

Ground Access Analysis Methodology and Results

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Regional Airport System Plan Analysis Phase 2

Aviation System Consulting, LLC
805 Colusa Avenue
Berkeley, CA 94707-1838

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Introduction

This technical memorandum documents the methodology and results of the ground access analysis undertaken for Phase 2 of the current Regional Airport System Plan Analysis. This work was part of the mid-point screening analysis performed to compare the Baseline Scenario with six system development scenarios defined in the study.

The regional aviation study adopted seven Goals and performance measures for each goal. The Convenient Airports goal measures the ease of airport use based on ground access distance and travel time (travel costs are also assessed, as an additional comparative metric). The ground access analysis also feeds into the evaluation of other study goals addressing the impact that each system scenario has on greenhouse gases and air pollution, by assessing the greenhouse gas and air pollution emissions produced by surface travel to and from airports.

Major outputs of the analysis, therefore, included estimation of the number of air passenger ground access and egress trips and the associated vehicle-miles of travel (VMT), travel distances, travel times and costs, and greenhouse gas (GHG) and air quality emissions (hydrocarbons and oxides of nitrogen, which combine to form smog). Underlying these calculations is the forecast distribution of air passenger trip ends in the Bay Area, as well as ground access travel by air passengers using the Bay Area airports with trip ends in the larger Northern California region.

The analysis was undertaken for the Baseline Scenario for the base year 2007 and for the Baseline and system development scenarios for the forecast demand levels in 2035. Since only those air passengers beginning or ending their air trips at the Bay Area airports contribute to ground access and egress travel, the analysis was based on the forecasts of origin and destination (O&D) passengers and excludes connecting passengers. Although airport ground access and egress travel involves trips both to and from the airports, for brevity this is referred to in the remainder of this memo as ground access travel and the trip ends are referred to as trip origins for consistency. It was assumed that the geographic distribution of trip origins and trip destinations is the same and the use of ground access and egress modes is symmetrical. Therefore the approach followed in the analysis distributed the total forecast O&D air travel to analysis zones based on the distribution of trip origins obtained from air passenger surveys conducted at the three primary Bay Area airports between 2001 and 2006, and then applied the

mode use percentages for ground access trips obtained from those surveys to determine the total amount of ground access travel by different modes.

Many air passengers travel to airports in travel parties of more than one person, which generally travel together in the same vehicle. Therefore calculations of VMT, emissions, and those aspects of travel costs that are vehicle-dependent (such as parking or taxi fares) need to be based on the number of air parties rather than the number of air passengers. The conversion of forecast air passenger trips to equivalent air party trips is discussed in more detail below.

System Development Scenarios

In addition to the Baseline Scenario, which was analyzed for both 2007 and forecast 2035 levels of Bay Area air passenger traffic, the mid-point screening analysis considered the following system development scenarios:

- Demand Redistribution
- Internal Secondary Airports
- External Airports
- High-Speed Rail
- New Air Traffic Control Technologies
- Demand Management

The ground access analysis was performed for the first four of these scenarios for forecast 2035 levels of air passenger traffic. The New Air Traffic Control (ATC) Technologies Scenario does not change the number or distribution of ground access trips from the Baseline Scenario, but reduces aircraft delays through improvements in runway capacity. The Demand Management Scenario reduces aircraft delays at San Francisco International Airport (SFO) through four effects: increasing average aircraft size for some operations, shifting flights from peak to off-peak hours, diverting some general aviation activity from SFO to other airports, and substituting bus service for some regional airline feeder flights between SFO and some of the closer small communities. Only the fourth of these effects will impact ground access analysis, adding a small number of bus trips. However, the overall effect of this on the number of ground access trips and the associated impacts is very small.

The Demand Redistribution Scenario shifts air trips between the three primary Bay Area airports, with associated changes in the ground access travel. The Internal Secondary Airports

and External Airports scenarios reflect a shift in air trips from the three primary Bay Area airports to other airports (within the region in one case and outside the region in the other), with associated changes in ground access travel.

The High-Speed Rail Scenario involves diversion of air travel to the planned California high-speed rail (HSR) system. While this reduces the number of ground access trips to the Bay Area airports, these trips become ground access travel to the HSR stations and are included in the analysis.

Analysis Zones

For ground access travel to airports and high-speed rail stations from trip origins within the nine-county Bay Area, the analysis was performed using the Metropolitan Transportation Commission (MTC) system of 1,454 travel analysis zones (TAZs). This was done partly to obtain adequate resolution of travel distances, times and costs, and partly because highway and transit network distances, travel times and costs were readily available at the TAZ level from MTC regional travel demand modeling, as discussed further below. Ground access travel from trip origins outside the nine-county Bay Area was analyzed using the system of External Travel Analysis Zones shown in Table 1. The assignment of estimated 2007 and forecast 2035 levels of regional O&D air travel to TAZs and external zones is described in a separate technical memorandum titled *Forecast Demand Allocation Methodology*.¹

Market Segmentation

The assignment of estimated 2007 and forecast future levels of regional O&D air travel to TAZs and external zones developed separate assignments for domestic and international trips, each divided into the following four market segments:

- Resident trips from home origins
- Resident trips from non-home origins
- Visitor trips from home origins
- Visitor trips from non-home origins.

¹ Aviation System Consulting, LLC, *Forecast Demand Allocation Methodology*, Prepared for the Metropolitan Transportation Commission, Regional Airport System Plan Analysis Phase 2, Berkeley, California, June 2010.

Table 1. External Travel Analysis Zones

Zone	Name	Counties
111	Lake County	
112	Mendocino County	
113	Merced County	
114	Monterey County	
115	Sacramento County	
116	San Benito County	
117	San Joaquin County	
118	Santa Cruz County	
119	Stanislaus County	
120	Yolo County	
131	Northern California	Butte, Colusa, Del Norte, Glenn, Humboldt, Lassen, Modoc, Plumas, Shasta, Sutter, Tehama, Trinity, Yuba
132	Sierra	Alpine, Amador, Calaveras, El Dorado, Inyo, Mariposa, Mono, Nevada, Placer, Sierra, Tuolumne
133	Central Valley	Fresno, Kern, Kings, Madera, Tulare
134	Central Coast	San Luis Obispo, Santa Barbara
135	Southern California	Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, Ventura

The ground access analysis was based on the projected number of annual air passenger trip ends from each analysis zone for each of the eight market segments. The number of trips in a given market segment from each analysis zone was divided among the three Bay Area airports in the Baseline Scenario according to the 2006 airport shares of trips from that zone determined from the most recent air passenger surveys for the three airports. As described in the *Forecast Demand Allocation Methodology* technical memorandum, the geographic distribution of trip origins for air passengers using Oakland International Airport (OAK) and SFO was obtained from the MTC 2006 Air Passenger Survey, while that for air passengers using Mineta San José International Airport (SJC) was obtained from the MTC 2001/2002 Air Passenger Survey. In each case the number of air passenger trip origins from each analysis zone and market segment was factored up to give the total O&D passenger traffic in 2006 at each airport.

Because the airport shares of trips in a given market segment vary widely from TAZ to TAZ, due to the limited number of survey responses in a given zone (many TAZs having no

responses at all), the airport shares were computed for a system of larger zones based on the 34 MTC superdistricts and the external zones described above. The airport shares for each superdistrict were then applied to each TAZ within that superdistrict.

Adjustments to this process were required in the case of the Demand Redistribution, Internal Secondary Airports and High-Speed Rail scenarios in order to calculate the changes in market share from each analysis zone as a result of the diversion of air passengers between the three primary Bay Area airports or from the primary airports to the secondary airports or high-speed rail. These adjustments are discussed in the *Forecast Demand Allocation Methodology* technical memorandum.

Air Party Size and Access Mode Use

In order to calculate the number of ground access vehicle trips by mode from each analysis zone, it was necessary to convert the number of air passenger trip origins to air party (strictly ground access travel party) trips. This was done by applying an average air party size for each market segment to the number of air passenger trip origins. The average air party sizes were calculated from the air passenger survey data on the basis of air parties with less than 10 air passengers. Air parties with 10 or more air passengers were calculated separately by applying the percent of air passengers in large air parties and the average large air party size to the total number of passengers in each analysis zone. Since there were only a few such large air parties in the air passenger survey data, it was felt that the geographic distribution of these trip origins were simply a result of the survey sample size and it was more reasonable to assume that large air parties could originate from any analysis zone in proportion to the total air passenger trip ends in that zone. Separate percentages of passengers in large air parties and the average large air party size were determined for domestic and international trips, but the air passenger survey data did not support a breakdown by other market segments.

The air parties from each analysis zone were then assigned to the following ground access modes based on the observed mode use in the air passenger surveys for each airport:

- Private vehicle – drop-off
- Private vehicle – parked for the air trip duration
- Rental car
- Transit

- Scheduled airport bus
- Shared-ride door-to-door van
- Taxi
- Limousine
- Hotel/motel courtesy shuttle
- Charter bus or van

The transit mode included all regional rail services as well as local bus service. Scheduled airport bus mode refers to privately operated bus services on a fixed route and schedule, such as Marin Airporter or Sonoma County Airport Express.

Separate ground access mode use percentages were calculated for each market segment and each airport for the following regional sub-areas:

- Peninsula (San Francisco and San Mateo Counties)
- South Bay (Santa Clara County)
- East Bay (Alameda and Contra Costa Counties)
- North Bay (Marin, Napa, Sonoma and Solano Counties)
- External zones.

The access mode use for each sub-region was applied to all the analysis zones within the region, under the assumption that differences in mode use between zones within a sub-region observed in the air passenger survey data are largely a result of survey sample size limitations. While there is likely to be some variation in mode use within a sub-region due to differences in access to fixed route modes and distance from the airports, the only way to account for this would be to develop and apply a mode choice model, which was beyond the scope of the study.

In the case of SJC, the East Bay and North Bay sub-regions were combined and the External sub-region only applied to the external zones to the south of the Bay Area, reflecting the limited number of air passenger trips from the North Bay or external zones to the north or east of the region in the air passenger survey data.

Private vehicle parked for the duration of the air trip was not considered a valid access mode for visitor trips, since the access trip to a Bay Area airport by visitors to the region occurs at the end of their visit and they would have no reason to park a vehicle at the airport during the

visit. However, all other access modes were considered valid modes for both residents and visitors, based on the mode use observed in the air passenger surveys.

The air passenger survey data sample size did not allow an explicit tabulation of ground access mode shares for each market segment and each regional sub-area. Tabulations were prepared of access mode use by market segment and by regional sub-area, as shown in Attachment A, and then a tabulation of access mode use by market segment for each regional sub-area was derived by a process of iterative adjustments until the resulting shares by market segment and regional sub-area agreed with the survey data.

Due to the limited number of such trips in the survey data, the same mode use by large air parties (10 or more air passengers) was assumed for both domestic and international trips.

Internal Secondary Airports

The access mode use to the internal secondary airports is likely to be rather different from that to the primary airports for a variety of reasons. These airports are only likely to have air service to major West Coast destinations, which will affect air party characteristics such as travel party size and trip duration, the trip origins are likely to be much closer to the airports on average, any transit service is likely to be very limited, and there is unlikely to be enough demand to support scheduled airport bus or shared-ride or charter van service. Because of the proximity of trip origins to the airport, there is not likely to be any rental car use by residents, since taxi would be cheaper, or use of hotel courtesy shuttles by residents or visitors with home trip origins.

Therefore the assumed access mode use was based on the observed access mode use at OAK in the 2006 MTC Air Passenger Survey for trips to West Coast destinations with trip origins in the two closest superdistricts, superdistrict 17 (Hayward and San Leandro) and 18 (Oakland and Alameda). This gave the access mode use shown in Table 2.

Access to High-Speed Rail Stations

The ridership forecasts for the planned California high-speed rail system include projections of station access modes based on the mode choice model used to estimate HSR ridership, which includes a station access mode sub-model.

Table 2. Assumed Ground Access Mode Use at Internal Secondary Airports

Ground Access Mode	Resident Trips		Visitor Trips	
	Home Origin	Other Origin	Home Origin	Other Origin
Private vehicle – drop off	58.8%	40.8%	85.3%	35.0%
Private vehicle – parked for trip	32.0%	57.1%		
Rental car			12.7%	38.3%
Taxi	7.8%	2.0%	1.0%	10.9%
Limousine	1.3%	0.0%	1.0%	1.6%
Hotel/motel courtesy shuttle				14.2%
Total	100.0%	100.0%	100.0%	100.0%

The station access model considered the following modes:

- Drive and drop-off
- Drive and park
- Rental car
- Taxi
- Transit
- Other

The HSR ridership forecasts gave the number of station access trips by mode that combined both inter-regional and intra-regional trips (those riders making high-speed rail trips entirely within the Bay Area). Since these two categories of trip are likely to have different access mode use, it was necessary to adjust the projected station access trips to exclude the intra-regional trips. Although the number of intra-regional boardings at each station was given, it was necessary to assume the access mode use for these trips. Except for the Gilroy station, where the intra-regional trips accounted for about 36 percent of all boardings, the share of boardings attributed to intra-regional trips was less than 10 percent, so any error in these assumptions would have a fairly small effect on the access mode use for inter-regional trips. It was further assumed that the “other” inter-regional access trips were divided equally between limousine and shared-ride van. This gave the access mode use shown in Table 3.

Table 3. Station Access Mode Use for High-Speed Rail Travel

Station Access Mode	High-Speed Rail Station				
	San Francisco	Millbrae	Redwood City	San José	Gilroy
Private vehicle – drop off	27.3%	34.5%	44.6%	32.1%	71.3%
Private vehicle – parked for trip	23.0%	29.1%	36.5%	27.8%	23.1%
Rental car	8.4%	9.6%	9.7%	8.8%	2.0%
Transit	19.7%	12.9%	2.2%	15.9%	1.0%
Shared-ride door-to-door van	7.6%	4.2%	0.9%	5.1%	0.2%
Taxi	6.4%	5.5%	5.1%	5.1%	2.2%
Limousine	7.6%	4.2%	0.9%	5.1%	0.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

The HSR forecasts of station boardings by access mode did not distinguish between the various market sectors, so the mode use shown in Table 3 was applied to all trips diverted to each station.

Travel Distances, Times and Costs

Highway distances and highway and transit travel times and costs for 2007 and 2035 were obtained from MTC highway and transit TAZ to TAZ network skim files from the regional travel demand model for the appropriate year. MTC staff had not run the travel demand model for 2007 conditions, so the travel times and costs from a run for 2006 conditions were used for 2007, with costs adjusted to 2007 dollars using the Bay Area consumer price index (CPI) for retail goods. A further adjustment was made for the increase in tolls on the state-owned Bay bridges that occurred between 2006 and 2007. This increased tolls by a dollar, which significantly exceeded the change in the CPI.

Highway travel times and costs

The MTC highway network travel cost data includes private vehicle operating costs as well as bridge tolls. No adjustment was made to bridge tolls for air parties large enough to qualify as a car pool during hours when car pools would be charged no toll or a reduced toll.

Accounting for the proportion of air party trips from a given analysis zone that would qualify as a car pool was considered to be beyond the level of detail that could reasonably be included in the analysis.

The MTC highway network data for 2006 and 2035 provides times and costs for two traffic conditions: AM peak and free-flow. MTC staff also provided data from an analysis that was performed for the year 2000 that divided the day into four periods (AM peak, midday, PM peak, and evening) that was prepared by MTC for a special study. Because there are significant differences between the travel times for the AM and PM peak for many TAZs, due to directional effects, and travel conditions at other times of day are often not free-flow, the 2000 data was used to develop weighted average travel times for 2006 and 2035, as follows:

1. Estimate the PM peak times for 2006 and 2035 by applying the ratio of the 2000 PM to AM peak times to the forecast AM peak times.
2. Estimate the midday and evening times for 2006 and 2035 by applying the ratio of the 2000 midday or evening to free-flow times to the forecast free-flow times.
3. Use the free-flow travel times for the remainder of the day (night and early morning).
4. Calculate the weighted travel time from each TAZ to an airport by weighting the times for each period by the percent of total passengers arriving at the airport terminal during the period, from the air passenger survey data. The peak period times were adjusted by 30 minutes to allow for the fact that a traveler arriving at the airport a few minutes into a period spent most of the access trip traveling in the previous period, giving the times and travel percentages for each period shown in Table 4.

In the case of the Internal Secondary Airports Scenario, the highway travel times and costs to each secondary airport used the weights for SFO, since this airport accounted for the majority of air passenger trips in the region. In the case of the High-Speed Rail Scenario, the highway travel times and costs to the HSR stations used the weights for SFO for trips to the San Francisco, Millbrae and Redwood City stations and the weights for SJC for trips to the San José and Gilroy stations.

Table 4. Weighting Factors for Highway Travel Times

Time Period	Arrival Time at Airport	Percent of Air Parties		
		OAK	SFO	SJC
Early AM	Midnight – 6:30 am	3.5%	5.6%	15.4%
AM peak	6:31 am – 10:30 am	16.6%	27.6%	31.3%
Midday	10:35 am – 3:30 pm	44.4%	42.1%	31.0%
PM peak	3:31 pm – 7:30 pm	29.5%	19.7%	16.4%
Evening	7:31 pm – midnight	6.0%	5.0%	5.9%

For all scenarios, the free-flow travel distance was used for calculating VMT. While the average distance driven may change by time of day, due to drivers taking different routes to avoid congestion, this was not considered to have a material impact on the results and therefore was not analyzed.

Since the external zones are not part of the nine-county Bay Area, their highway network is not included in the MTC highway network data used to determine travel times and distances in the analysis. Therefore travel times and distances from each zone to the three primary Bay Area airports, and other Bay Area airports or planned high-speed rail stations where needed, were obtained from the online trip-planning tool Mapquest by selecting a representative city or town within each of the external zones as the trip origin. No consideration was given to changes in travel time by time of day. Highway travel costs were estimated from the driving distance using the average vehicle operating cost assumed for the MTC Transportation 2035 Plan for the San Francisco Bay Area.² The vehicle operating costs were converted from 1990 dollars to 2007 dollars using the Bay Area retail CPI.

Parking Costs

Average parking costs for air parties parking for the trip duration were estimated from the airport parking rates for 2007 and the average trip duration determined from the air passenger surveys. Separate average costs were calculated for each airport and the four resident market segments (domestic and international trips from home and other origins), as shown in Table 5.

There was insufficient survey data to obtain reliable estimates of the average trip duration for international trips for market segments other than resident trips from home origins at SFO. Therefore it was assumed that all international trips had the same average duration.

Table 5. Average Parking Costs (2007 \$)

Airport	Domestic Trips		International Trips	
	Home Origins	Other Origins	Home Origins	Other Origins
OAK	57.00	47.00	83.00	69.00
SFO	67.00	50.00	98.00	73.00
SJC	66.00	57.00	97.00	83.00

The average daily parking rate at each airport considered the distribution of air party trip durations and the different use of the various parking facilities (which have different daily rates) with increasing trip duration, as determined from the air passenger surveys. This gave a generally decreasing average daily rate with increasing trip duration as a higher proportion of air parties with longer trip durations used the less expensive parking facilities. The same average daily rate for a given trip duration was applied to all market segments, as there was insufficient survey data to calculate separate average daily rates for a given trip duration for each market segment. The average parking cost for each market segment was then rounded to the nearest dollar.

Transit travel times and costs

The MTC transit network data provides travel times and costs for two access modes to transit, auto (private vehicle) access and walk access, and two time periods, AM peak and off-peak. The auto access mode is only calculated for the AM peak and accounts for the fact that someone using private vehicles to access transit has more options and most likely boards the transit system for the first time at a different location from someone walking to transit. This is particularly true for people using BART or one of the other rail systems. Separate travel times are given for walking, waiting, in-vehicle time, and (where relevant) auto access time. Transit costs include private vehicle operating costs for auto access where relevant.

² Metropolitan Transportation Commission, *Travel Forecasts Data Summary: Transportation 2035 Plan for the San*

However, different times and costs for AM peak auto access and walk access are not given for all TAZ pairs. For those TAZ pairs where auto access does not provide a travel time advantage over walk access, the auto access and walk access times and costs are the same. Also, the transit network data does not distinguish between the different transit services, particularly between bus and rail, but simply assumes that each traveler selects the best route through the entire transit system.

The transit times and costs used in the ground access analysis were therefore based on the AM peak auto access times and costs (which in many cases were the same as the walk access times and costs), and not adjusted for any changes at different times of day. Transit schedules do not vary that much over the day (except for late evening hours), particularly for BART and light rail services, and airport travelers using rail transit are likely to have someone drop them off at a BART or light rail station (or park nearby), rather than walk with their baggage to a local bus line to get to the rail station. The travel times used in the analysis combined walking, waiting, in-vehicle, and (where relevant) auto access times without any weighting for the different trip components. While travel demand modeling typically considers time walking and waiting as having a higher perceived disutility per unit time than in-vehicle time, the total travel time to the airport is given by the sum of the unweighted times.

Distance-based relationships were estimated for transit access trips to SFO using the 2006 travel times and costs (in 2007 dollars). This gave the following relationships:

$$\text{Travel time} = 35.5 + 1.785 * \text{Distance}$$

$$\text{Travel cost} = 3.67 + 0.1354 * \text{Distance}$$

for travel times in minutes, costs in dollars and distances in miles. These relationships were used to calculate transit times and costs from external zones.

Other Public Modes

Travel time and cost data for other public modes (taxi, limousine, scheduled airport bus, and shared-ride van) for access from each TAZ to the three primary Bay Area airports in 2001 had been assembled in the course of an earlier project.³ Fares were updated to 2007 dollars using

Francisco Bay Area, Oakland, California, December 2008, Table B.1.

³ Xiao-Yun Lu, Geoffrey D. Gosling, *et al.*, *A Combined Quantitative and Qualitative Approach to Planning for Improved Intermodal Connectivity at California Airports*, California PATH Research Report UCB-ITS-PRR-2009-27, University of California, Berkeley, April 2009.

the Bay Area retail CPI, but it was assumed that fares had not changed in real terms. Travel times for taxi, limousine, and shared-ride van were based on the highway travel times discussed above. Travel times for scheduled airport bus service assumed that there had been no change in bus schedules, run times, or bus stop access times since 2001. Shared-ride van fares were based on the fares for one-person travel parties with no allowance for any discounts for multi-person parties. The majority of share-ride van users have trip origins at hotels and many operators do not offer multi-person discounts for trips from hotel origins. The ground access analysis was not performed at a level of detail that would have allowed adjustments for different air party sizes or to distinguish between hotel origins and other origin types.

In the course of the earlier project, distance-based relationships for taxi and limousine fares had been developed to estimate fares from TAZs for which no fare data was available. These relationships were adjusted to 2007 dollars and used to estimate taxi and limousine fares from external zones or from TAZs to internal secondary airports or HSR stations.

Scheduled airport bus services were available in 2007 to SFO and SJC from Monterey and Santa Cruz Counties. An analysis of the schedules, run times and fares gave an average headway of 90 minutes, a run time of 10 minutes above the highway travel time, and a fare that was approximately 40 cents per mile. These relationships were used to estimate travel times and costs for scheduled airport bus service from those external zones for which no actual service data was available. The travel times were assumed to include an average wait time (schedule delay) of half the headway, consistent with the assumptions for transit service. However, no allowance was made for access time or cost to the scheduled airport bus stops, since the travel time estimates for the other modes from external zones assumed that all trips from the zone began at the reference point in the representative city.

The shared-ride van fares from external zones were assumed to be the same as limousine fares, since it was assumed that the two modes would essentially be the same, given the relatively low level of demand from external zones. However, in the case of shared-ride van service to HSR stations, a distance-based relationship was estimated from the shared-ride van fares to SFO, giving the following relationship:

$$\text{Shared-ride van fare} = 22.16 + 0.632 * \text{Distance}$$

for costs in dollars and distances in miles.

Vehicle-Miles of Travel

In general VMT was simply calculated by the number of vehicle trips from each origin zone to each airport, with appropriate adjustments for the number of air parties per vehicle for shared-ride modes and additional travel involved in drop-off or pick-up trips. For air parties dropped off by private vehicle, the VMT was doubled to account for the return trip. For air parties using taxi the access distance was increased by 10 percent to allow for some one-way travel without fares (deadheading). In the case of air parties using limousine it was assumed that all vehicles made an empty trip one way, so VMT was doubled. This may be somewhat overstated, since some limousine operators may be able to schedule a revenue trip in both directions. However, it is unlikely that the second trip would be to the same general area as the first trip origin, so this would involve some deadheading anyway. Also, limousine operators generally cover a fairly wide service area, so there would be some deadhead travel involved in picking up the first party.

It was assumed that hotel/motel courtesy shuttles would carry three air parties on average, while shared-ride door-to-door vans would carry two. No deadheading was assumed for these modes or for charter bus or van, since in general these services carry passengers in both directions and compensate for variations in demand through changing passenger loads. Charter van service is commonly provided by the same operators that provide shared-ride van service, and so they can avoid deadheading by reassigning vehicles between charter and shared-ride service as needed. This is not in general true for charter bus service, but this a fairly small proportion of total charter bus and van use.

No VMT was assigned to air parties using transit or scheduled airport bus because these services were assumed to operate anyway whether or not air passengers rode them.

Greenhouse Gas and Air Quality Emissions

Emission rates per vehicle-mile for greenhouse gases, expressed as carbon dioxide (CO₂), as well as hydrocarbons (HC) and oxides of nitrogen (NO_x) were provided by MTC staff, and are shown in Table 6. These rates were determined using the California Air Resources Board Emission Factors (EMFAC) model for the Bay Area vehicle fleet. This weighted the different vehicle classes in the EMFAC model to give a composite value for the Bay Area vehicle fleet, which was assumed to correspond to the vehicle fleet used for airport access travel. Since the

majority of airport access vehicle trips are by private vehicles, any differences in the fleet composition are likely to have a fairly small impact on emission rates. While airport access travel may involve a higher proportion of taxis, limousines, and shuttle vans than the Bay Area vehicle fleet in general, efforts by airports to promote the use of low-emission vehicles by commercial operators using the airport will tend to offset this effect.

Table 6. Fleetwide Average Vehicle Emission Rates
(grams per mile)

	2007	2035
Hydrocarbon (HC)	0.3438	0.0659
Oxides of Nitrogen (NO _x)	0.4412	0.0504
Carbon Dioxide (CO ₂)	481.95	320.22

The emission rates show a dramatic reduction in HC and NO_x per vehicle mile from 2007 to 2035, with a much less significant reduction in CO₂ emission rates. The CO₂ emission rates for 2035 assume the most stringent Pavley Phase 2 CO₂ emission standards for California, consistent with the assumptions used in MTC's latest Regional Transportation Plan environmental impact report..

The emission rates were applied to the annual VMT calculated for each scenario and converted into metric tons per day.

Access Trips to High-Speed Rail Stations

In order to calculate the ground access travel to HSR stations by passengers diverted from air travel, it was necessary to estimate the trips from each analysis zone that were diverted to HSR and allocate these trips to an HSR station. The *Forecast Demand Allocation Methodology* technical memorandum describes the process by which this was done. In summary, the number of passengers diverted to HSR from each analysis zone was assigned to the closest HSR station, based on the MTC highway network distance for free-flow conditions in 2000.

The number of diverted passengers from a given analysis zone in each market segment was converted to air parties using the average air party size for that segment and then the number

of trips for each station access mode calculated from the access mode use percentages described above in the section on Air Party Size and Access Mode Use.

Travel Distances, Times and Costs

Highway distances, travel times, and costs, and transit travel times and costs from each analysis zone to the relevant TAZ for the nearest HSR station were determined from the MTC highway and transit network data in the same way as for the airports.

Access costs for other modes from each analysis zone were estimated using the cost to distance relationships described above.

VMT and emissions were then calculated in the same way as for airports.

Ground Access Analysis Model

In order to apply the extensive calculations involved in the ground access analysis in a consistent way, a spreadsheet model was created in Microsoft Excel that comprised a separate Excel workbook for each scenario. In the case of the Internal Secondary Airports and HSR scenarios, two separate models were developed for each scenario. The first model calculated the number of undiverted trips at each of the three primary airports and their associated ground access performance measures. The second model calculated the number of trips diverted to each secondary airport or HSR station from each of the three primary airports and the associated ground access performance measures of the diverted trips.

Since the catchment areas of each secondary airport or HSR station did not overlap, the ground access performance measures for trips diverted from each airport to a given secondary airport or HSR station from each TAZ or external zone could be identified and then summed across the three primary airports to give the ground access performance measures for each secondary airport or HSR station (although the results presented in this technical memorandum are not shown by station).

The details of the Excel model structure are described in Attachment B.

External Airport Scenario

In the External Airports Scenario, a proportion of the air passenger trips from the external zones are diverted to three airports in the external zones, reducing the total number of air passenger trips to the Bay Area primary airports. No account is taken in the ground access

performance measures of the ground access travel by these diverted trips, since this occurs entirely outside the region. While air passenger vehicle trips to the External airports would still produce greenhouse gases and other air quality emissions, there is still a net environmental benefit to the larger Northern California region due to the shorter trip lengths from these diverted trips.

Ground Access Analysis Results

The ground access performance measures for each airport and the region as a whole for the 2007 Baseline Scenario are shown in Attachment C. The corresponding performance measures for each of the 2035 scenarios under the Base Case forecast are shown in Attachment D. The comparative ground access performance measures for the Baseline Scenario for 2007 and 2035 are summarized in Table 7.

Table 7. Baseline Scenario Ground Access Performance Measures

	2007	2035	Percent Change
Total annual O&D passengers	50,192,688	81,179,487	61.7%
Total passenger access time (hr)	40,510,766	67,695,658	67.1%
Total passenger access distance (000 mi)	1,464,624	2,418,000	65.1%
Total access cost (\$000)	962,105	1,672,443	73.8%
VMT (000)	1,243,874	2,029,387	63.2%
VMT per passenger	24.78	25.00	0.9%
Average passenger access distance (mi)	29.18	29.79	2.1%
Average passenger access time (hr)	0.807	0.834	3.3%
Average cost per passenger (\$)	19.17	20.60	7.5%
GHG (CO2) emissions (metric ton/day)	1,642	1,780	8.4%
NOx + HC emissions (metric ton/day)	2.675	0.647	(75.8%)

It can be seen that the total passenger access distance, passenger access time, passenger access cost, and vehicle-miles of travel all increased by more than the increase in total annual O&D passengers, with the average passenger access cost increasing somewhat faster than the

average access distance and time. This is largely a result of the assumed increase in real private vehicle operating costs from 2007 to 2035. VMT per passenger increases by less than the increase in average passenger access distance, due largely to changes in the share of the regional passenger traffic handled by each airport. In the Baseline Scenario the share of regional passengers using SFO increases due to the higher forecast growth in international travel, while SFO has the lowest VMT per passenger of the three airports due to the greater use of higher occupancy modes, as can be seen from the detailed results by airport in Attachments C and D. Greenhouse gas emissions increase by about 8 percent from 2007 to 2035 in spite of the assumed improvements in average emission factors, due to the increase in VMT more than offsetting the reduction in emission factors. However, the air quality emissions (HC and NO_x) decrease by over 75 percent due to the large assumed reduction in average vehicle emission factors.

The differences in ground access performance in 2035 between the four system development scenarios with differences in ground access travel are shown in Table 8, expressed as a percentage change from the Baseline Scenario.

Table 8. Comparative Scenario Ground Access Performance Measures for 2035

	Percent Change from Baseline Scenario			
	Demand Redistrib- ution	Internal Secondary Airports	External Airports	High- Speed Rail
Total annual passengers	-	-	(2.1%)	-
Total passenger access time (hr)	(0.8%)	(3.5%)	(3.8%)	(1.8%)
Total passenger access distance (000 mi)	(0.2%)	(4.1%)	(5.7%)	(2.6%)
Total access cost (\$000)	0.0%	(2.5%)	(4.7%)	(0.4%)
VMT (000)	1.0%	(3.6%)	(6.2%)	(3.0%)
VMT per passenger	1.0%	(3.6%)	(4.2%)	(3.0%)
Average passenger access distance (mi)	(0.2%)	(4.1%)	(3.7%)	(2.6%)
Average passenger access time (hr)	(0.8%)	(3.5%)	(1.7%)	(1.8%)
Average cost per passenger (\$)	0.0%	(2.5%)	(2.7%)	(0.4%)
GHG (CO ₂) emissions (metric ton/day)	1.0%	(3.6%)	(6.2%)	(3.0%)
NO _x + HC emissions (metric ton/day)	1.0%	(3.6%)	(6.2%)	(3.0%)

The Demand Redistribution Scenario shows a 1 percent increase in VMT and associated greenhouse gas and air quality emissions over the Baseline Scenario, no change in the average cost per passenger, and the least reduction in average passenger access distance and time of the four scenarios. The apparently counter-intuitive result in which the average passenger access distance goes down slightly while VMT increases by about 1 percent results from the shift of domestic traffic from SFO to OAK and SJC. It can be seen from the results for each airport in Attachment D that SFO generates somewhat fewer VMT per passenger than the other two airports (particularly OAK), due to the greater use of higher occupancy modes, particularly transit. Thus redistributing traffic from SFO to OAK and SJC increases VMT, although the average passenger access distances at OAK and SJC are less than at SFO (and the average passenger access distance goes down slightly at OAK compared to the Baseline Scenario), leading to a slight overall reduction in average passenger access distance for the region. As can be seen from the detailed results in Attachment D, the average VMT per passenger goes down slightly at OAK and SJC in the Demand Redistribution Scenario compared to the Baseline Scenario, but increases at SFO, largely reflecting the increase in average passenger access distance at SFO, which results in part from the increase in the proportion of international trips (as domestic trips get redistributed), which have a longer average access distance.

Not surprisingly, the External Airports Scenario shows the most improvement in all ground access performance measures compared to the Baseline Scenario, because the number of annual passengers using the Bay Area airports is reduced by about 2 percent, while the average passenger access distance is also reduced as longer access trips from the external zones are diverted to the external airports. The combined effect of reduced passenger trips and reduced average access distance reduces VMT (and the associated emissions) by about 6 percent.

Of the other two scenarios, the Internal Secondary Airports Scenario shows somewhat greater improvements from the Baseline Scenario than the High-Speed Rail Scenario in all the ground access performance measures. The Internal Secondary Airports Scenario shows the greatest reduction in average passenger access distance and average passenger access time of the four scenarios, as the passenger trips that are diverted to the secondary airports have greatly reduced access distances and times. However, the reduction in VMT (and the associated emissions) and average passenger access cost are somewhat less than the reduction in average passenger access distance due to the greater use of private vehicles in the assumed access mode

use for the secondary airports, which increases the VMT per passenger relative to the change in the average access distance.

Although the High-Speed Rail Scenario projects a much higher diversion of passengers trips from the three primary Bay Area airports than the Internal Secondary Airports Scenario, the improvement in all the ground access performance measures compared to the Baseline Scenario is somewhat less, particularly for the average passenger access time and the average cost per passenger, since the high-speed rail stations are located fairly close to two of the airports, so there is a much smaller reduction in average passenger access distance and related measures. The even smaller reduction in average passenger access time and access cost results from the mode use assumptions for access trips to the HSR stations.

Summary and Conclusions

The ground access performance calculations described in this technical memorandum have been derived from an extensive analysis of air party characteristics derived from the results of the most recent air passenger surveys at the three primary Bay Area airports. These air party characteristics have been combined with detailed transportation level of service data for airport ground access modes obtained from MTC travel demand modeling for the regional highway and transit networks and data for other public modes developed in the course of previous research.

The analysis has been performed by developing a complex model in Microsoft Excel that allowed the ground access performance measures for the various system development scenarios to be derived in a repeatable and consistent way.

The results of the analysis show that for the Baseline Scenario the growth in demand from 2007 to 2035 will result in a significant increase in VMT of about 63 percent and a more modest increase in greenhouse gases of about 8 percent due to improvements in vehicle emission rates. There will be a significant reduction in other air quality emissions of about 75 percent, also due to stringent California vehicle emission standards. Average passenger distance, access time and cost increase between 2 and 7.5 percent.

Of the four system development scenarios for which ground access performance measures were calculated for 2035, the largest improvements compared to the Baseline Scenario were given by the External Airports Scenario, due both to the reduction in total passenger demand at the Bay Area airports and the fact that the passengers diverted to external airports had

some of the longest access journeys when they used the Bay Area airports. However, these reductions in VMT were not large enough to completely offset the increase in greenhouse gas emissions in the Baseline Scenario. While they reduced the average passenger access distance for those air passengers using the Bay Area airports below the average distance in 2007, this effect was not enough to reduce the average passenger access time and cost below their levels in 2007.

Of the other three scenarios, the Internal Secondary Airports Scenario gave the largest improvement in ground access performance measures compared to the Baseline Scenario. This scenario reduced the average passenger access distance and time below the levels experienced in 2007, although this was not enough to reduce the average passenger access cost below its 2007 level.

Attachment A

Ground Access Mode Use at Primary Bay Area Airports**Ground Access Mode Use by Market Segment**

(Air Parties of Less than 10 People)

OAKLAND INTERNATIONAL AIRPORT – 2006

Ground Access Mode	Resident Trips		Visitor Trips	
	Home Origin	Other Origin	Home Origin	Other Origin
	Domestic Trips			
Private vehicle – drop off	45.7%	31.0%	67.2%	22.4%
Private vehicle – parked for trip	31.5%	36.6%	n/a	n/a
Rental car	0.7%	0.7%	14.5%	39.5%
Transit	11.7%	24.1%	12.0%	16.9%
Scheduled airport bus	1.7%		0.9%	0.4%
Shared-ride door-to-door van	2.0%	2.6%	1.7%	5.6%
Taxi	2.7%	1.0%	1.5%	7.1%
Limousine	1.2%	1.0%	0.5%	2.6%
Hotel/motel courtesy shuttle	0.2%	2.6%	0.1%	3.9%
Charter bus or van	2.6%	0.3%	1.5%	1.5%
Total	100.0%	100.0%	100.0%	100.0%
	International Trips			
Private vehicle – drop off	84.2%		90.9%	33.3%
Private vehicle – parked for trip	13.2%		n/a	n/a
Rental car			9.1%	16.7%
Transit				16.7%
Scheduled airport bus				
Shared-ride door-to-door van				16.7%
Taxi				16.7%
Limousine				
Hotel/motel courtesy shuttle				
Charter bus or van	2.6%			
Total	100.0%		100.0%	100.0%

Notes: No survey data for resident international trips from non-home origins.

n/a = not applicable

Ground Access Mode Use by Market Segment
(Air Parties of Less than 10 People)

SAN FRANCISCO INTERNATIONAL AIRPORT – 2006

Ground Access Mode	Resident Trips		Visitor Trips	
	Home Origin	Other Origin	Home Origin	Other Origin
	Domestic Trips			
Private vehicle – drop off	40.4%	26.9%	63.7%	11.8%
Private vehicle – parked for trip	21.6%	24.7%	n/a	n/a
Rental car	1.3%	1.3%	13.9%	32.1%
Transit	12.3%	19.4%	9.4%	7.4%
Scheduled airport bus	3.7%	0.9%	3.2%	0.3%
Shared-ride door-to-door van	5.0%	5.3%	2.4%	19.4%
Taxi	9.5%	7.9%	4.5%	16.6%
Limousine	3.6%	0.4%	0.9%	6.2%
Hotel/motel courtesy shuttle	0.4%	11.9%		4.8%
Charter bus or van	2.4%	1.3%	2.1%	1.4%
Total	100.0%	100.0%	100.0%	100.0%
	International Trips			
Private vehicle – drop off	52.9%	30.0%	66.4%	13.5%
Private vehicle – parked for trip	12.2%	2.5%	n/a	n/a
Rental car	1.2%		15.1%	29.6%
Transit	9.8%	10.0%	10.3%	9.0%
Scheduled airport bus	2.7%	2.5%	0.7%	0.3%
Shared-ride door-to-door van	4.4%	10.0%	1.4%	21.9%
Taxi	8.3%	2.5%	3.4%	15.1%
Limousine	5.1%	10.0%	1.4%	5.8%
Hotel/motel courtesy shuttle	0.5%	32.5%		3.9%
Charter bus or van	2.9%		1.4%	1.0%
Total	100.0%	100.0%	100.0%	100.0%

Ground Access Mode Use by Market Segment
(Air Parties of Less than 10 People)

SAN JOSE INTERNATIONAL AIRPORT– 2001/2002

Ground Access Mode	Resident Trips		Visitor Trips	
	Home Origin	Other Origin	Home Origin	Other Origin
	Domestic Trips			
Private vehicle – drop off	55.9%	37.6%	76.5%	17.0%
Private vehicle – parked for trip	28.4%	36.4%	n/a	n/a
Rental car	1.2%	8.0%	19.3%	63.6%
Transit	1.7%	4.7%	1.5%	1.3%
Scheduled airport bus	0.4%	1.3%		0.9%
Shared-ride door-to-door van	1.4%	0.3%	0.6%	0.6%
Taxi	9.4%	9.2%	1.3%	9.3%
Limousine	1.4%	0.6%	0.6%	1.0%
Hotel/motel courtesy shuttle		1.6%	0.2%	6.1%
Charter bus or van		0.3%	0.1%	0.3%
Total	100.0%	100.0%	100.0%	100.0%
	International Trips			
Private vehicle – drop off	66.0%	41.0%	85.4%	22.0%
Private vehicle – parked for trip	13.4%	20.5%	n/a	n/a
Rental car	2.0%	5.1%	8.4%	50.4%
Transit	1.9%	10.3%	1.8%	1.4%
Scheduled airport bus			0.9%	2.1%
Shared-ride door-to-door van	1.9%		0.9%	1.4%
Taxi	12.3%	17.9%	1.8%	11.3%
Limousine	2.1%		0.9%	5.7%
Hotel/motel courtesy shuttle	0.5%	5.1%		4.3%
Charter bus or van				1.4%
Total	100.0%	100.0%	100.0%	100.0%

Ground Access Mode Use by Air Parties of 10 or More Passengers
(Domestic and International Trips)

Ground Access Mode	OAK 2006	SFO 2006	SJC 2001/2002
Private vehicle – drop off	12.5%	13.5%	22.5%
Private vehicle – parked for trip		5.4%	2.5%
Rental car	25.0%	10.8%	50.0%
Transit	12.5%		2.5%
Scheduled airport bus			
Shared-ride door-to-door van			5.0%
Taxi	12.5%	5.4%	
Limousine		2.7%	7.5%
Hotel/motel courtesy shuttle			2.5%
Charter bus or van	37.5%	62.2%	7.5%
Total	100.0%	100.0%	100.0%

Ground Access Mode Use by Regional Sub-area
(Air Parties of Less than 10 People)

OAKLAND INTERNATIONAL AIRPORT – 2006

Ground Access Mode	Domestic Trips				
	Peninsula	South Bay	East Bay	North Bay	External Zones
Private vehicle – drop off	25.6%	50.5%	48.8%	32.0%	46.8%
Private vehicle – parked for trip	9.8%	18.3%	16.0%	20.5%	21.6%
Rental car	11.2%	22.0%	15.1%	26.8%	21.6%
Transit	36.4%	5.4%	9.1%	3.1%	2.2%
Scheduled airport bus				6.6%	1.4%
Shared-ride door-to-door van	7.3%	2.2%	2.2%	1.0%	
Taxi	6.2%		3.9%	1.0%	1.4%
Limousine	3.3%	1.1%	1.0%	0.6%	1.4%
Hotel/motel courtesy shuttle	0.1%		2.6%	1.2%	2.9%
Charter bus or van	0.1%	0.5%	1.3%	7.2%	0.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Ground Access Mode	International Trips				
	Peninsula		East Bay		Other Zones
Private vehicle – drop off	60.0%		91.7%		80.0%
Private vehicle – parked for trip	10.0%		4.2%		15.0%
Rental car					5.0%
Transit	10.0%				
Scheduled airport bus					
Shared-ride door-to-door van	10.0%				
Taxi	10.0%				
Limousine					
Hotel/motel courtesy shuttle					
Charter bus or van			4.2%		
Total	100.0%		100.0%		100.0%

Note: Other Zones combines South Bay, North Bay and External Zones for international trips.

Ground Access Mode Use by Regional Sub-area
(Air Parties of Less than 10 People)

SAN FRANCISCO INTERNATIONAL AIRPORT – 2006

Ground Access Mode	Domestic Trips				
	Peninsula	South Bay	East Bay	North Bay	External Zones
Private vehicle – drop off	25.0%	40.8%	33.3%	27.7%	31.4%
Private vehicle – parked for trip	5.7%	13.9%	11.1%	13.3%	16.6%
Rental car	13.5%	28.1%	18.6%	27.7%	31.4%
Transit	10.2%	4.1%	25.9%	1.7%	
Scheduled airport bus	0.1%	0.3%		14.2%	2.3%
Shared-ride door-to-door van	17.1%	5.8%	3.1%	1.4%	1.7%
Taxi	18.5%	2.5%	2.6%	1.2%	1.1%
Limousine	5.2%	3.5%	3.5%	1.7%	2.3%
Hotel/motel courtesy shuttle	4.1%	1.0%	0.7%	0.7%	9.1%
Charter bus or van	0.5%	0.0%	1.2%	10.4%	4.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Ground Access Mode	International Trips				
	Peninsula	South Bay	East Bay	North Bay	External Zones
Private vehicle – drop off	29.8%	54.2%	45.5%	40.8%	43.3%
Private vehicle – parked for trip	2.0%	11.9%	7.5%	7.0%	7.2%
Rental car	14.1%	16.4%	3.7%	12.7%	15.5%
Transit	9.1%	3.0%	27.6%	4.2%	4.1%
Scheduled airport bus				16.9%	2.1%
Shared-ride door-to-door van	19.7%	3.0%	3.0%		4.1%
Taxi	16.9%	4.0%	5.2%	1.4%	4.1%
Limousine	4.8%	6.5%	5.2%	1.4%	5.2%
Hotel/motel courtesy shuttle	3.3%	0.5%		2.8%	11.3%
Charter bus or van	0.3%	0.5%	2.2%	12.7%	3.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Ground Access Mode Use by Regional Sub-area
(Air Parties of Less than 10 People)

SAN JOSE INTERNATIONAL AIRPORT – 2001/2002

Ground Access Mode	Domestic Trips			
	Peninsula	South Bay	External (South)	Other Zones
Private vehicle – drop off	52.1%	51.3%	46.6%	47.9%
Private vehicle – parked for trip	15.8%	14.3%	24.1%	15.3%
Rental car	22.7%	17.9%	26.4%	32.0%
Transit	4.3%	1.8%	0.2%	0.9%
Scheduled airport bus	0.6%	0.5%	0.7%	0.4%
Shared-ride door-to-door van	1.2%	0.9%	1.0%	0.2%
Taxi	1.5%	10.0%		1.7%
Limousine	1.5%	1.1%	0.7%	1.0%
Hotel/motel courtesy shuttle	0.4%	2.1%	0.2%	
Charter bus or van				0.6%
Total	100.0%	100.0%	100.0%	100.0%
	International Trips			
		South Bay	External (South)	Other Zones
Private vehicle – drop off		59.9%	69.4%	65.8%
Private vehicle – parked for trip		7.1%	6.7%	11.9%
Rental car		10.6%	17.7%	14.9%
Transit		1.3%	4.7%	3.0%
Scheduled airport bus		0.8%		
Shared-ride door-to-door van		1.3%	1.6%	
Taxi		14.6%		
Limousine		2.8%		1.5%
Hotel/motel courtesy shuttle		1.3%		1.5%
Charter bus or van				1.5%
Total		100.0%	100.0%	100.0%

Notes: External (South) comprises Monterey, San Benito, and Santa Cruz Counties and Central Coast external zones.

Other Zones includes Peninsula for international trips and East Bay, North Bay and other external zones for all trips.

Attachment B

Ground Access Analysis Model Structure

The Microsoft Excel spreadsheet model to perform the ground access analysis calculations for a given scenario comprises a separate calculation worksheet for each airport, a summary worksheet presenting the ground access performance measures for each airport and the regional total, and several ancillary worksheets containing supporting data for the calculations.

Primary Airport Worksheets

The worksheets in each Excel file for each of the three primary Bay Area airports are organized in a large table with a row for each superdistrict, external zone and TAZ. The columns are organized into a series of panels as follows:

- Columns A and B Superdistrict, external zone, regional sub-area and TAZ numbers and labels
- Columns C to J Regional air passengers by superdistrict, external zone and TAZ for each market segment
- Columns L to S Air passengers from each superdistrict, external zone and TAZ allocated to the primary airport in question by market segment based on the airport share data in the ancillary worksheets, with a adjustment factors to reconcile the airport total domestic and international passengers to the forecast demand for that airport
- Columns U to AD Air parties from each superdistrict, external zone and TAZ allocated to the primary airport in question by market segment based on the average air party size for each market segment, and divided into air parties with less than 10 air passengers by market segment and larger air parties grouped by domestic and international trips

- Column AE The reference code for the relevant sub-regional area for each superdistrict, external zone and TAZ
- Columns AF to AO The number of air parties from each superdistrict, external zone and TAZ using each mode to access the primary airport in question, based on the mode use data in the ancillary worksheets for each market segment and regional sub-area
- Columns AQ to BB The resulting travel distances, travel times and costs by access mode for each external zone and TAZ
- Columns BD to BJ Calculation of the associated ground access performance measures for each external zone and TAZ, together with the regional total for each performance measure.

The adjustment factors described for Columns L to S correct for any differences in total airport passengers arising from applying the airport share data from the air passenger survey results by superdistrict and external zone to the assigned zonal demand. However, these adjustment factors also provide a means to adjust the number of air passengers from each analysis zone, and hence the number of air parties, trips by access mode, and ground access performance measures, for the changes in airport passengers under the Demand Redistribution Scenario.

Because the calculations of travel distances, travel times and costs by access mode and the ground access performance analysis is performed at the level of TAZs and external zones, no specific calculations of ground access performance are performed for superdistricts, although superdistrict totals can be obtained by summing the relevant values for the TAZs within each superdistrict.

Ancillary Worksheets

All the Excel files contain the following worksheets:

- **Shares** provides a table showing the airport shares by superdistrict and external zone for each market segment

- **ModeUse** provides a table showing the ground access mode use for each airport by market segment and regional sub-area
- **Factors** provides a table of the emission factors per vehicle-mile for 2007 and 2035
- **LOS** provides a table showing the highway, transit and other public mode levels of service (highway distance, and travel times and costs for each mode) for each airport from each TAZ
- **Park** provides a table of the average parking cost for each airport by resident market segment.

In addition, the Excel files for the Internal Secondary Airports, External Airports, and High-Speed Rail Scenarios each contain the following worksheet:

- **Diversion** provides a table showing the number of passengers diverted from each primary airport to each secondary airport, or to the external airports or HSR (depending on the scenario), as well as the associated diversion rates.

For the Internal Secondary Airports Scenario, this table shows the total number of domestic trips allocated to each of the primary airports in the Baseline Scenario from each TAZ and external zone, the TAZs or external zones within the catchment area of each secondary airport, the total number of domestic trips at each primary airport from each catchment area, and the diversion rate for the trips to each primary airport from each catchment area. This diversion rate is then assigned to the relevant TAZs or external zones and used in the primary airport calculation worksheets to calculate the number of trips from a given TAZ or external zone diverted to a secondary airport and the associated ground access performance measures.

For the External Airports Scenario, the table shows the total number of passengers diverted to the external airports from each of the primary airports as well as the diversion rate for air passengers from each external zone to each primary airport, and in the case of OAK from two of the Bay Area superdistricts.

In the case of the High-Speed Rail Scenario, the table simply shows the number of diverted and undiverted passenger trips for each primary airport and the associated diversion rate, since this rate is applied to all TAZs and external zones for that airport.

In the case of the Excel file for the ground access performance measures for trips diverted to internal secondary airports, the **LOS** worksheet for the three primary airports is replaced by a **LOS-Int** worksheet that gives the highway distances, travel times and costs from each TAZ to the relevant secondary airport. Since only some TAZs lie within the catchment area of one of the secondary airports, much of the table has zero values.

In the case of the Excel file for the ground access performance measures for trips diverted to HSR, the **LOS** worksheet for the three primary airports is replaced by a **LOS-HSR** worksheet that gives the highway distances and highway and transit travel times and costs from each TAZ to the closest HSR station.

Summary Worksheet

The summary worksheet contains a table showing the number of O&D air passengers and ground access performance measures for each primary airport, together with the regional total.

In the case of the Internal Secondary Airports Scenario, the summary worksheet for the first Excel workbook shows the number of *undiverted* air passenger trips and associated ground access performance measures for each primary airport while the summary worksheet for the second Excel workbook shows the number of *diverted* air passenger trips at each secondary airport and the associated ground access performance measures.

In the case of High-Speed Rail Scenario, the summary worksheet for the first Excel workbook is the same as for the Internal Secondary Airports Scenario while the summary worksheet for the second Excel workbook shows the number of *diverted* air passenger trips at each primary airport and the associated ground access performance measures.

In addition to the number of O&D air passengers and ground access performance measures for each primary airport, the summary worksheet for the External Airports Scenario also shows the number of air passenger trips diverted to each of the external airports.

Attachment C

Ground Access Analysis Results – 2007

Baseline Scenario – Base Case Forecast

	OAK	SFO	SJC	Total
Total annual O&D passengers	13,763,823	26,311,905	10,116,959	50,192,688
Total passenger access time (hr)	11,244,844	22,354,691	6,911,231	40,510,766
Total passenger access distance (000 mi)	394,422	793,381	276,821	1,464,624
Total access cost (\$000)	271,790	514,357	175,957	962,105
VMT (000)	382,560	602,215	259,099	1,243,874
VMT per passenger	27.79	22.89	25.61	24.78
Average passenger access distance (mi)	28.66	30.15	27.36	29.18
Average passenger access time (hr)	0.817	0.850	0.683	0.807
Average cost per passenger (\$)	19.75	19.55	17.39	19.17
GHG (CO2) emissions (metric ton/day)	505	795	342	1,642
NOx + HC emissions (metric ton/day)	0.823	1.295	0.557	2.675

Note: OAK Oakland International Airport
SFO San Francisco International Airport
SJC San José International Airport

Attachment D

Ground Access Analysis Results – 2035

Baseline Scenario – Base Case Forecast

	OAK	SFO	SJC	Total
Total annual O&D passengers	19,391,868	46,432,621	15,354,998	81,179,487
Total passenger access time (hr)	15,412,011	42,115,212	10,168,435	67,695,658
Total passenger access distance (000 mi)	550,476	1,462,589	404,935	2,418,000
Total access cost (\$000)	402,802	979,712	289,928	1,672,443
VMT (000)	537,266	1,112,737	379,384	2,029,387
VMT per passenger	27.71	23.96	24.71	25.00
Average passenger access distance (mi)	28.39	31.50	26.37	29.79
Average passenger access time (hr)	0.795	0.907	0.662	0.834
Average cost per passenger (\$)	20.77	21.10	18.88	20.60
GHG (CO2) emissions (metric ton/day)	471	976	333	1,780
NOx + HC emissions (metric ton/day)	0.171	0.355	0.121	0.647

Demand Redistribution Scenario – Base Case Forecast

	OAK	SFO	SJC	Total
Total annual O&D passengers	21,795,104	42,108,851	17,275,532	81,179,487
Total passenger access time (hr)	17,314,455	38,426,390	11,439,937	67,180,782
Total passenger access distance (000 mi)	617,971	1,340,317	455,532	2,413,820
Total access cost (\$000)	452,792	893,685	325,851	1,672,328
VMT (000)	602,744	1,020,868	426,666	2,050,278
VMT per passenger	27.66	24.24	24.70	25.26
Average passenger access distance (mi)	28.35	31.83	26.37	29.73
Average passenger access time (hr)	0.794	0.913	0.662	0.828
Average cost per passenger (\$)	20.77	21.22	18.86	20.60
GHG (CO2) emissions (metric ton/day)	529	896	374	1,799
NOx + HC emissions (metric ton/day)	0.192	0.325	0.136	0.653

Note: OAK Oakland International Airport
SFO San Francisco International Airport
SJC San José International Airport

Internal Secondary Airports Scenario – Base Case Forecast

	OAK	SFO	SJC	Total Primary
Total annual O&D passengers	18,018,338	45,225,205	15,298,351	78,541,894
Total passenger access time (hr)	13,712,956	39,977,618	10,059,843	63,750,417
Total passenger access distance (000 mi)	481,629	1,390,594	400,416	2,272,638
Total access cost (\$000)	364,244	944,664	287,964	1,596,872
VMT (000)	469,604	1,062,014	375,444	1,907,062
VMT per passenger	26.06	23.48	24.54	24.28
Average passenger access distance (mi)	26.73	30.75	26.17	28.94
Average passenger access time (hr)	0.761	0.884	0.658	0.812
Average cost per passenger (\$)	20.22	20.89	18.82	20.33
GHG (CO2) emissions (metric ton/day)	412	932	329	1,673
NOx + HC emissions (metric ton/day)	0.150	0.338	0.120	0.608

	Sonoma County	Concord Buchanan	Travis AFB	Total Secondary
Total annual O&D passengers	705,157	1,127,120	805,316	2,637,593
Total passenger access time (hr)	492,485	455,209	619,854	1,567,548
Total passenger access distance (000 mi)	15,386	12,407	19,028	46,820
Total access cost (\$000)	10,628	11,708	10,599	32,935
VMT (000)	16,944	14,338	18,396	49,678
VMT per passenger	24.03	12.72	22.84	18.83
Average passenger access distance (mi)	21.82	11.01	23.63	17.75
Average passenger access time (hr)	0.698	0.404	0.770	0.594
Average cost per passenger (\$)	15.07	10.39	13.16	12.49
GHG (CO2) emissions (metric ton/day)	15	13	16	44
NOx + HC emissions (metric ton/day)	0.005	0.005	0.006	0.016

	Primary	Secondary	Total
Total annual O&D passengers	78,541,894	2,637,593	81,179,487
Total passenger access time (hr)	63,750,417	1,567,548	65,317,965
Total passenger access distance (000 mi)	2,272,638	46,820	2,319,458
Total access cost (\$000)	1,596,872	32,935	1,629,807
VMT (000)	1,907,062	49,678	1,956,741
VMT per passenger	24.28	18.83	24.10
Average passenger access distance (mi)	28.94	17.75	28.57
Average passenger access time (hr)	0.812	0.594	0.805
Average cost per passenger (\$)	20.33	12.49	20.08
GHG (CO2) emissions (metric ton/day)	1,673	44	1,717
NOx + HC emissions (metric ton/day)	0.608	0.016	0.623

External Airports Scenario – Base Case Forecast

	OAK	SFO	SJC	Total Bay Area
Total annual O&D passengers	18,930,199	45,983,287	14,561,110	79,474,596
Total passenger access time (hr)	14,791,759	41,179,680	9,154,238	65,125,677
Total passenger access distance (000 mi)	516,853	1,410,624	352,782	2,280,259
Total access cost (\$000)	384,792	951,654	257,314	1,593,760
VMT (000)	501,383	1,070,047	331,608	1,903,038
VMT per passenger	26.49	23.27	22.77	23.95
Average passenger access distance (mi)	27.30	30.68	24.23	28.69
Average passenger access time (hr)	0.781	0.896	0.629	0.819
Average cost per passenger (\$)	20.33	20.70	17.67	20.05
GHG (CO2) emissions (metric ton/day)	440	939	291	1,670
NOx + HC emissions (metric ton/day)	0.160	0.341	0.106	0.606

	Trips Diverted to External Airports			
	SMF	MRY	SCK	Total
Total annual O&D passengers	611,595	996,606	96,689	1,704,891

	Bay Area	External	Total
Total annual O&D passengers	79,474,596	1,704,891	81,179,487

Note: SMF Sacramento International Airport
MRY Monterey Peninsula Airport
SCK Stockton Metropolitan Airports

High-Speed Rail Scenario – Base Case Forecast

	OAK	SFO	SJC	Total Airports
Total annual passengers	17,616,075	44,214,784	13,420,348	75,251,207
Total passenger access time (hr)	14,006,261	40,223,065	8,887,587	63,116,913
Total passenger access distance (000 mi)	500,602	1,399,871	353,966	2,254,439
Total access cost (\$000)	365,864	935,585	253,741	1,555,191
VMT (000)	488,884	1,065,614	331,753	1,886,251
VMT per passenger	27.75	24.10	24.72	25.07
Average passenger access distance (mi)	26.73	30.75	26.17	29.96
Average passenger access time (hr)	0.795	0.910	0.662	0.839
Average cost per passenger (\$)	20.77	21.16	18.91	20.67
GHG (CO2) emissions (metric ton/day)	429	935	291	1,655
NOx + HC emissions (metric ton/day)	0.156	0.340	0.106	0.601

	Total Airports	HSR Stations	Total
Total annual passengers	75,251,207	5,928,280	81,179,487
Total passenger access time (hr)	63,116,913	3,365,808	66,482,721
Total passenger access distance (000 mi)	2,254,439	99,526	2,353,965
Total access cost (\$000)	1,555,191	110,317	1,665,507
VMT (000)	1,886,251	81,578	1,967,829
VMT per passenger	25.07	13.76	24.24
Average passenger access distance (mi)	29.96	16.79	29.00
Average passenger access time (hr)	0.839	0.568	0.819
Average cost per passenger (\$)	20.67	18.61	20.52
GHG (CO2) emissions (metric ton/day)	1,655	72	1,726
NOx + HC emissions (metric ton/day)	0.601	0.026	0.627