.50	closed doors 20 sec. early
SJ 1st St Civic Ctr	09:24:10	walk across street		
SJ 1st St Civic Ctr	09:33:20	VTA 180 bus N	$3.00	discourteous driver, 7:50 min. late arrive
Fremont BART	10:11:50	run		ran because bus arrived late
Fremont BART	10:12:20	BART train N	$3.00	depart 6:20 min. late, arrive 4:50 min. late
Coliseum/OAK BART	10:38:50	walk		
Coliseum/OAK BART	10:40:30	AirBART bus W	$2.00	exact fare only
OAK	10:53:00	walk		
OAK	11:01:40	AirBART bus E	$2.00	difficult payment
Coliseum/OAK BART	11:12:30	walk		
Coliseum/OAK BART	11:17:20	BART train N	$3.15	delayed twice
SF streets	11:50:00	walk		ate lunch
SF Mission Street	12:10:50	SamTrans KX bus S	$3.50	depart 2:50 min. late, unhelpful driver
SFO Terminal 2	12:41:00	run		ran length of terminal
SFO Terminal 1	12:48:10	SFO AirTrain	$0.00	
SFO BART	13:13:00	BART train W	$1.50	depart 5:40 min. late, arrive 0:50 min. late
Millbrae	13:25:00	CalTrain train S	$4.25	confusing platforms
Santa Clara	14:41:00	VTA 10 bus E	$0.00	arrive 2 min. early
SJC	14:56:30	walk		finish
Total	5:50:20		$19.90	

transportation agency	journey portion	vehicle
Santa Clara Valley Transportation Agency (VTA)	SJC to Fremont BART, Santa Clara to SJC	bus, train
San Francisco Bay Area Rapid Transit (BART)	Fremont BART to Oakland, Oakland to San Francisco, SFO to Millbrae	train
AirBART	Oakland BART to and from OAK	bus
San Mateo County Transit (SamTrans)	San Francisco to SFO	bus
San Francisco International Airport	within SFO	train
CalTrain	Millbrae to Santa Clara	train

Table 2: The public transit journey involved six different transportation agencies.

BART connects Alameda, San Francisco, and San Mateo counties, while CalTrain connects San Francisco, San Mateo, and Santa Clara Counties. SFO operates an inter-terminal train although it is not a transportation agency per se.

The entire journey required 5:50:20 hours, $19.90, and twelve separate travel segments excluding walking. The SJC to OAK segment was the most difficult, requiring two VTA busses, one VTA train, one BART train, and one AirBART bus. Two connections were almost missed. The OAK to SFO segment required the most walking, walking two long blocks through San Francisco streets and through one crowd of protesters. One AirBART bus, one BART train, walking, and one SamTrans bus were required. The SFO to SJC segment has the best train service, but the train services are not integrated, and waiting times are long. One SFO train, one BART train, one CalTrain train, and one VTA bus were ridden. This need to repeatedly change vehicles and service providers to make a simple journey between three major airports is the aspect of public transportation needing the most improvement. See Section 5 for more discussion.

Transit information was frequently difficult to find during the journey. For example, the bus stop in San Francisco on Mission Street between Second and New Montgomery streets was served by three different agencies but had only a San Francisco MUNI map. No bus schedules nor maps for the

SamTrans or Golden Gate agencies were available so riders had to know of their services before arriving at the bus stop. The bus stop maintainer did however find space for huge advertisements. Transit information in languages other than English was extremely difficult to find even though a significant minority of San Jose-San Francisco-Oakland Combined Statistical Area residents do not have English as a first language; for example in the cities of San Jose, San Francisco, and Oakland, the fractions of people five years or old speaking a language other than English at home are 51.2%, 45.7%, and 36.8%, respectively [CB00].

Many vehicle operators were unprofessional or unhelpful. Admittedly, they are subject to ill-treatment by many of their patrons, and they are repeatedly asked the same questions every day. Despite this, few or none of the drivers demonstrated courteous customer treatment that encourages customers to ride in the future. For example, the driver of the VTA 180 bus from San Jose to Fremont was wearing a Manchester United hat in addition to his VTA uniform. His answers to my questions concerning payment were terse and not helpful.

All transit agencies except for CalTrain forbid consumption of food and drink while aboard vehicles. This yields cleaner vehicles but makes eating food during the almost six-hour journey difficult. We consumed lunch while walking through the San Francisco streets and while waiting for the SamTrans bus to SFO.

Finding public toilets is also difficult. Again, only CalTrans provides restrooms aboard its vehicles. The author used toilets in both OAK and SFO.

4 The Driving Journey

The author drove the SJC, OAK, SFO, SJC circuit using his private automobile on the same day 2004 Oct 09 after completing the circuit using public transportation. Details of the journey are described in Section B.

Starting at the Continental Airlines ticket counter in SJC Terminal C, the author ran to his car parked in the Terminal C short-term parking, drove on streets to the I-880 north freeway to OAK. Traveling to OAK's and SFO's Continental Airlines ticket counters similarly used freeways, city streets, short-term parking, and running through terminals. No congestion was encountered while driving.

The journey's total distance was 101.2 miles, total cost was $44.95, and total time was 2:10:30 hours. Costs include parking fees, bridge tolls, and operating costs of $0.375 per mile.

Despite having to drive among all the other vehicles on the streets and freeways, the author found this journey much less stressful because the entire journey required only three travel segments without any need for intermediate transfers between airports.

5 Conclusions

Public transportation remains an underutilized resource in the San Jose-San Francisco-Oakland Combined Statistical Area, serving less than seven percent of Bay Area weekday journeys. To test the effectiveness of public transit in this region, the author issued the Bay Area Transit Triathlon (BATT) Challenge:

> Using only regularly scheduled transit, travel among all three major San Francisco Bay Area airports in as short as time as possible.

The Secondary BATT Challenge contrasts public transportation and private vehicular journeys:

> Complete the Bay Area Transit Triathlon Challenge in at most twice the time to complete a comparable journey using any ground-based transportation.

The author's 2004 Oct 09 public transportation journey from SJC to OAK to SFO to SJC required 268% of the time for his private vehicular journey but only 44% of the cost. Thus, the public transportation failed to provide timely service between the three major San Francisco Bay Area airports.

Public transportation provides an adequate alternative to private vehicle journeys only if

- it requires comparable time,
- it is simple to negotiate, and
- it is inexpensive.

There are several aspects to reducing transit times to acceptable levels. The first is providing quickly moving vehicles. Most of the trains operate on controlled access tracks with no intersections yet train speeds remain at or below freeway speeds. When combined with the numerous stops trains must make, the average transit speed is much lower than a point-to-point driver can experience, e.g., 33 mph for BART [BAR05]. It is not clear to the author why trains serving local stations in Europe can regularly reach at least 100 mph, but trains in the Bay Area do not exceed 80 mph.

The author's journey demonstrated that transit agencies can design schedules to facilitate transfers between services with minimal waits, but these same agencies require passengers to repeatedly transfer during a single journey. For example, traveling from SJC to OAK required transferring from a bus to a train to a bus to a train to a bus. No transfer required much time or much walking, but why were five separate travel segments and four separate payments required?

The first two transfers were within the VTA system. The VTA has chosen to connect busses to its light-rail train rather than connect busses directly. The VTA 10 service, connecting the Santa Clara CalTrain station, SJC, and the light-rail system, could just as easily also serve the San Jose Civic Center, connect with the major VTA 22 bus route, serve the San Jose Convention Center, and serve the San Jose CalTrain station which has express train service to San Francisco. Its pool of potential customers would increase greatly while reducing the number of transfers needed to reach SJC.

Most transfers were between different transit providers. For example, the SFO to SJC segment required transferring from the SFO AirTrain to an inter-county BART train to an inter-county CalTrain train to a Santa Clara County VTA bus. The first three segments all involve trains so why must passengers switch trains rather than have trains switch tracks? Analogously, it would be ridiculous for drivers to have to switch automobiles when they cross a county line or when they switch from a state highway to a federal highway.[1]

A journey's complexity increases more than linearly in the number of travel segments because of the increased number of transit possibilities and the number of timetables involved. Furthermore, each transfer presents an

[1]BART purposefully chose a nonuniform track width so its trains cannot operate on regular tracks, and other systems' trains cannot operate on its tracks. Thus, interoperability is not possible without an expensive capital change.

opportunity to miss a connection so the probability of the entire journey's success drops geometrically. For example, if the probability of missing a connection is a relatively low 25%, the probability of missing two connections is 44% (almost half), and three is 58%. Transfers are also sometimes physically difficult to make between segments, particularly when moving luggage, children, or packages.

Transit agencies need to focus more on moving their passengers where they want to go and less on their particular geographic monopoly. This is a solved problem for street and highway construction where federal, state, county, and city divisions cooperate with each other to yield a system accessible to any vehicle and facilitating transfers. Instead of maintaining separate systems and integrating timetables, integrate the systems in a way similar to the private vehicular system: Each vehicle should perform a few local stops then express to another region and serve a few local stops. The size of these vehicles would probably be much smaller than traditional trains or busses, which seek to pack passengers with lots of varying origins and destinations into the same vehicles.

The public transportation system is too difficult to use, especially for first-time users. Each transit provider has its own payment rules and options, sometimes differing within the system. Some systems accept credit cards, debit cards, and cash, while others accept only exact change. Each has its own daily, monthly, and weekly passes. The San Francisco Bay Area Metropolitan Transportation Commission is testing a TransLink® smart card supported by various transit agencies [MTC]. An entirely new distribution network and infrastructure must be developed to use these cards. It is unclear this proprietary payment system is needed when just uniformly extending payment options to include credit cards, debit cards, and prepaid cards would prove sufficient. Doing so would permit use of off-the-shelf, commodity card readers, and any person having a MasterCard or Visa card could easily participate.

Almost all observed system information was in English even though almost a majority of local residents do not use English at home. Many bus stops and train platforms do not have time schedules nor maps for the routes serving them. System-wide maps are rare. Many public transit vehicles do not have oral or verbal indications of the next location. All these minor hindrances discourage first-time use. In this, the public transit agencies are short-sighted. The additional cost to produce and distribute such information is probably considerably less than the long-term revenue stream lost

when a first-time user has a frustrating experience and never returns to the system.

The author encourages public citizens and transit officials to accept the Bay Area Transit Triathlon Challenge, publishing results, so that public transportation in the San Jose-San Francisco-Oakland Combined Statistical Area can improve.

References

[BAR05] Bay Area Rapid Transit. http://en.wikipedia.org/wiki/Bay_Area_Rapid_Transit, April 2005.

[CB00] U.S. Census Bureau. GCT-P11. Language, school enrollment, and educational attainment: 2000: California. http://factfinder.census.gov/servlet/GCTTable?_bm=y&-geo_id=04000US06&-_box_head_nbr=GCT-P11&-ds_name=DEC_2000_SF3_U&-_lang=en&-redoLog=false&-format=ST-7&-mt_name=DEC_2000_SF3_U_GCTP11_US9&-_sse=on, 2000.

[CB04] U.S. Census Bureau. Population estimates by county. http://www.census.gov/popest/counties/CO-EST2004-01.html, 2004.

[IRS04] Internal Revenue Service. *Your Federal Income Tax*. Number 17. Department of the Treasury, http://www.irs.gov/formspubs/index.html, 2004.

[MTC] Metropolitan Transportation Commission. TransLink®: The Bay Area's one card system for public transit. http://www.translink.org/jsp/index.jsp.

[MTC02] Metropolitan Transportation Commission. 511 TakeTransit™trip planner. http://transit.511.org/tripplanner/index.asp, 2002.

[MTC04] Metropolitan Transportation Commission. 511. http://www.511.org/, 2004.

[TC05] Metropolitan Transportation Commission. San Francisco Bay Area regional demographic and travel characteristics. http://www.mtc.ca.gov/maps_and_data/datamart/stats/baydemo.htm, 2005.

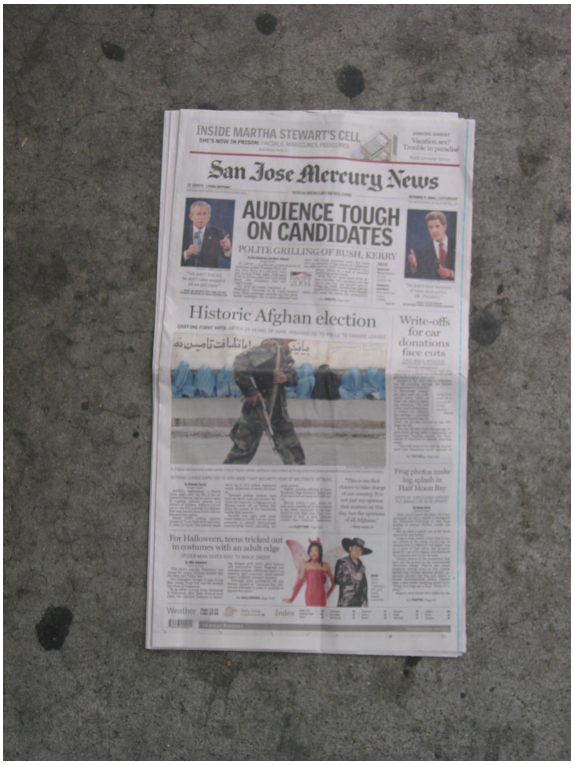

Figure 1: The front page of the *San Jose Mercury News* paper for 2004 Oct 09. The paper will occur in many of the subsequent photos.

A Transit Journey Details

We describe details of the 2004 Oct 09 public transit journey from SJC to OAK to SFO and back to SJC. Times, waiting times, observations, and photographs taken are listed in a journal format. Observations mainly concern transit information and facilities, omitting cleanliness and smoothness of vehicle rides and also omitting descriptions of airport signage. A summary of this raw data appears in Table 2 on page 7. All times, listed using a twenty-four hour format, are approximate as the author's first goal was to ensure all transfers were successfully completed, but most times are accurate within ten seconds. Many photographs contain portions of the 2004 Oct 09 San Jose Mercury News front page (Figure 1) as proof the journey occurred on that date.

Figure 2: The journey began at the Continental Airlines ticket counter at SJC. Note the front page of the day's *San Jose Mercury News* in the foreground. In the background, the time is displayed on the red LED display. The clock is a minute slow, as it is also in Figure 23.

Throughout this document, we abbreviate the three airports using their three-letter abbreviations:

SJC: Mineta San José International Airport, located in northern San Jose,

SFO: San Francisco International Airport located in San Mateo County south of San Francisco, and

OAK: Oakland International Airport located in southwestern Oakland.

We visited the Continental Airlines at all the airports per BATT Rule 1.

A.1 09:06:10 Journey Initiation

The journey began in Terminal C of SJC near the Continental Airlines check-in counter. A photograph (Figure 2) of a nearly invisible clock in the terminal, the Continental counter, and the bottom of the Mercury News front page indicates the journey's initiation.

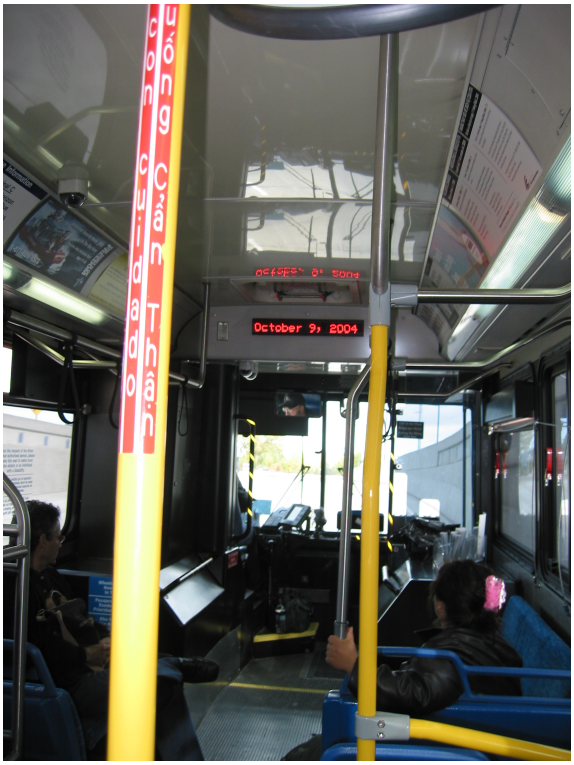

Figure 3: Aboard the VTA 10 bus east from SJC to the VTA light-rail train. Note the date on the red LED display.

A.2 09:06:20 Walk to VTA 10 Bus Stop

The approximately thirty meter walk from SJC Terminal C to the VTA 10 bus stop is short but requires crossing either three lanes of traffic and a bus lane or crossing five lanes of traffic. All traffic entering the airport must use this road. In contrast, passengers of private vehicles need not cross any traffic.

Figure 4: Aboard the VTA 10 bus east from SJC to the VTA light-rail train. Note the time on the red LED display.

A.3 09:13:50 VTA 10 from SJC to LRT

The author rode the Valley Transportation Agency (VTA)[2] bus route 10 east from SJC to First Street at Metro Drive in San Jose to transfer to the VTA's light-rail system (LRT). The 09:09 bus arrived late at 09:13:50. The bus stop, having a cover and benches, also listed scheduled bus times but did not have any system-wide information, any fare information, nor any information except in English. The bus pulled much past the bus shelter so all passengers had to walk one and a half lengths of the bus to board. The driver was moderately friendly, giving verbal instructions to a passenger as he disembarked the bus at the LRT stop. On board, there were some bus route schedules, fare information, and airport terminal information but no system-wide information. There is no indication of the bus's next stop despite the presence of a red LED display that could easily display this information. Riding the bus is free. The bus, scheduled to arrive at First Street at Metro at 09:16, arrived late at 09:18.

Figures 3 and 4 inside the bus displaying the date and time on the red LED monitor were taken at 09:15. The bus had no internal bus identification number.

A.4 09:19:40 VTA 901 (LRT) to San Jose Civic Center

Soon after the author disembarked from the VTA 10, the southbound VTA 901 light-rail train arrived so the author dashed from the VTA 10 bus stop on the west side of First Street, across Metro Drive and then (illegally[3]) across the two southbound lanes of First Street) to the LRT platform in the center of First Street. Already having exact change in his hand, he continued running at full speed to the second ticket machine, inserted the money, obtained a ticket, and boarded the train. The train arrived two minutes early at 09:18, and closed its doors twenty seconds early at 09:19:40. It departed exactly at 09:20:00.

If the author

- had not run full speed down the platform,

[2]The Santa Clara Valley Transportation Agency (`www.vta.org`) has a virtual monopoly on public transportation in Santa Clara County, a county with 1.7 million inhabitants [CB04].

[3]This was a violation of BATT Rule 7.

Figure 5: Riding the VTA 901 light-rail train to the San Jose Civic Center. The car number 957A appears on a blue sticker, and a VTA map appears to its left.

- had not known exactly the right buttons to push on the ticket dispenser, and
- had not previously had exact change available,

he would have missed the train. A recent prior experience with this transfer when the author was traveling from SJC to his home indicates the bus's late arrival and the train's early door closing occurs repeatedly.

Because of the train's early arrival and departure, the train platform was not inspected. Prior familiarity with the platform ticket dispensers indicates these machines accept cash and give change albeit in dollar coins.

The train arrived at Civic Center early at 09:24. It departed on time at 09:25:10.

A.5 09:24:10 Walk to VTA 180 Bus Stop

The approximately thirty meter walk from the light-rail platform in the center of First Street, San Jose, to the VTA bus stops on the east side of northbound First Street requires crossing the light-rail train tracks and two lanes of traffic. An alternate route, approximately eighty meters long, is to walk the length of the light-rail platform to a traffic signal to cross the northbound portion of First Street and then walk back the length of the platform to the bus stop. Most people choose to jaywalk across the tracks and the northbound lanes.

A.6 09:33:20 VTA 180 from San Jose to Fremont

The author rode the VTA bus route 180 from the San Jose Civic Center to the Fremont BART station. The bus stop had covered benches, two system maps, and one time schedule. All information was available only in English.

The 09:32 bus arrived at 09:32:50, departed at 09:33:20, and cost $3.00 exact change to travel on this express bus to the Fremont BART station. No receipt was given.

The bus driver, sporting a Manchester United hat in addition to his VTA uniform, answered questions but was not friendly.

Author: How much is it?

Driver: Do you have a flash pass or a day pass?

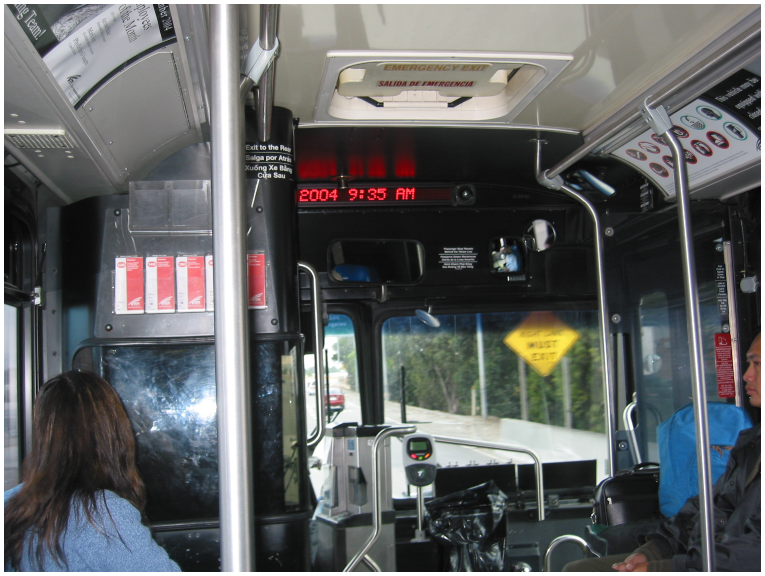

Figure 6: Aboard the VTA 180 bus from San Jose to Fremont. The red LED display indicates the current time of 9:35 a.m.

Figure 7: Riding the VTA 180 bus from San Jose to Fremont. Note the partial date displayed on the red LED display.

Author: No.

Author: Can you can give change?

Driver: $3

Author: May I have a receipt?

Driver: (shrug)

The bus, scheduled to arrive at the Fremont BART station at 10:04, actually arrived at 10:11:50, despite experiencing no delays because of traffic, because of passenger transfers from other busses, or because of slow passenger embarking or disembarking.

Figures 6 and 7 show the time and date near the beginning of the journey. The bus has no visible internal identification, but route 180 schedules are visible in the left side of the photograph. The camera shook when taking another photograph indicating the author's presence inside the bus at 10:09, i.e., a late arrival, so that photo is not shown.

A.7 10:11:50 Walk to Fremont BART Station

The Fremont BART bus station permits bus passengers to easily move between busses and the station. The distance is minimal. Since the author ran to catch the waiting BART train, nothing further is known.

A.8 10:12:20 BART from Fremont to Coliseum/OAK

The author rode the Bay Area Rapid Transit train (BART)[4] train from the Fremont station to the Coliseum/Oakland Airport station. Even though the train was scheduled to depart at 10:08, the author was able to board the waiting train at 10:12:20, and it did not leave the station until 10:14:20.

Since the author already had a prepaid BART fare card, he did not purchase a ticket at the Fremont Station.[5] It is unclear if he would have missed the train if he had needed to purchase a ticket. These machines accept cash,

[4]The San Francisco Bay Area Rapid Transit (`www.bart.gov`) provides train and subway service through portions of the San Jose-San Francisco-Oakland Combined Statistical Area but does not serve San Jose.

[5]This is a violation of BATT Rule 5 that all fare must be paid during the journey.

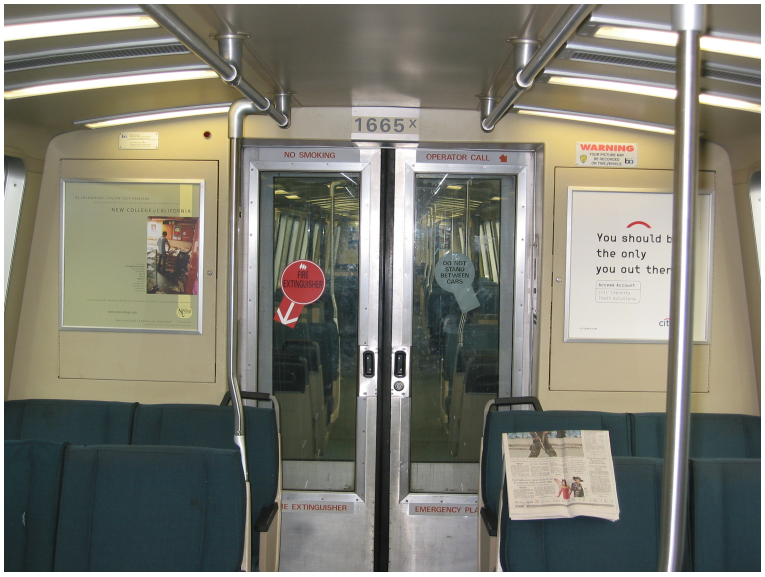

Figure 8: Riding the BART train from Fremont to the Coliseum/Oakland Airport station. Note the car number and the newspaper's front page. A blue "ba" is faintly visible on the silver plaque in the upper, left corner of the photograph.

credit cards, and debit cards, issuing change and dispensing cards with any desired value. BART fares are distance-based. Determining a particular fare is usually possible by consulting a grid-based display near the ticket dispensers. The journey cost $3.00.

Both platforms and trains display schedules and system-wide maps, but the train cars have no indication of the next station. Red LED signs on the platforms usually display "important safety information" but occasionally display the time until the next train. When a train approaches, the train's destination and length are displayed.

The BART system is constructed so there is no need for employee-patron interaction. Despite this, the BART driver repeatedly chided two bicyclists for having bicycles in the first train car even though they were causing no problems and speaking in Spanish might have been more effective. After the situation was resolved, he chided, again in English, the bicyclists to read the bicycle rules but did not indicate where these rules are located.

The train, scheduled to arrive at the Coliseum/OAK station at 10:34, actually arrived at 10:38:50.

A photograph (Figure 8) aboard the train car indicate the car number. A blue "ba" BART emblem is barely visible in the upper left corner of the photograph.

A.9 10:38:50 Walk to AirBART Bus Stop

The AirBART bus stop is immediately outside the Coliseum/Oakland Airport BART station. Anyone exiting the station to the west must walk past the bus stop.

A.10 10:40:30 AirBART from Coliseum/OAK BART to OAK

AirBART is a shuttle linking the Coliseum/Oakland Airport BART station with OAK, usually running every fifteen minutes.

Scheduled to leave at 10:40, it left on time at 10:40:30. Exact cash for the $2.00 fare is required. The `511.org` website indicated BART fare cards were valid on the bus, but the bus had no BART card reader so one has to deposit the entire BART fare card. This was not explained on the webpage.

The driver was not particularly friendly. She did explain the exact fare

Figure 9: The AirBART bus takes passengers from the Coliseum/Oakland Airport BART station to OAK. The bus is equipped with a red LED display, but it was not operating. Neither was the bus driver's name displayed.

Figure 10: Arriving at the Continental Airlines ticket counter in OAK marks the end of the first third of the journey.

requirement although her terse explanation required some thought to understand.

The bus was devoid of identifying information including fare information, route information, route schedules, and system-wide route information. The bus was equipped with an internal red LED display, but this was not used. See Figure 9. The bus driver's name was supposed to be displayed, but it was not. There was no indication of the particular bus number.

Scheduled to arrive at OAK at 10:55, it arrived early at 10:53:00.

A.11 10:53:00 OAK

The author crossed several lanes of private vehicular traffic to enter the terminal. Unlike at SJC, the crosswalk is protected by a traffic signal, improving pedestrian safety.

The author took a photo of the Continental ticket counter at OAK (Figure 10) and used the airport restroom. No bathroom facilities had been available during the previous two-hour journey (except possibly at the Fremont BART station at which the author arrived late).

Figure 11: Riding the AirBART bus from OAK back to the Coliseum/Oakland Airport BART station.

A.12 11:01:40 AirBART from OAK to Coliseum/OAK BART

Returning to the OAK Terminal 1 AirBART bus platform, the author noted the covered bench and the sparse AirBART schedule information. The information basically said busses run every ten minutes during particular hours. There was no AirBART route map, BART map, AC Transit information, phone numbers, or other transit information for Alameda County. The benches were positioned so close to the curb that, if anyone person stopped between the bench and the curb, no one else could walk past. Such congestion happened both when waiting and when disembarking the bus. When disembarking, passengers can leave the back of the bus but are trapped by the embarking passengers. Gridlock could occur in some situations.

There was a machine accepting the exact $2.00 fare in cash. The machine's credit card function had been taped over and then broken through so it was unclear whether credit cards were actually accepted.

Seeing an AirBART bus at the Terminal 2 AirBART platform, the author ran to the waiting bus, boarding 11:01:20. The bus left at 11:01:40, slightly

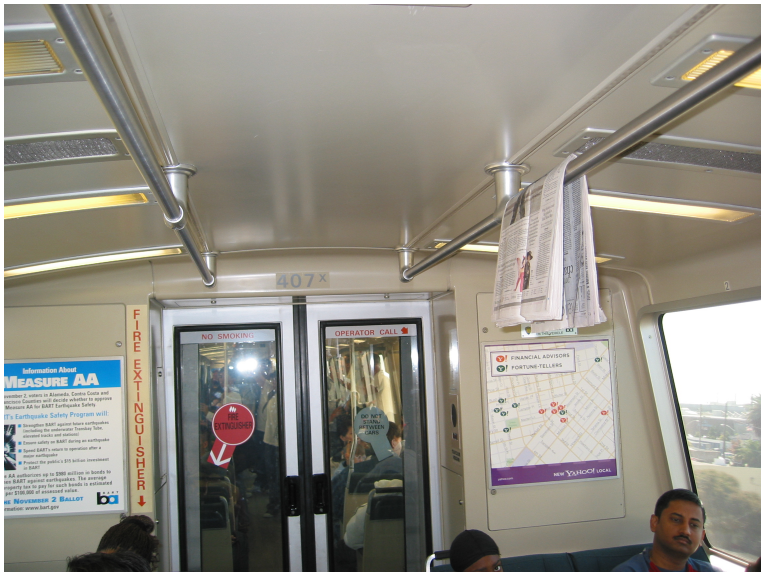

Figure 12: The BART train from Coliseum/Oakland Airport to San Francisco Montgomery stations was full of passengers. The train car number 407X is visible.

after its scheduled departure at 11:00. Since the author had planned for more time at OAK, he was now ten minutes ahead of his planned schedule.

This bus had one more piece of information than the previous AirBART bus: the driver's name "Eduardo," as noted in Figure 11. Eduardo answered passenger's fare questions but not in a particularly friendly way.

The bus arrived at the Coliseum/Oakland Airport BART station at 11:12:30, before its scheduled 11:15 arrival. The author was now thirteen minutes ahead of his anticipated schedule.

A.13 11:12:30 Walk to Coliseum/OAK BART

As mentioned in Section A.9, the AirBART bus stop is adjacent to the Coliseum/Oakland Airport BART station.

Figure 13: The blue BART advertisement displays BART's "ba" symbol.

A.14 11:17:20 BART from Coliseum to Montgomery

By 11:13:30, the author was waiting for a San Francisco-bound BART train, which arrived at 11:17:20, 3:20 minutes after its scheduled time.[6] Although there was a chance the train would arrive in San Francisco in time to make the next train-to-bus transfer thirty minutes earlier than expected, the BART was delayed in west Oakland, across from the U.S. Postal Service Oakland office, because of a track inspection at the San Francisco Embarcadero Station. The train was also delayed again before arriving at Embarcadero Station. Thus, the possibility of taking an earlier bus was eliminated. A phone call to a BART telephone operator, connected through the 511 Bay Area transit telephone service [MTC04], indicated a BART train was scheduled to arrive at SFO sixteen minutes earlier than the author originally scheduled, but he guessed that train would also be delayed so he decided to ride a bus to SFO instead.

The train arrived at the San Francisco Montgomery Station at 11:49,

[6]For this travel segment, actual times are correct, but the scheduled times were obtained from the 2005 Apr 17 schedule, which may have been different from the 2004 Oct 09 schedule. The author does not have access to the latter.

fourteen minutes late. The journey cost $3.15.

Figures 12 and 13 inside the BART train demonstrate the large number of passengers on-board and the large number of OAK airport passengers using the service.

A.15 11:50:00 Walk to SamTrans KX Bus Stop

The author ran 1.5 blocks from the BART Montgomery Station to the SamTrans bus stop on Mission Street between Second Street and New Montgomery Street. Arriving at 11:52:20, he began waiting at the covered bus stop having three "flopping" seats that turn vertical when not in use. The bus stop, served by three different agencies, had a system-wide map in English for the San Francisco MUNI transit agency and lots of ads but no more information. There was no transit information for the eight SamTrans lines serving this stop and not even the numbers of the Golden Gate Transit busses serving the stop.

The author ate lunch at the bus stop since food consumption is not permitted on any transit taken except for CalTrain.

A.16 12:10:50 SamTrans KX from San Francisco to SFO

The San Francisco International Airport (SFO) is located in San Mateo County, not San Francisco, so one must travel there from San Francisco. The San Mateo County Transportation Agency[7] operates the KX express bus from downtown San Francisco City and County to SFO and then just across the southern San Mateo County line to northern Palo Alto. This bus does cross county lines and so San Francisco restricts what passengers can carry and where passengers can disembark, presumably to protect its transportation agency's jurisdiction from "unfair" competition.

The 12:08 SamTrans KX arrived at 12:10:50. Exact cash fare of $3.50 is required. The unfriendly driver informed me that there were four stops at SFO but replied "I don't know either" to my query which stop was for

[7]The Sam Mateo County Transit (SamTrans, `http://www.samtrans.com/`) has a virtual monopoly on public transportation in San Mateo County, a county with 0.7 million inhabitants [CB04].

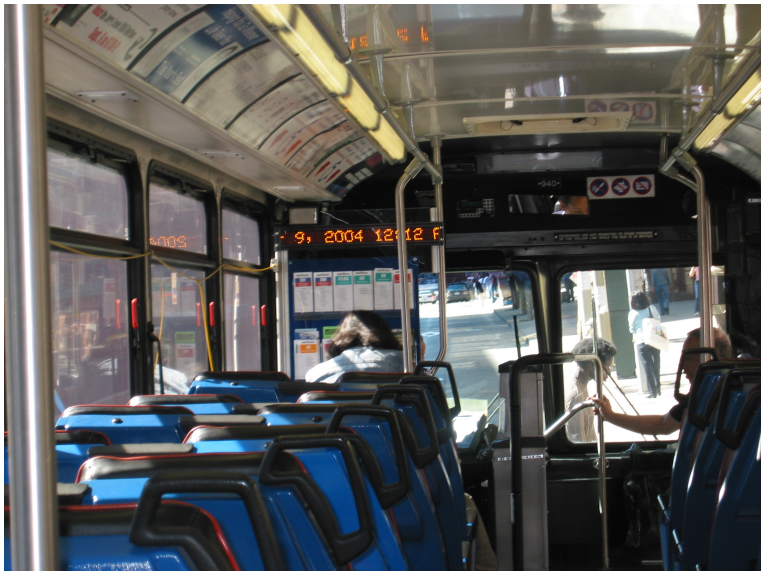

Figure 14: Riding the SamTrans KX bus from downtown San Francisco to SFO. Note part of the time and part of the date on the yellow LED sign.

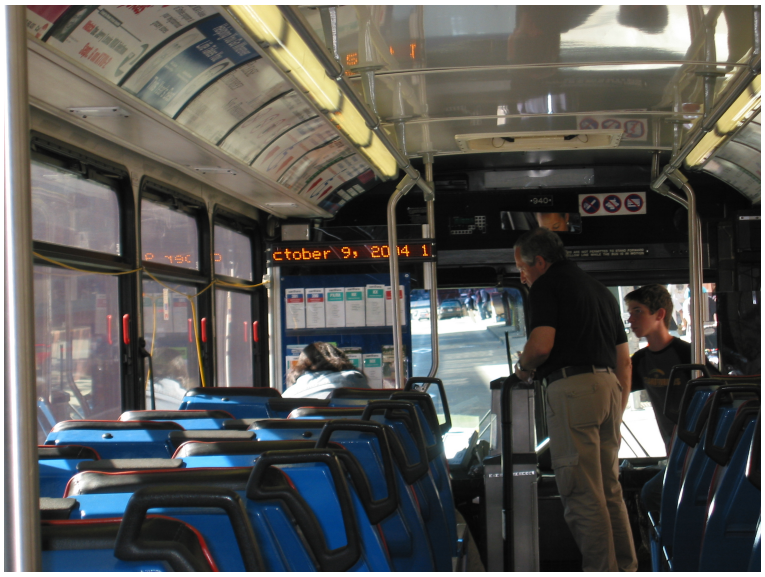

Figure 15: The yellow LED display aboard the SamTrans KX bus shows the rest of the date.

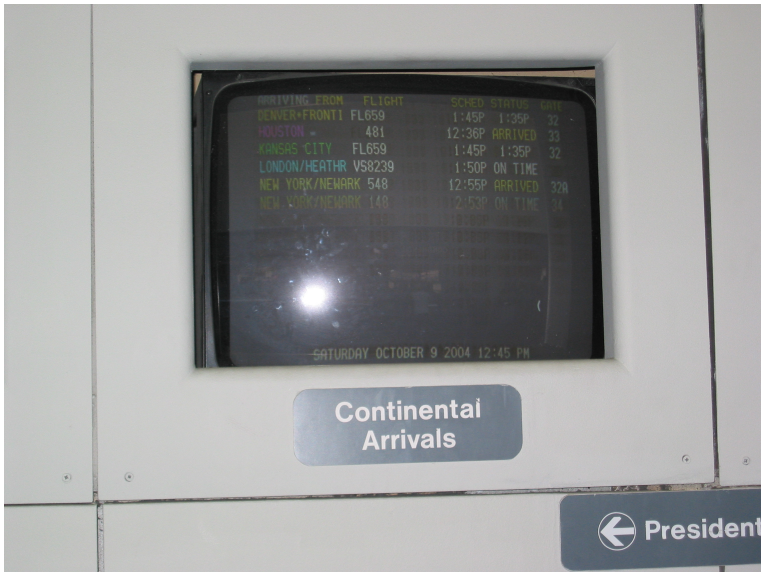

Figure 16: The SFO Continental Airlines arrival monitor indicates both the date and time.

Continental Airlines. She did not inform me that there would be a verbal announcement of airlines before each stop.

On the bus, there were schedules for individual bus routes and fare information, both available in English only. There was no system-wide information nor any non-verbal information about the SFO and its terminal even though a large portion of this bus's customers use it to travel to SFO.

The bus, scheduled to arrive at SFO at 12:40, arrived slightly late at 12:41:00. The SFO Terminals 1 and 2 bus stop is located next to the unused Terminal 2 so passengers must walk back to Terminal 1 to enter the terminal.

Figures 14 and 15 inside bus 940 demonstrate an LED display indicating the date and time on the bus and some of the individual bus route schedules.

A.17 12:41:00 Walk Through SFO

As mentioned in the previous section, the SamTrans bus stop is located next to Terminal 2 so the author ran more than half the length of Terminal 1 and up two escalators to reach the Continental Airline ticket counter. The Continental monitor (Figure 16) shows the date and time. He also used the

restroom since none of the transit agencies used provided bathroom facilities.

A.18 12:48:10 SFO AirTrain to BART SFO

The SFO AirTrain connects the various terminals, rental car agencies, and parking garages at SFO. The red line circles clockwise, while the blue line circles counter-clockwise and also serves the rental car agencies.

The journey through Terminal 1 to reach the Terminal 1 AirTrain Station required walking through a long tunnel having a moving sidewalk, going up four flights using an elevator or stairs, across another long tunnel also with a moving sidewalk, and up another flight of stairs.

The AirTrain platform has maps and LED displays near the two platforms. There are no schedules because trains run extremely frequently. (It usually takes longer to walk through a terminal to reach the AirTrain than the entire AirTrain journey including waiting for an arriving train.) The LED displays are misleading because the red line signs indicate serving all terminal and the BART station, while the blue line signs indicate serving all terminals and the rental car agencies. In fact, the blue line also serves the BART station. Further adding to the confusion is the fact that red and blue trains usually arrive almost at the same time so the trains' verbal announcements occur simultaneously.

The author boarded a red line AirTrain at 12:48:10. Inside the train are maps indicating all terminals, local BART stations, and CalTrain at Millbrae, which is outside SFO. There are verbal indications of the next stop, but no visual indications. The train arrived at the SFO BART Station at 12:53.

No photographs were taken inside the train.

A.19 13:13:00 BART from SFO to Millbrae

The author took BART south from the SFO Station to the Millbrae Station. The AirTrain and BART SFO stations are integrated with the BART SFO station one level below the AirTrain platforms. The author arrived on the BART platform at 12:54:10. The platforms are well-signed with maps, schedules, and an occasional bench.

The train, scheduled to leave at 13:04, arrived at 13:04:20 and departed the station late at 13:09:40. Despite this, the train arrived at BART Millbrae at 13:13:00, only fifty seconds late. Upon arrival, there was a verbal announcement concerning connecting to CalTrain. The journey cost $1.50.

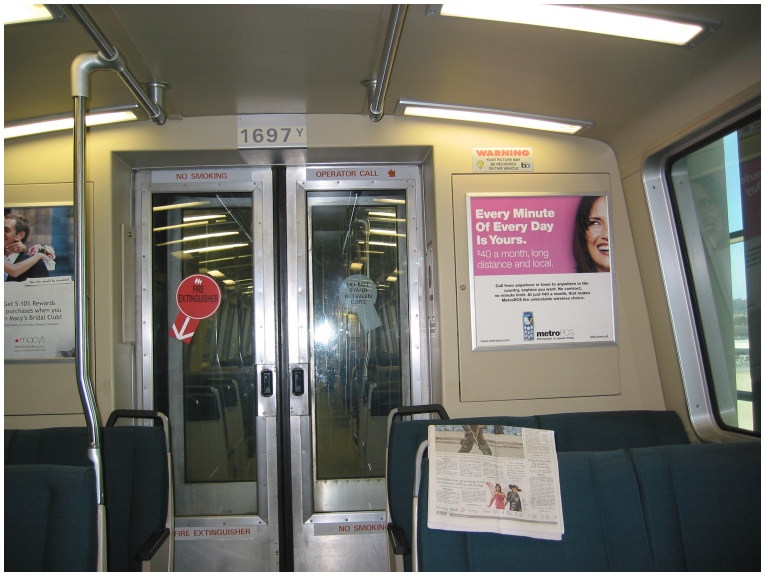

Figure 17: Riding the BART train car 1697Y from SFO to Millbrae.

Figure 17 indicates the BART train car.

A.20 13:25:00 CalTrain from Millbrae to Santa Clara

CalTrain (`http://www.caltrain.com/`) serves San Francisco Peninsula and South Bay cities from San Francisco to San Jose and Gilroy using heavy diesel locomotives. The CalTrain Millbrae and BART Millbrae Stations are integrated with platforms immediately next to each other. Thus, the author arrived at the San Jose-bound platform 5 at 13:15:50 after purchasing a $4.25 ticket from a vending machine. The machine accepts cash and credit cards and presumably gives change.

In this train station which opened in 2003, there are many signs indicating ways to reach other platforms but almost no signs indicating the destination of the platform on which one is waiting. Many LED signs flash "important safety announcements," the time, and upcoming events, but not the time until the next train's arrival nor the cities it will serve. See Figures 18 and 19. On platform 5 there are only two indications the platform serves only southbound trains. On the bottom of two LED signs in small letters, "San Jose Platform" appears. System maps and schedules are available on

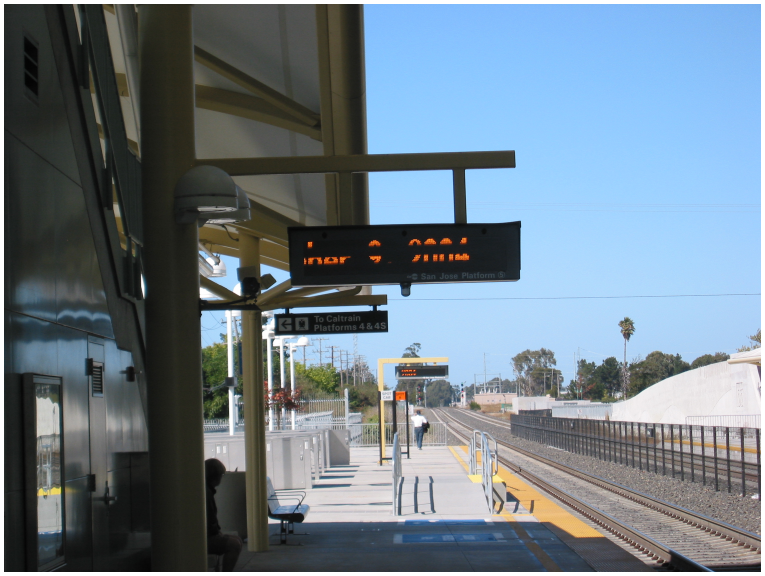

Figure 18: Waiting for the southbound CalTrain at the Millbrae train station. The date is partially visible on the yellow LED display.

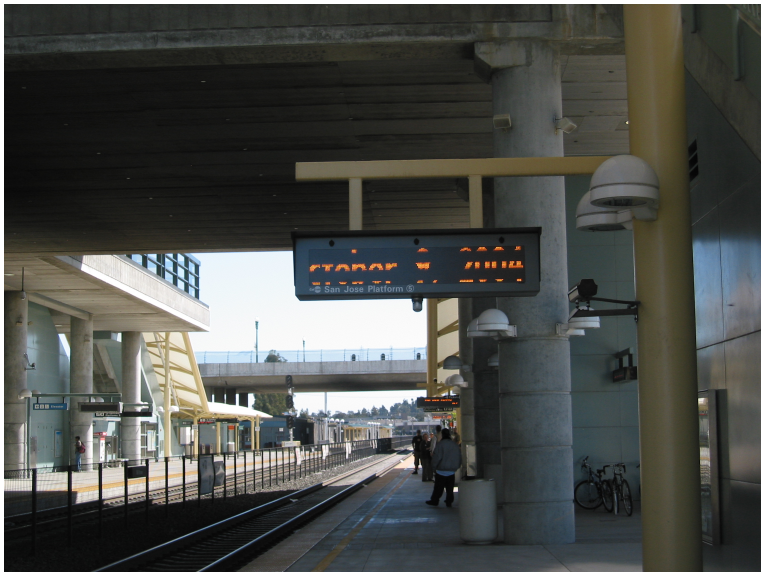

Figure 19: Looking south while waiting for the southbound CalTrain. The date is partially visible on the yellow LED display.

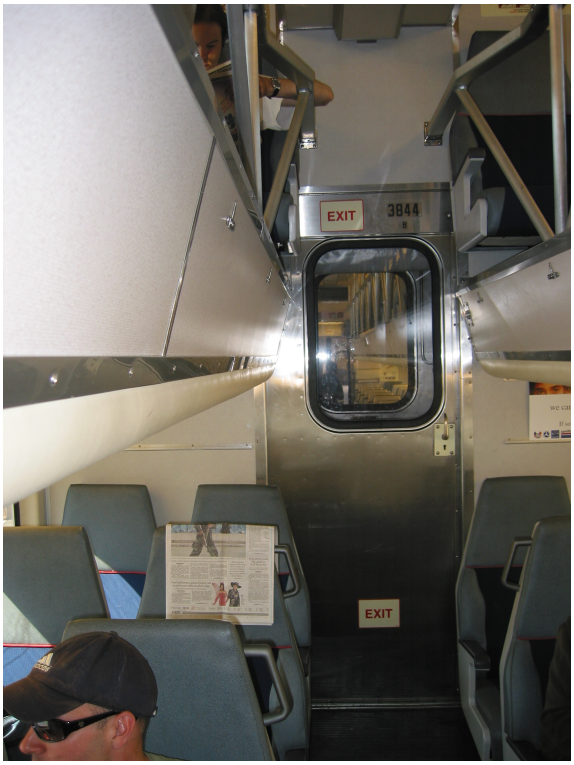

Figure 20: Aboard CalTrain car 3844, traveling from Millbrae to Santa Clara.

the platform.

The 13:24 train arrived at 13:24:20, leaving at 13:25:00. Inside the train, schedules and maps are available. Although a conductor walked through the car twice, he did not ask for tickets. While riding, a conductor verbally announces the next stop, but there are no visual indications of the next station, and very few platform signs so passengers were repeatedly heard asking "What station is this?". The train arrived at the CalTrain Santa Clara Station at 14:29:20, 1:20 minutes late.

Figure 20 inside the CalTrain train car indicates the train car number.

A.21 14:41:00 VTA 10 from Santa Clara to SJC

The author rode the free VTA 10 from the Santa Clara CalTrain Station to SJC Terminal C. The VTA 10 bus stop is located approximately twenty

Figure 21: The VTA 10 bus connects the Santa Clara train station with SJC. Note part of the date on the red LED display.

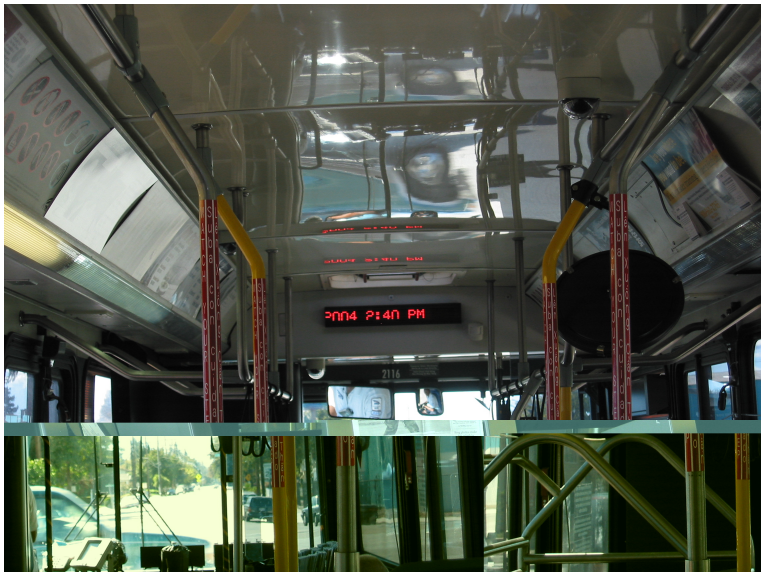

Figure 22: The time is displayed aboard the VTA 10 bus. A flash memory error corrupted the bottom portion of this figure.

Figure 23: The journey ends at the Continental Airlines ticket counter at SJC at 14:56:30. The time of 2:55 is barely visible as a red LED clock in the middle left. The clock is a minute slow. A flash memory error caused the lower portion of the photograph to be green.

meters from the CalTrain platform so the author arrived at 14:30:30. The doors of bus 2116 opened at 14:38:20, and the bus departed ten seconds earlier than its scheduled 14:41 departure. The driver was talking on a mobile phone upon entry so he was not friendly.

The bus stop is covered, has benches, and a schedule. The author does not remember if system-wide information is available. It had no CalTrain information even though many disembarking passengers use CalTrain.

The bus arrived at SJC C Terminal at 14:55:00, earlier than the scheduled 14:57 arrival.

Figures 21 and 22 inside the bus indicate the date and time.

A.22 14:56:30 Walk to SJC

As noted in Section A.2, VTA 10 bus passengers must cross several lanes of traffic to reach the SJC terminal. The author arrived at the Continental Airlines counter of SJC at 14:56:30, five hours, fifty minutes, and twenty

seconds (5:50:20) after initiating the journey. See Figure 23.

B Driving Journey Details

The same SJC, OAK, SFO, SJC circuit was driven using the author's private automobile to compare and contrast with the public transit journey. Admittedly, the two journeys could not begin at the same time, but they did both occur on 2004 Oct 09 so day-specific factors were eliminated.

The journey began at the Continental Airlines counter of SJC C Terminal at 16:07:30. After running to the parked car in the short-term parking lot of the terminal, the author drove through the airport on Airport Road to Coleman Avenue and then onto the I-880 freeway north. Twenty-two miles later, he exited 98th Avenue in Oakland, headed west to OAK, parked in Terminal 1 short-term parking, and ran to the Continental ticket counter.

Returning to the car, he retraced his route back to I-880. There were two obvious choices of routes to SFO, one traveling north on I-880 to I-80 through San Francisco and to US 101 south. The author's experience indicates this route is usually congested at all times on all days so he instead drive south on I-880, west on CA 92, paying a toll, and north on US 101 to SFO, which has an exit immediately off US 101. The author has a FasTrak automatic toll payment mechanism, greatly reducing the time to pay a toll and also reducing its cost from $3.00 to $2.00.[8]

After parking at SFO Terminal 1, he ran down one flight of stairs, through the long tunnel with a moving sidewalk to the terminal and then up two flights of escalators to the Continental ticket counter. After returning to the car along the same route, he drove out of the airport onto US 101 south thirty-one miles to CA 87, which he almost immediately exited to enter SJC. The journey ended at 18:18:00, two hours, ten minutes, and thirty seconds (2:10:30) after it began.

Table 3 presents times and mileage for the driving journey from SJC to OAK to SFO to SJC. Times and mileage were recorded when each event began, e.g., he drove onto I-880 north at 16:17:20 after driving 2.1 miles from the journey's initiation. Some times and miles were inadvertently not recorded by the author. All distances are measured in miles since the author's automobile's odometer displays miles. Out-of-pocket costs of parking and

[8]The author subsequently decided this was a violation of BATT Rule 5 that all costs must be paid during the journey.

Table 3: Times, mileage, and costs for the driving journey SJC to OAK to SFO to SJC.

Location	Time	Mileage	Cost
SJC Terminal C	16:07:30	0.0	
SJC short-term parking	16:11:00	0.2	$1.00
San Jose surface streets	16:14:40	1.8	
I-880 north	16:17:20	2.1	
Oakland surface streets (98th Avenue)	16:49:30	34.4	
OAK streets	*unknown*	*unknown*	
OAK Terminal 1	16:57:30	36.6	
OAK short-term parking	17:00:10	*unknown*	$2.00
OAK streets	*unknown*	*unknown*	
Oakland surface streets (to 98th Avenue)	*unknown*	*unknown*	
I-880 south	17:05:10	38.9	
CA 92 west	17:12:30	46.8	$2.00[a]
US 101 north	17:25:30	59.9	
SFO streets	17:31:50	66.3	
SFO Terminal 1	17:37:30	67.5	
SFO short-term parking	*unknown*	*unknown*	$1.00
SFO streets	17:41:50	67.8	
US 101 south	17:17:53	69.0	
CA 87 south	18:12:50	100.0	
SJC streets	18:13:20	100.7	
SJC Terminal C	18:18:00	101.2	
SJC short-term parking	N/A	N/A	$1.00
Total	2:10:30	101.2	$7.00

[a]This cost paid using a FasTrak automatic payment device was $1.00 cheaper than the cash fare that should have been paid under BATT Rule 5.

tolls are listed. Both the OAK parking and the second SJC parking fees were waived by the parking lot attendants since the time spent in the lot was minimal, but the table indicates the fee that should have been charged. The last entry indicates the final cost of parking at SJC. No times nor mileage are indicated since the journey back to the SJC Continental ticket counter had finished but the parking fee still needed to be paid.

Out-of-pocket parking costs constitute only a small portion of the actual cost of operating an automobile. To these costs, we add mileage costs using the U.S. Internal Revenue Service's standard mileage rate of $0.375 per mile to figure the deductible costs of operating a car for business purposes [IRS04, Ch. 28]. This figure, adjusted annually, indicates an average vehicular operating cost rate. This rate omits the cost of acquiring a vehicle but does incorporate some costs amortized over many miles such as repairs, insurance, and licensing. The alternative of using a marginal cost consisting of gasoline and oil costs only underestimates true operating expenses. At $0.375 per mile, the 101.2 miles of driving cost $37.95. Adding cost of parking and tolls, the total journey cost was $44.95, 2.26 times larger than the transit cost.

C Bay Area Transit Triathlon Rules

The author hopes others will participate in the Bay Area Transit Triathlon, trying to minimize times and costs for journeying via public transit or private vehicle. Continuing triathlons into the future will encourage transit agencies to streamline their operations to better serve the public. It is also fun!

To ensure comparable results that actually test transit systems, the following rules must be obeyed:

1. The journey must visit all three major Bay Area airports: SJC, OAK, and SFO, returning to the journey's origin. The journey must include visiting the ticket counter of the same airline at all airports. No contact with airport employees need be made. The origin need not be an airport. The journey need not be a circuit.

2. Participants must make a reasonable attempt to document triathlon times either through photography or obtaining verifiable signatures of witnesses. The time stamp from a camera, watch, or mobile phone is not sufficient because it can be manipulated. Better is photographing an airport clock together with the front page of that day's newspaper.

If witnesses are used, it must be possible for an independent party to contact the witnesses to confirm reported times. Witnesses must not have any conflict of interest or relationship with the participants.

3. Be courteous. It is forbidden to knock over or interfere with ordinary people during the journey.

4. No special treatment not otherwise available to one or more members of the general public is acceptable. For example, a police escort or a special request of a bus driver to be dropped off at a place other than a usual bus stop is forbidden. Use of carpool lanes is acceptable.

5. All amounts paid must be at least the regular fares for an ordinary vehicle or for one adult. No use of passes or special discounts is permitted. All costs must be paid during the journey. Purchasing gasoline is excepted.

6. When using transit, one cannot use any motorized vehicles excepting regularly scheduled services available to any member of the public. Taxis are not regularly scheduled so they are prohibited, but walking, running, skateboarding, and cycling are permitted. Motorized scooters are prohibited. "Regularly scheduled" implies the service must be available at least once every week so special monthly or annual services are excluded, but weekly services available only seasonally may be used.

7. During the journey, obey all laws. If operating a vehicle such as a bicycle or a car,

   (a) Obey all traffic laws and regulations including traffic lights, stop signs, speed limits, warning and caution signs, and warning or caution speed limits. If no speed limit is posted, the default speed limit must be obeyed. In particular, bicyclists musts obey all vehicular laws including stop signs, traffic lights, and yield signs.

   (b) Vehicles must be parked at each airport in a location legal to completely vacate a vehicle. Short-term parking lots and parking meters are acceptable. Temporarily parking a car along a drop-off curb is not. Parking in disabled parking is prohibited because it is not available to the general public. Bicycles can be parked anywhere they do not obstruct others.

(c) The cost of parking at the origin must be counted twice, once at the journey's beginning and once at the journey's end.

For the driving variant, using any ground-based vehicle is acceptable, including motorcycles.