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The All-Electric Commute:
An Assessment of the Market Potential for
Station Cars in the San Francisco Bay Area

Robert Cervero
Alfred Round
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Working Paper
UCTC No. 249

The University of California
Transportation Center

University of California
Berkeley, CA 94720

The University of California Transportation Center

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The All-Electric Commute: An Assessment of the Market Potential for Station Cars in the San Francisco Bay Area

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with
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Carma Reed
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Executive Summary

Electric station cars have the potential of filling an important market niche — namely, providing on-call, door-to-door access to and from rail transit stations as well as midday automobility for those who patronize transit. They would make getting from home to work via rail transit virtually seamless. Their greatest promise is in the suburbs. In the San Francisco Bay Area, there are thousands of jobs beyond walking distance of suburban BART stations. Given the choice of driving from home to work or taking BART and transferring to a bus to reach jobs, most suburban workers choose the former. The availability of free parking at the workplace and the generally poor quality of many suburban bus services reinforce this overwhelming preference for solo commuting.

One factor that distinguishes station cars from other electric vehicles (EVs), including neighborhood cars, is that because most rail access trips are made over fairly short distances — typically under five miles and often in built-up areas at modest speeds (25-35 mph) — a low-performance vehicle can adequately serve many of these trips. Thus, because of the limited range and modest speeds of most station-car trips, highly advanced, full-sized batteries are not necessary.

The station-car concept is largely untested. One scenario might involve a resident driving an EV to a suburban station in the morning, parking the EV near the station, and catching a train to work. The same vehicle might be then picked up by a suburban office worker who just arrived at the station. This person drives the car to a nearby job site and has use of the vehicle during the midday, returning the EV to the station in the evening. The same resident who dropped off the EV in the morning would then pick it up in the evening and drive it home. This arrangement would be efficient because the EV would be fully used throughout the day and evening, plus the vehicle would almost never have to be parked at the rail station — parked instead at either someone's home or at a work site. Participants would be making an "all-electric commute," allowing them to travel long distances without directly burning up fossil fuels in the process. Electricity would become the propulsion system for both the access and the line-haul portions of commutes.

Station cars would yield important environmental benefits by both luring solo commuters to rail transit and converting existing park-and-ride trips to EV-and-ride trips. Since electrifed station cars produce no direct tailpipe emissions and have no catalyst or hot/cold-start distinction, they would improve air quality to the degree they replace large numbers of ICE trips. Because station cars are small and many would be away from rail stations during the day, they would also relieve transit agencies of the need to build more parking lots. Station cars would also help conserve energy and, because they are human-scale, would be compatible with pedestrian-friendly design schemes.

Because there are currently no large-scale station-car programs in the U.S. designed around mini-EVs, we simulated station-car services by having residents and workers from the San Francisco Bay Area drive a Kewet (a Danish-made mini-EV) to and from BART stations. Based on survey responses from 163

Bay Area residents and workers who participated in the field tests, there was considerable enthusiasm for the station-car concept. People liked the Kewet station car for its environmental benefits and ease of driving and parking. Liked least was the Kewet station car's limited range and top speeds. Overall, five times more people gave the Kewet station car a positive than a negative rating. Factors like travel distance, occupations, and perceptions of vehicle performance were most strongly correlated with peoples' likelihood of leasing station cars.

On average, those field-testing the Kewet were willing to pay around $2 per day for station-car access at one end of their rail commute trip and $3.30 for both ends. This is around $2 more than what respondents perceive as their current commuting bill. It is considerably less, however, than the over $20 per day that would have to be recouped to fully recover the cost of providing and maintaining an EV station car. If station cars could be mass-produced so as to cut the purchase cost in half and leased on weekends (say, as part of a car co-op program), daily lease rates could be as low as $6.75. Still, it is clear a station-car program will require some level of subsidy support to be financially sustainable. Logically, support should come from those benefitting the most — such as rail agencies and large employers who face less demands for parking spaces as well as the larger public, which benefits from cleaner air and reduced fossil fuel consumption. Some form of cost-sharing between station-car users, employers, transit agencies, electric utilities, and taxpayers will be necessary if station cars are to be financially feasible.

Combining survey results with 1990 commuting statistics, we estimate that there is currently a market demand for over 10,000 daily station-car leases in the San Francisco Bay Area. This is based on the assumption that users would pay between $2 and $4 per day to access a vehicle, with the remainder of expenses covered by subsidies. We also estimate that these 10,000+ station-car round-trips would substitute for over 180,000 daily vehicle miles traveled in ICE vehicles.

An important step toward implementing station cars on a large scale is to mount a successful demonstration program. If a demand for station cars can be empirically demonstrated, we believe market forces will eventually allow full-scale implementation of station cars. Among the criteria considered in selecting one or more sites for a large-scale station-car demonstration program are: limited existing shuttle and bus transit services; work sites and residences within a 0.5- to 4-mile catchment of rail stations; parking capacity; corporate interest; local community and political interest; and balanced numbers of access trips to and egress trips from rail stations. A coalition of station-car interests should be formed to implement a full-scale station-car demonstration in the near future.

Chapter One

Introduction: Station Cars and Market Demand

1.1. Station Cars: Filling a Market Niche

One of the more disappointing transportation trends of the 1980s was mass transit's declining market share of metropolitan trips throughout the U.S. Despite the infusion of tens of billions of dollars in public assistance for constructing new facilities and supporting bus and rail operations, transit's nationwide share of total commute trips fell from 6.4 percent in 1980 to 5.3 percent in 1990 (Pisarski, 1992). In California, while transit journeys rose in absolute numbers during the 1980s (one of the few states where this was the case), transit's share of commute trips fell in the state's four largest metropolitan areas, all of which have new rail systems: greater Los Angeles — 5.4 to 4.8 percent; San Francisco Bay Area — 11.9 to 10 percent; San Diego — 3.7 to 3.6 percent; and Sacramento — 3.7 to 2.5 percent.

Given that California has invested over $7 billion statewide in urban rail transit infrastructure and is poised to spend upwards of $200 billion more over the next 30 years (mainly in Southern California), these trends are worrisome. Creative responses will be necessary to reverse transit's downward spiral and capitalize on expensive sunk investments in rail. Station cars, we believe, are a response with high payoff potential.

Station cars are small vehicles that function mainly to provide access to and egress from transit stations. Presently, no formal large-scale station-car program exists in the U.S. As envisaged by backers, station cars would be electrically propelled because of the energy efficiency of batteries for short, stop-and-go travel, such as access trips to rail stops, as well as to cut down on tailpipe emissions (Knack, 1992; Bernard, 1994). During non-commuting hours, station cars might be used for other purposes, such as midday trips to a restaurant several miles from an office complex or as neighborhood cars for those driving the vehicles home in the evening. While station cars could be used for accessing other mass transportation terminals, such as bus park-and-ride lots and ferry terminuses, their greatest promise lies in ferrying commuters back and forth to urban and commuter rail stations (mainly because these trips constitute the largest share of access trips made by mechanized, or non-walking, modes). One factor that distinguishes station cars from other electric vehicles (EVs), including neighborhood cars, is that because most rail access trips are made over fairly short distances — typically under five miles and often in built-up areas at modest speeds (25-35 mph) — a low-performance vehicle can adequately serve many of these trips. Thus, because of the limited range and modest speeds of most station-car trips, highly advanced, full-sized batteries are not necessary. Fairly small two-seater vehicles that weigh less than 2,000 lbs., that operate up to 40 mph and as far as 40-50 miles before recharge, that contain heaters, radios, and other accessories, that use light but strong composite materials and pass federal crashworthy tests, but that cannot operate on freeways because of their limited speeds, probably would meet the specification requirements of a station car. The hope is that the limited performance features of a station car would help keep costs low. Currently, the only four-wheel vehicle that meets these specifications is the Danish-made Kewet, which sells for around $16,000 new, though other vehicles will likely enter the market within the next few years. Some have estimated the sticker price of a Kewet or similar vehicle could be cut in half and perhaps driven down to as low as $5,000 if there were sufficient sales to justify automated assembly-line production (Sperling, 1994; MacCreadie, 1994). Sperling (1994) calls station cars a "neighborhood electric vehicle (NEV) variation," implying that it involves the use of NEVs for a fairly specialized application.

While the concept of station cars has been experimented within in Europe and Japan using motorcycles and three-wheelers, the concept remains largely untested. We are thus left to imagine how station cars might function and operate. A conceivable scenario might involve a resident driving an EV to a suburban station in the morning, parking the EV near the station, and then catching a train to work. The same vehicle might be then picked up by a suburban office worker who just arrived at the station. This person drives the car to a nearby job site, say two or three miles away, and has use of the vehicle during the midday, returning the vehicle to the station in the early evening. The same resident who dropped off the EV in the morning would then pick it up in the evening and drive it home; alternately, people would pick up different EVs at different times depending on availability. The arrangement would continue throughout the work week. It would be incredibly efficient because the radial commuter (who lives in the suburbs and works downtown) and the reverse commuter (who lives in the city and works in the suburbs) would be sharing the same vehicle to reach and leave stations. With at least as many jobs today in the suburbs as in the downtowns of most American metropolises, the trend toward more balanced directional commute flows makes this scenario all the more feasible.

Presumably, a transit authority would sponsor the station-car program, leasing vehicles to transit users, perhaps as part of an integrated fare system. A private third party (such as a car rental agency) might be contracted to manage the station-car fleet. Smart-card technology would allow passengers to promptly access the first car in a "stacked" queue of EVs just outside stations and to pay for station-car services at the end of the month. The ability to access the vehicles on-call would dramatically reduce the waiting portion of a rail trip (such as when transferring to a shuttle bus), the most onerous and disliked part of commuting and perhaps what deters many commuters from riding transit. This real-time connection from rail to station car would result in a fluid, seamless form of transit travel: from home, onto the train, out the exit station into a waiting car, and to one's workplace. It would also mean an "all electric commute," placing some commuters in the rare position of traveling long distances without directly burning up fossil fuels in the process. Electricity would become the propulsion system for both the access and line-haul portions of commutes.

In addition to being able to get by with traditional battery technology and relatively low performance, several other features distinguish station cars from NEVs and underscore their potential costeffectiveness. One, because most rail transit stations are sited near fairly busy streets and in fairly built-up areas, station cars would travel mainly in slow-moving, sometimes stop-and-go, traffic. The fairly dense grid of surface streets surrounding many rail stations results in interrupted vehicular flows at traffic signals and stop signs. Thus, in most settings, station cars would commingle with other vehicles without compromising safety. By contrast, more general-purpose NEVs might require costly investments in sequestered pathways to protect them from faster moving and heavier cars in other suburban environs (Garrison and Clarke, 1977). Second, station cars might find stronger institutional support than other NEVs because of the potential for transit properties and possibly large employers (at the insistence of air quality boards) to sponsor them for economic and environmental reasons.

1.2. Purpose of Research

The main purpose of this research is to help assess the market potential for station cars, using the San Francisco Bay Area as a case context. Because no formal, large-scale station-car programs currently exist in the U.S., we are left to make educated guesses about their possible success. One group, the National Station Car Association (NSCA), has been formed to develop and implement a national demonstration of the station-car concept. NSCA's membership consists of large U.S. transit agencies with rail services as well as local electric utilities drawn from the same regions. Full-blown in-field demonstrations sponsored by NSCA, however, are at least several years away, so data and findings on the travel choices and preferences of station-car users will not be available anytime soon. Moreover, the NSCA demonstrations will rely mainly on the use of subcompacts, like Geo Metros, that are converted to battery propulsion and that fully meet federal vehicle safety standards and can operate on freeways. As such, these vehicles will be much larger (and potentially more expensive) than mass-produced, limited performance EVs. Our research is intended to help fill existing knowledge gaps about the station-car concept, focusing mainly on the market penetration potential of a fairly limited-range, low-performance vehicle that serves transit stops. In light of the pressing need for information on the potential demand for station cars, we have conducted field tests of a Kewet EV as an access mode to rail stations in the San Francisco Bay Area and elicited attitudinal responses from those driving the vehicle, which included both transit users and non-users. Thus, unlike the NSCA demonstration that will monitor actual travel demand over time, we have sought to gauge the stated preferences of potential station-car customers using field simulations. This approach has the advantage of providing empirical insights into consumer preferences of a latent technology quickly. The survey results were then merged with data on the 1990 origin-destination patterns of commute trips in the Bay Area. Estimates of the potential market demand for station-car use in the Bay Area are derived, and the broader policy implications of these estimates are discussed.

While the scenarios discussed above suggest that station cars could serve many access and egress trips, we believe the greatest potential lies with a fairly specialized, more narrowly defined market niche: trips from suburban stations to work sites several miles away and back. Thus, our research focuses particularly on this submarket. We hold high hopes for this submarket, which we will call "work-end" station-car trips, for three reasons. One, most suburban stations have park-and-ride lots that easily serve "home-end" access trips (from one's residence to a station); even if EVs were subsidized, we would expect many commuters to still drive their internal combustion engine (ICE) cars to park-and-ride lots. In contrast, access from suburban stations to work sites several miles away is often poor. While those working downtown or in centralized areas can often reach their jobs by foot or convenient bus connections, many suburban areas are poorly served by transit, and special shuttle runs are rare (Cervero, 1993b). While it would be difficult for station cars to compete with bus transit, taxis, and other options in inner-city settings, they might be embraced by suburban workers who eschew waiting a half an hour or so for a connecting suburban bus. Additionally, many large employers in non-attainment areas are required to introduce programs that lower drive-alone rates among their workforce. Many have hired coordinators, subsidized transit usage, and built an in-house capacity to encourage alternative modes of commuting. Large employers within several miles of suburban rail stations might be willing to financially support station-car usage by their employees in order to satisfy trip reduction mandates. Some might even consider station cars less costly then company-sponsored shuttle services to rail stations; rail-station-car trips might even eliminate the need for some company-sponsored vanpools. In summary, we believe the work-end station-car submarket holds particular promise because station cars would find less competition in these settings, might save large suburban employers money, and would fill a genuine market void.

1.3. Potential Benefits of Station Cars

Access to rail stops has always been an Achilles' heel of America's rail transit industry. One-quarter-mile has become an industry standard for gauging what share of residents are within walking distance of transit stops (Vuchic, 1992). Those living within a quarter-mile walking radius of a station, however, will never constitute the majority of rail transit's customers.[1] Despite recent campaigns to encourage transit-oriented developments (TODs) and pedestrian pockets (Calthorpe, 1993) around rail stations, America's suburbs will continue to be spread out and auto-oriented. To effectively compete with the private automobile, transit will always need to substantially expand its catchment beyond the one-quarter-mile walking distance. Station cars are one means of extending transit's catchment.

In general, as densities fall and distances to downtowns increase, people need some mechanized means to reach stations. In downtowns, most people reach transit stops by foot. In 1992, for instance, over 60 percent of rail users reached downtown stations of the Bay Area Rapid Transit (BART) system by foot (BART, 1993). As one leaves downtown stations and heads outward, the share of walk-on trips falls steadily, replaced by access trips made by some mechanized mode — normally, park-and-ride, kiss-

[1]At relatively high residential densities of 15 dwelling units per acre, for instance, no more than 2,200 dwelling units can be built within a quarter-mile walking distance of a transit hub in such TODs as Sacramento County's Laguna West project (Calthorpe, 1993).

and-ride, and bus-and-ride. In the case of BART stations, like Ashby and Glen Park, that lie in fairly built-up, urbanized areas but that have park-and-ride facilities, around 50 percent of customers reach stations by car, 8 percent ride a bus, and 37 percent arrive by foot. And at suburban stations, like Walnut Creek and Fremont, upwards of 85 percent of access trips to BART are by passenger car, and fewer than 5 percent are by foot or bicycle travel. Studies in greater Washington, D.C., metropolitan Toronto, and the Bay Area show that beyond one mile of a suburban rail station, around 60 to 80 percent of access trips are by automobile, with the share steadily rising with access distance (Stringham, 1982; JHK and Associates, 1989; Cervero, 1993; BART Planning Office, 1993).

The conversion of rail access and egress trips from motorized forms of travel to small EVs would potentially yield a number of important benefits. One potential beneficiary would be transit agencies, especially to the degree that station cars unleash new demand for transit riding. Society at large could also benefit, potentially in the form of cleaner air, less energy consumption, and more efficient trip-making. This section elaborates on the potential benefits of station cars.

1.3.1. Benefits to Transit Agencies

The primary benefit to transit agencies would be increases in transit ridership, mainly in the form of latent trips: motorists switching to rail travel because of the time savings provided by station-car access. The degree to which this is a benefit, however, depends partly on the capacity to serve additional line-haul demand. Since a large share of station-car users would be commuters, and most trains operated by large rail systems are full during peak hours, the benefits of new demand would certainly be less than if this demand was stimulated at other hours. At the extreme, a surge in ridership induced by station cars might force some transit properties to incur new costs in expanding peak hour services, such as purchasing new rail cars. However, if the additional demand was mainly in the form of more standees accommodated with existing rolling stock, the additional revenues generated would no doubt cover costs. Moreover, to the extent that a large share of station-car riders are reverse-commuters using the EVs on the work-end of their trips, capacity would likely be less of a problem since most radial rail systems still have available seating during the peak hour in the reverse-flow direction.

Perhaps the more immediate benefit of station cars that has piqued the interest of rail properties, including BART, is the chance to relieve parking demand at already over-saturated suburban park-and-ride lots. Station cars might increase existing parking capacity in three ways: because EVs are small; through the use of creative parking schemes (e.g., queues, stackable EVs); and because many of the vehicles would be away from the station during the day (Bernard, 1994). Indeed, if they are at stations for any prolonged period at all, station cars would mainly be parked during the evening and weekends when there is minimal parking demand. If the same EVs are used to access stations by residents and then to reach job sites by workers, little parking takes place on transit property; rather, cars are parked far more at residences and workplaces. Thus, station cars could effectively replace existing park-and-ride ICE trips with other vehicular access trips that require little or no parking.[2] In the case of BART, suburban parking supplies have been identified by Board members as a serious constraint on expanding services. Even recent joint development projects, such as the Central Grand Apartments being built on the existing 2.7-acre surface parking lot at the El Cerrito del Norte station, were approved by the Board only on the condition that lost surface parking be replaced by an equal amount of structured parking (Cervero et al., 1994). BART recently opened a new 941-space parking structure near the Concord station at a cost of $10 million. The parking garage at the Pleasant Hill station cost $16.4 million for 1,350 spaces, or $12,100 per space. Any parking cost savings provided by a station-car program would be warmly welcomed by the BART Board.

1.3.2. Environmental Benefits

The conversion of some access trips from ICE vehicles to EVs would reduce air pollution and greenhouse gas emissions. Importantly, station cars could replace the most polluting and inefficient trips of gasoline vehicles — slow, short urban trips. Converting park-and-ride trips to station-car-and-ride trips is especially crucial for California since all of its large metropolitan areas exceed federal and state clean air standards for ozone and carbon monoxide.

Air Quality Benefits

For a three-mile automobile trip, the typical distance driven to access a suburban BART park-and-ride lot, around 84 percent of hydrocarbon (HC) emissions and 54 percent of nitrogen oxide (NO_x) emissions are due to cold starts (inefficient cold engines during the first minute of driving) and hot evaporative soaks (Barry and Associates, 1991). That is, most tailpipe emissions of the two main precursors to photochemical smog occur from turning the ICE on and off. Motorized access trips to rail stations, regardless how short they are, emit levels of pollutants that are not too much below those of the typical 10-mile solo commute. Rail trips that rely on park-and-ride access do very little to improve air quality.

Since EVs have no catalyst and no cold-hot distinction, emissions from the last mile are as low as from the first. Additionally, on short, stop-and-go trips, such as to rail stations, ICEs emit high concentrations of pollutants, especially when they idle. EVs, on the other hand, do not idle while stopped.

Since electrified station cars produce no direct tailpipe emissions, they could make a significant contribution to improving air quality when used to replace large numbers of ICE access trips. Sperling (1994b) estimates that relative to a subcompact gasoline car, a Kewet (1,650 lbs. including batteries) driven

[2]There might even be timing benefits with station cars. Assume, for example, that a station car is used by a resident to reach a station. The car might be parked for, say, 45 minutes in the morning, from 7:15 to 8:00 a.m., before another commuter arrives to take the same car to his or her workplace. This might mean that the parking lot does not completely fill up at 7:00 a.m. in the morning, as is the case with a number of suburban BART lots, but rather space opens up later on. This would allow parking demand to be more fully accommodated at more times during the morning peak.

an average of 2.5 miles per trips between zero and 35 mph would reduce emissions of carbon monoxide (CO) by 99 percent, HC by 99 percent, and NO_x by 93 percent.

Air quality benefits would be offset to the degree that fossil fuels are burned at power plants to generate electricity used in recharging station-car batteries. Power companies in the U.S. are turning increasingly to renewable resources like wind, geothermal, and hydroelectric sources to generate electricity. Presently, the main supplier of electricity to the San Francisco Bay Area, Pacific Gas and Electric (PG&E), generates 81 percent of its electricity from non-fossil fuel sources (Meldgin, 1992). Additionally, even if fossil fuels are used at power plants, a distinction has to be made between point of emissions and human exposure. Most electrical power plants are outside of cities, sometimes in the countryside, where exposure levels are relatively low. Pollutants like CO become harmless a few hundred yards from their source and thus are no longer a health threat when released in remote settings. While ICE trips to rail transit stations can increase the concentration of pollutants in urbanized areas, the transfer of a small fraction of these pollutants to outlying power plants for recharging EVs would have a negligible impact on regional air quality levels. Since clean air standards are defined in terms of concentrations rather than emissions, moreover, states and local air districts would clearly be making progress toward attainment by promoting station-car programs.

It might be noted that the greatest air quality benefit would come from substituting station cars for kiss-and-ride trips. Having someone make automobile trips just to drop-off and pick-up rail patrons has to be the most inefficient of all urban travel. Typically, four short ICE trips are made to serve a round trip by rail. Many kiss-and-ride rail trips probably pollute the air more than drive-alone commutes made over the same distance. The air quality benefits of converting these to station-car trips would have to be close to two-to-one.[3]

Other Environmental Benefits

Station cars would also possibly reduce the emission of greenhouse gases and such precursors to acid rain as sulfur dioxide (SO_2), especially where EV charging energy comes from powerplants that do not rely on fossil fuels (Bernard, 1994). EVs will not increase utility SO_2 emissions, but will reduce diesel-powered vehicle SO_2 emissions to a small degree. Energy-efficient EVs charged from most powerplants are likely to reduce total emissions of carbon dioxide (CO_2) as well.

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[3]Kiss-and-ride trips are particularly inefficient because the ICE is typically turned on and off four times for the purpose of serving a transit trip. However, this is unlikely equivalent to four cold starts since, in the morning, someone drops off the rail commuter at a station entrance, probably in most cases without turning off the engine, and proceeds on to the next destination, either home or elsewhere. Thus, the initial kiss-and-ride dropoff may involve only one cold start and, if part of a linked trip, may not be terribly inefficient. Whether people picking up rail passengers in the evening are making two cold starts depends on how closely they schedule pick ups with the timed arrival of trains, and how long they have to wait for arriving passengers. In most cases, the kiss-and-ride wait is probably sufficiently short so that the ICE is warm enough for the catalytic converter to work effectively.

1.3.3. Energy Conservation Benefits

In most instances, EVs will reduce energy consumption to the same degree they eliminate tail-pipe emissions. The potential energy savings of station cars are particularly high because in many instances they will substitute for ICE trips requiring frequent stops and starts near rail stations. Unlike an ICE vehicle, EVs require no energy, except for accessories, when they idle. In stop-and-go traffic, an EV can use regenerative braking — i.e., some of the kinetic energy of the vehicle is channeled back to the battery during braking. Moreover, since EVs do not go through a cold-start cycle, their energy efficiency is much higher than an ICE vehicle used for short urban trips.[4]

Bernard (1994) estimates that the typical station car of the future will use 0.2 kilowatt hours (kWh) per mile. Assuming this vehicle is driven 15 miles per weekday and 25 miles during weekends, or 5,200 miles per year, it will consume 1,040 kWh of electricity annually. This is less electricity than what two 60 W light bulbs would consume if lit an entire year, according to Bernard. At today's average cost of 10 cents per kWh, recharging the car's battery will cost only about $100 annually. An ICE vehicle driven the same annual mileage, at an average of 10 mph in urban traffic, will consume over 500 gallons per year, at an annual cost of well over $700. Bernard calculates that over the course of a year, the ICE vehicle will consume around six times as much primary energy (BTUs) as the EV.

The energy demands of station cars would be modest and would unlikely ever create the need to expand power plant capacity. Battery charging could be done at night, when slow charging (which increases battery life) is feasible and prices are cheapest because demand is off-peak. At low-charging wattage, no special home wiring would be required for those charging station cars at their residences.

A secondary energy-related benefit of EVs is that they would reduce the nation's dependency on foreign fuel sources. This would not only help safeguard the nation's economy from possible disruptions in the supply of imported oil, but would also help reduce the nation's trade deficit and improve the balance of trade.

1.3.4. Other Social Benefits

Station cars would yield a number of other important benefits over time. For one, they would potentially help reduce traffic congestion by attracting some motorists to an "all electric" commute. Having motorists switch to rail transit for the linehaul segment of commutes would relieve traffic tie-ups along many urban corridors in southern and northern California.

Station cars would also promote a more efficient use of urban space. Because they are small, EVs could be accommodated by narrower lanes and less asphalt for parking. And because they are light, they would inflict far less pavement damage than other vehicles. The infrastructure requirements of EVs, such

[4]Station cars would be particularly well suited to states with Mediterranian climates like California where less energy is consumed for heating in the winter and air conditioning is not always needed during the summer, particularly in coastal communities.

as for bridges and fly-overs, are far more modest than for automobiles and trucks. If EVs were to multiply in numbers, this would mean more modest, less expensive infrastructure could be built to accommodate increased travel demand along certain corridors. Such low-cost infrastructure is presently found in several new communities—like Peachtree City, Georgia; Sun City, Arizona; and Palm Desert, California—wherein small EVs and golf carts operate on modest pathways and bridges that span throughout these communities.

Because they operate at fairly modest speeds, EVs might also prove to be more compatible than cars in pedestrian-oriented environments, such as commonly found around transit stations. While the slower speed of EVs might reduce the potential severity of collisions with pedestrians and cyclists, the incidence of accidents could increase due to the relatively quiet operation of EVs.[5]

The slow speeds and space advantages of station cars make them particularly compatible with a number of emerging urban design principles, such as traditional neighborhood development and "new urbanism." Station cars are more human-scale, and because they are environmentally benign, are less obtrusive when operated in residential neighborhoods. A growing number of urban designers, such as Solomon (1992), Calthorpe (1993), and Katz (1993), call for designing new communities like those of yesteryear. They contend that undoing the rigid street hierarchy, returning to conventional gridiron and radial street forms, narrowing street widths and allowable building setbacks, and landscaping for pedestrian scale will reduce the dominance of the automobile and reduce dependence on it. Calthorpe has proposed the formation of "pedestrian pockets" around light rail systems in Sacramento, San Diego, and Portland — moderately dense, mixed-use neighborhoods that tie directly into light-rail stations. Calthorpe's Laguna West project in the suburbs of Sacramento uses a modified grid overlaid by radial connectors in an effort to focus neighborhoods around transit stops. Station cars would blend in nicely with such design schemes, providing access to those living and working beyond a one-quarter mile-walking distance and intermixing with foot traffic near rail stations.

Lastly, an emerging station-car market would add momentum to the buildup of a successful EV industry in California and other states. Southern California, in particular, seems well suited to EV production because of its large local market, abundance of skilled labor, and multi-faceted industrial base (Scott, 1993). Station cars, in particular, could find a comfortable market niche in southern California in view of the planned construction of over 300 miles of rail lines throughout the region over the next 30 years. Wolff et al. (1993) estimate that the formation of an electric vehicle industry in southern California in response to current air quality regulations could produce 24,000 new jobs by the year 2003.

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[5]Since the engines of EVs have no moving parts, they are relatively quiet when moving or idling. Most noise is emitted by pneumatic tires. The risk of accidents could be reduced by improved signage and public education, for both EV motorists and pedestrians. Over time, pedestrians might gain greater awareness of the possible presence of EVs and exercise appropriate caution. To the degree station cars are intermixed with ICE vehicles, accidents rates might also increase because of the varying speeds of vehicles. Improved vehicle design and safety measures might lower accident risks, however.

1.4. Potential Costs of Station-Car Initiatives

The anticipated benefits of station cars must be weighed against the potential costs. While the concept of station cars is too new and untested to support any rigorous economic calculus of benefits versus costs, it is helpful to reflect on the costs that would be incurred in introducing station-car services on a significant scale. As with any infant industry, there would be substantial start-up costs. The largest cost would be for purchasing vehicles. Currently, a two-seater EV with a maximum speed of 35 mph and a 30-40 mile range, like the Danish-made Kewet El-Jet, sells for around $16,000. Additional expenses would be incurred for registering, licensing, and insuring the vehicle, though these would be no higher than for any other motorized vehicle and perhaps less because of tax credits.[6] The annual maintenance costs of station cars would be comparatively low, as noted earlier, requiring only around $100 annually in electricity expenses. Since EVs have no motors with moving parts, annual maintenance expenses would be much less than for otherwise comparable vehicles with ICEs. The most significant maintenance costs of station cars would be incurred every three or so years for replacing worn-out batteries. The estimated costs of replacing the 500-lb. lead-acid battery pack of a vehicle like the Kewet is $4,000 to $5,000. Batteries need to be replaced every 20,000 miles, or three to four times over the full useful economic life of the vehicle.

The high cost-to-performance ratio of EVs is often cited as a reason why they will never gain wide market acceptance. Indeed, station cars and EVs constitute an infant industry that face high start-up costs and risks. In light of the many potential external benefits of station cars, an argument could be made that the fledgling station-car industry should receive government subsidies so that it can expand enough to eventually achieve economies of scale and become self-sustaining. Indeed, one of the original justifications for federal capital grants to public mass transit was to strengthen the industry by giving it a one-time financial boost that, backers hoped, would eventually lead to self-sufficiency (Cervero, 1982). A similar case could be made for station cars. Another strategy would be to grant EV purchasers fee-bates — using higher taxes imposed on polluting and gas-guzzling vehicles to provide rebates for cleaner vehicles (Sperling, 1994a). Costs might also be lowered by granting companies that underwrite EVs credits toward achieving mandated air-quality targets, such as part of a tradeable permit program.[7] If the

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[6]The 1992 National Energy Policy Act provides a federal income tax credit of 10 percent, up to $4,000, for the purchase of an EV. California allows an income tax credit for 55 percent of the cost differential between a CARB-certified low-emissions vehicle and a comparable gasoline-fueled vehicle, up to $1,000 per vehicle. California also allows a sales tax exemption based on the share of the cost that exceeds the cost of a comparable gasoline-fueled vehicle.

[7]Under a tradeable permit program, industries would receive permits that allow them to emit a specified amount of pollutants each year. They can exceed limits, however, if they take actions to reduce pollution from other sources, such as subsidizing EVs that reduce ICE travel. Thus, pollution reduction attains a market value, and firms are encouraged to find the most economically efficient way to mitigate air quality impacts. Station cars and EVs might be subsidized by large industrial polluters under such a scheme.

EV industry expanded enough to allow mass production and economies of scale, industry observers estimate that the cost of producing a vehicle like the Kewet could be cut in half (Sperling, 1994a).

Since station cars would operate mainly on existing surface streets, no guideway expenses, new outlays for road space, or major facilities costs would be incurred, perhaps outside of special signage. Because EVs are small and light, the marginal facilities costs for accommodating station cars (e.g., resurfacing, striping, etc.) would be negligible. Perhaps the only other direct expenses of any magnitude would be the transactive costs. Transit agencies would incur expenses in providing parking and perhaps overnight security for station cars. To the degree station-car trips substitute for park-and-ride trips, however, the demand for parking might actually fall. Minor expenses would also be incurred for installing charging stations at parking stalls. Other expenses would be incurred in administering and managing a station-car program, whether directly or through a third-party contractor, and for incidental expenses, such as smart debit cards that track vehicle lease transactions.

There would appear to be few external costs associated with station cars. Perhaps the most significant one would be the increased accidents that might result from light, slow-moving, and slow-accelerating stations car intermixing with heavier, faster vehicles. To the degree station cars operate in stop-and-go traffic and do not enter freeway streams, the risk of serious collisions with bigger vehicles at high speeds is reduced. Where the risk of accidents is high, special pathways might be built and curbside lanes reserved for EVs and other slow-moving vehicles.

1.5. A Receptive Policy Environment for Station Cars

Several recent laws and mandates have created a receptive policy environment for possible commercialization and widespread adoption of station cars. Most important has been the Zero Emission Vehicle (ZEV) rulings of California's Air Resources Board (CARB). In recognition of the need to substantially improve air quality within the state, CARB has mandated that by 1998, at least 2 percent of all cars and light-duty trucks sold in California be ZEVs. By 2003, ZEVs must constitute at least 10 percent of new car sales — or around 120,000 vehicles annually.[8] Because California represents one-tenth of the nation's vehicle market, automakers cannot afford to simply ignore these requirements. Moreover, Massachusetts and New York have passed similar ZEV legislation to California's, and at least ten states and the District of Columbia are currently seeking federal approval to invoke ZEV requirements for implementing state air quality plans. ZEV mandates have become the most stringent clean-vehicle standards in the world, and could do more to jump-start California's EV industry than any single factor.

One important outcome of California's ZEV mandates has been the forging of new institutional alliances for advancing electric vehicle technologies. Most notable has been Calstart, a consortium of

[8] The CARB regulations were passed in 1990. CARB standards also call for 15 percent of new vehicles to have ultra-low emissions (involving a combination of electrically operated and methanol/ethanol/CNG-propelled vehicles), and for the remaining 75 percent to have low emissions.

over 120 California utilities, defense contractors, high-tech companies, national laboratories, government agencies, labor representatives, and universities. Partly as a defense conversion strategy, Calstart's mission is to make California an international leader in the manufacture of EVs. Calstart's four core programs involve building and showcasing electric vehicles, developing EV infrastructure (like quick-charging stations), designing a prototype electric bus, and market testing of small neighborhood electric vehicles. As noted earlier, another important alliance has been the National Station Car Association (NSCA), a coalition of transit agencies and electric utilities committed to mounting a demonstration of around 500 station cars in nine cities, five of which are in California: Los Angeles, Orange County, San Francisco (BART), San Diego, and Sacramento.[9] BART has been at the forefront of the national station-car movement, helping to establish the NSCA as well as initiating one of the first in-field demonstrations of station cars in early 1994 — the testing of 45 battery retrofitted subcompacts available to BART and Pacific Gas & Electric (PG&E) employees at five BART stations.

Another state program that could spur station-car demonstrations is AB434, which allows air districts to impose a surcharge of up to $4.00 on motor vehicle registrations within their jurisdictions. Surcharge revenues must be used to implement various transportation measures that will improve air quality. Among the eligible projects specified in the bill are "the provision of local feeder bus or shuttle service to rail and ferry stations" and "implementation of .... alternate fuel vehicles." Station cars would appear to be a viable candidate for AB434 funding support.

At the federal level, several recent landmark acts have further paved the way for the mass introduction of EVs and station cars. The 1988 Alternative Motor Fuels Act (AMFA) provided CAFE (corporate average fuel economy) credits to automakers that produce vehicles running on alternative fuels. Although EVs were not included in AMFA, according to Bernard (1994, p. 21), "this act served as an ice-breaker, motivating automakers to branch out into AFV (alternative fuel vehicle) production." The 1990 Clean Air Act Amendments (CAAA) further strengthened the federal commitment to clean vehicles by setting AFV requirements for states with the dirtiest air basins and most polluted cities.[10] States like California with severe and extreme non-attainment areas must also adopt transportation control measures (TCMs) that will help achieve clean air standards. While EVs and station cars themselves are not specified in the Act as control measures, implementation of such designated TCMs as "programs to reduce cold starts and vehicle idling" and "improved public transit" would complement and help facilitate the introduction of station cars. Among the many programs in the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) that promote balanced and sustainable transportation, the Congestion Mitigation and Air Quality (CMAQ) program allocates $6 billion for innovative demonstrations that will

[9]The nine cities and number of station cars are: Atlanta (50), Boston (35), Chicago (50), Los Angeles (50), Orange County (65), Sacramento (50), San Diego (5), San Francisco BART (50), and Washington, D.C. (50).

[10]For California, the CAAA require that by 1999, AFV sales must total at least 300,000 vehicles per year. Local governments in severe non-attainment areas, like greater Los Angeles and San Diego, are also required to purchase clean vehicle fleets.

mitigate congestion and improve air quality. Station cars would be viable candidates for these funds. Last, the 1992 National Energy Policy Act (NEPA) authorizes $485 million for a joint public-private EV and battery research and development program as well as various tax credits for EV purchases.

Collectively, recent federal and state initiatives to improve air quality and reduce energy consumption have created a policy environment that is highly conducive to station-car development. The combination of supportive public policies and a demonstrated market demand through field tests would be a powerful force toward an eventual full-scale commercialization and adoption of station cars.

1.6. Demonstrations and Studies on the Market Demand for Station Cars

Little is currently known about the market demand for station cars. Motorcycles and three-wheel mini-cars have been tested as station access modes in Europe and Japan, though according to Sperling (1994), with limited success.[11] Current demonstrations of station cars by the National Station Car Association (NCSA) and BART are examining market demand; however, it is important to point out that as presently designed, these demonstrations are not market-testing the kinds of mini-EVs (under 2,000 lbs.) like Kewets that are studied in this report. NCSA's electric vehicles will be freeway-certified, meeting all applicable crashworthiness standards of the Federal Motor Vehicle Safety Administration. In the case of BART's current testing of 45 electric vehicles at five rail stations, Geo Metros converted to battery propulsion are being used by a selected group of BART and PG&E employees. The project focuses on the reverse commute. BART and PG&E employees pick up EVs at stations, drive them to work sites, and return them to stations in the evening, where they are recharged.[12] Because conventional four-seater sedans are being used and the program is limited to employees, the demonstration will likely provide more useful information on the reliability of battery technologies and the logistics of station-car operations than on market potential or the likelihood of acceptance by the general public. In contrast, the research findings summarized in this report focus centrally on the market potential of small mini-EVs that would function mainly as access and egress vehicles to rail stations.

More work has been conducted to date on the potential receptiveness of Americans to more general-purpose EVs, like neighborhood electric vehicles (NEVs). With the support of a grant from Calstart, researchers at the University of California, Davis, have been examining consumer attitudes and behavior toward neighborhood electric vehicles. Preliminary studies reveal that the market penetration potential of EVs might be as high as 13 percent of all households nationwide (Nesbitt et al., 1992). Because most

[11]A transit agency in Switzerland offers free recharging for battery-powered vehicles. Customers supply their own vehicles, but can plug them into a recharging station at will.

[12]EVs will also be used as pool cars for work sites. Besides BART stations, where recharging stations have been intalled, recharging will also take place at workplaces and residences. The program is attempting to maximize pollution reductions per vehicle by targeting current drivers of pre-catalyst (pre-1974) vehicles. Participants pay an average of around $100 per month to lease a vehicle. BART's program is supported by grants from the Bay Area Air Quality Management District, Pacific Gas & Electric, the California Department of Transportation, Calstart, and BART itself.

Americans have no experience with limited-range vehicles, UC Davis researchers have found that many initially respond fairly negatively toward the concept of NEVs (Sperling, 1994A). Upon reviewing their trip for the previous week, however, they appear to be far more receptive to NEVs once they realize they can satisfy a large share of trips with a limited range vehicle. This is supported by recent findings by Rutherford et al. (1994) that 94 percent of daily travel needs can be met by EVs with a range of 90 miles. Earlier research by Beggs and Cardell (1980; 1981) and Greene (1985) established that consumers are highly sensitive to the range limitations of EVs, and are generally willing to pay a large premium for an EV with a range of 200 miles versus one with a range of only 50 miles.

Last, at least one demonstration has been conducted to date on short-term vehicle leasing. Leasing makes sense for those who need specialized vehicles, like station cars, on a periodic basis. In the early 1980s, the STAR (short-term automobile rental) project was launched in the Park Merced district in San Francisco by a group of private investors. The expectation was that neighborhood residents might prefer to lease specialized vehicles like vans for weekend excursions or mini-cars for local shopping, rather than own a "one-size-fits-all" second or third vehicle. A rental car agency was hired to manage the program and supply vehicles, including cars and vans of varying sizes that were alternated between the Park Merced site on weekends and airport rental offices on weekdays. While initially successful, the STAR program eventually began experiencing financial problems and shut down within the first year. More successful car-sharing programs currently exist in several German cities. Called Stattauto (city car), Germany's car co-ops have around 3,000 members who share cars on an advanced reservation basis.[13] A small group in Eugene, Oregon, has recently formed a car co-op modeled after the German experience (LaFond, 1994).

1.7. Research Focus and Report Outline

As already noted, much remains to be learned about whether station cars can attract enough users to become economically viable and self-sustaining. Recent legislation like California's ZEV mandates provide impetus for the station-car movement; however, until more of a market potential is demonstrated, the risks of such ventures will remain high. According to the National Station Car Association, "in order to entice vehicle manufacturers to offer a reasonably priced station car with good characteristics, a market must be demonstrated" (Bernard, 1994: 7). In the absence of much experience with the use of

[13]Members of Stattauto, wishing to use a vehicle, simply get on the phone and dial a reservation number. Ninety percent of the time, the callers get the car they want immediately. In Berlin, where the first German car co-op was formed in 1988, a variety of automobiles are distributed around 14 lots. Car keys and travel logs are kept in safe-deposit boxes at lots, to which members have magnetic card-keys. Members fill out travel reports for record-keeping and accounting. Stattauto bills monthly, for kilometers travelled, hours of use, and the taxi rides that can also be billed to members' cards. Becoming a Stattauto member requires a $600-$900 investment (returned upon leaving the group), an initiation fee of $75, and monthly dues of $5 to $7.50. Surveys show the typical Stattauto member is 35, earns $2,500 per month, has a university degree, votes Green, is a professional, and is a former car owner (LaFond, 1994).

light-weight, two-seater, limited-performance EVs as station cars, this research aims to help define the market potential of such a service.

BART was chosen as a case context for conducting this research. The primary inputs used in assessing market demand were the results of a survey of potential customers based on field tests as well as a study of commuting patterns in the Bay Area that are best suited to station-car access. Combining these two inputs provided estimates of future possible demand levels for station cars, stratified by various subgroups, such as work-end station-car trips and former ICE commuters.

The remainder of this report is organized around four chapters. Chapter Two describes the research methods and data sources in further detail. In addition to discussions on the research design, techniques used in conducting field tests and eliciting responses are covered. Chapter Three presents the results of the field tests. Reactions of participants to various features of EVs as well as to the station-car concept are presented. Factors most strongly associated with participants' ratings of station cars, such as the occupations and travel distances of respondents, are identified. Additionally, estimates on what consumers might be willing to pay for station-car services are presented. Chapter Four presents estimates of market demand for station cars in the San Francisco Bay Area by merging results of the in-field surveys with commuting statistics. The potential air quality benefits of converting ICE trips to station cars are also discussed. Chapter Five concludes the study by summarizing the key findings and addressing their implications for public policy.

Chapter Two

Research Methodology and Data Sources

2.1. Research Approach

Two primary data inputs were used to estimate the market demand potential of station cars, using the BART rail system as a case context: (1) survey evaluations of the station-car concept by a sample of Bay Area workers who field-tested a station car; and (2) statistics on the origin-destination patterns and modal splits of commute trips in the San Francisco Bay Area. Commute statistics provided an estimate of the number of journeys to work by rail with trip ends within a range of BART stations that might be suitable for station-car trips. In-field survey results indicated levels of receptiveness among those who are the most likely candidates to drive station cars. Factoring these two data inputs together provided an "order of magnitude" estimate of the potential market demand for station cars in BART's service district.

Field tests focused on two distinct submarkets of potential station-car patrons. One consisted of those working at an employment site within several miles of a suburban rail station with park-and-ride facilities, what we call the "work-end" submarket. Station-car "simulations" were conducted by having workers drive a Kewet mini-EV between their work site and the nearest BART station and back. The other submarket consisted of commuters who might drive an EV between their residences and rail stations (i.e., as a replacement for park-and-ride ICE trips) — what we call the "home-end" submarket. For this group, field tests were conducted by having BART customers drive a Kewet along streets near two BART stations surrounded by residential neighborhoods. Following field tests, participants were asked to complete questionnaires that allowed them to evaluate their driving experience and the station-car concept.

The second phase of the research involved enumerating commute volumes in the San Francisco Bay Area that met various criteria that were considered necessary for station-car travel. One criterion was that the origins or destinations of commutes had to be between one-half mile and four miles of a BART station with park-and-ride facilities. Another was that commutes had to occur over a distance equivalent to traveling between at least five suburban (East Bay) BART stations. Using origin-destination and modal split data from the 1990-91 Bay Area Travel Survey (BATS), we estimated a "potential" market of station-car consumers based on these and other criteria. This estimate was then factored by the share of those field-testing the Kewet station car who seemed very receptive to the concept. This yielded an overall estimate of daily market potential. This estimate was further factored by the share of potential users who would likely be former ICE commuters to make a preliminary assessment of environmental benefits.

The use of surveys and field tests as primary inputs for assessing market potential was necessitated by the absence of station-car services using mini-EVs in the San Francisco Bay Area or elsewhere. For this reason, we opted for stated preference techniques as a "second-best" alternative to recording revealed market behavior. Since attitudinal responses were elicited from actual in-field tests rather than as responses to simple verbal or written descriptions, our approach was far from hypothetical. The testing procedure might be viewed as an in-field simulation of station-car operations. As such, our research approach represented a middle ground between market research based solely on stated preferences versus actual demand revealed by a large-scale pilot program.

2.2. Field Testing and Surveying of the Station Car

Carrying out the in-field tests and compiling survey data involved four major steps: (1) acquiring a mini-EV; (2) recruiting employers and participants; (3) designing a questionnaire; and (4) scheduling and conducting field tests. Each step is discussed in this section.

2.2.1. Acquiring a Mini-EV

The choice of a mini-EV for market testing of the station-car concept was limited by what is currently available in the U.S. Stein et al. (1994) define mini-EVs as two-seater, battery-operated vehicles under 2,000 lbs., no more than 9 feet in length and 4.7 feet in width, and that travel up to 40 mph with a range typically under 50 miles. As the technology currently stands, "range is low, speeds are slow, crash-worthiness is low, and prices are high" (Stein et al., 1994: 3).

At the time field tests were conducted, in the spring of 1994, the only four-wheel mini-EV that met federal safety standards and is certified by California's Department of Motor Vehicles (DMV) for non-freeway travel is the Danish-made Kewet El-Jet. First sold in the U.S. in 1993, a Kewet can be directly leased or purchased in California through a licensed distributor, Green Motorworks, Inc., of Burbank. The Kewet is smaller than a standard subcompact car, with a top speed of 40 mph, a range of 35 to 40 miles, two seats, and space for packages. The Kewet is essentially hand-built, using what Sperling (1994) calls "primitive technology." It weighs 1,650 lbs, with the lead-acid battery pack making up about a third of total weight. The vehicle is operated similarly to a standard ICE vehicle, although it has no gear shift. The vehicle moves forward or backward by flipping a directional switch on the panel and pressing a foot pedal. For purposes of carrying out our market research and field tests, we leased a Kewet from Green Motorworks, Inc. for the three-month period of April-June 1994.

2.2.2. Recruiting Participants

Field simulations and surveys focused on both "work-end" and "home-end" station-car submarkets. Approaches used to solicit participants for both submarkets are outlined below.

Recruiting Employers and Participants for Work-End Tests

As discussed in Chapter One, the suburban work-end station-car submarket is considered particularly promising for two reasons: one, suburban areas generally have meager bus services, thus there is likely an untapped market niche for specialized access services; and two, many large suburban employers have active commute alternatives programs in response to air quality mandates, and thus have the institutional capacity (e.g., in-house transportation coordinators) to help sponsor a station-car program.

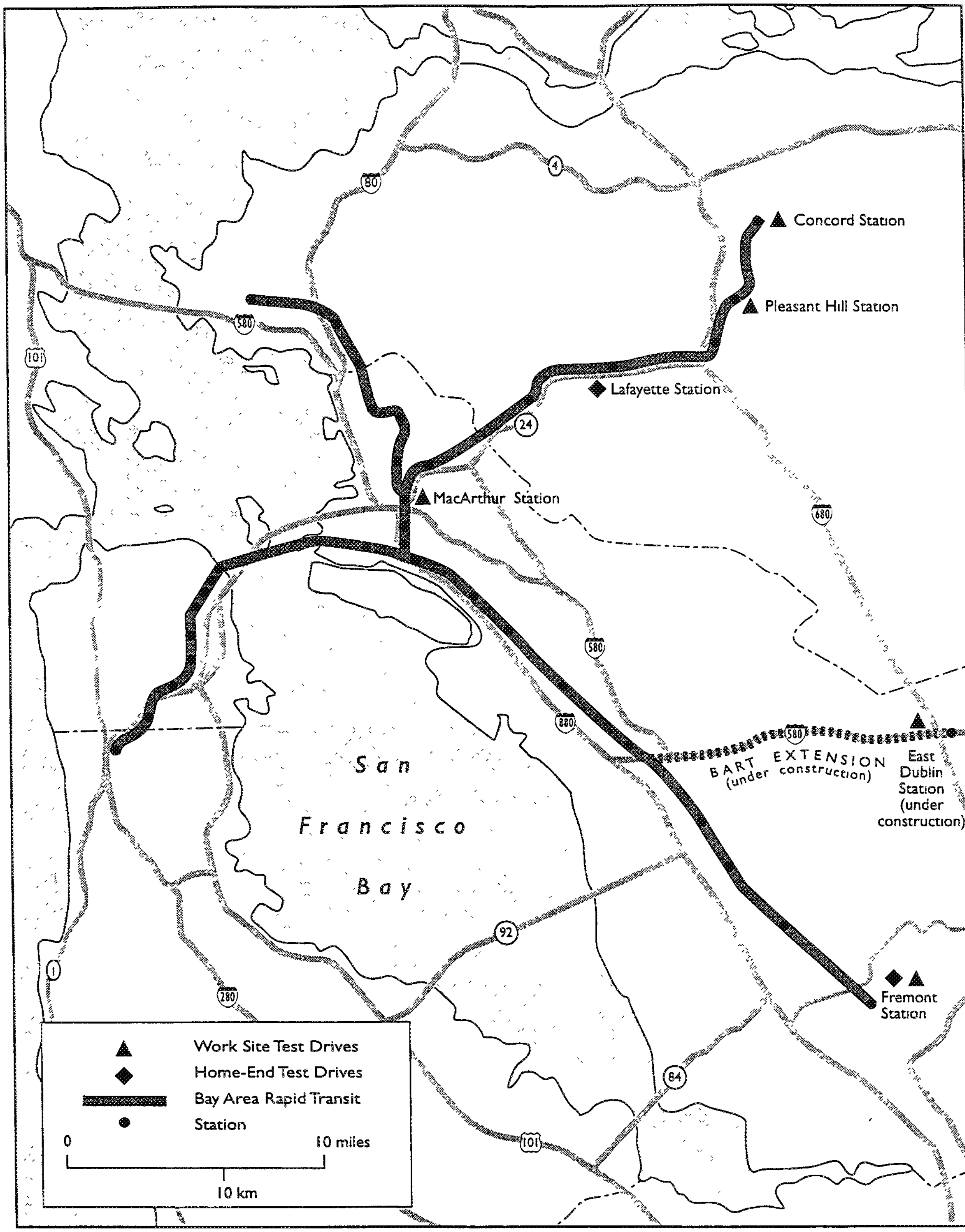
In recruiting employers to test the work-end station-car concept, we initially obtained an inventory of the Bay Area's largest employers (> 100 workers) from RIDES, Inc., the regional rideshare organization. Letters explaining the purpose of our research and requesting assistance were sent to over 100 large Bay Area employers with offices in the East Bay that were within five miles of an existing or planned suburban BART station.[14] Most letters were addressed to the designated transportation coordinators of each firm. (All Bay Area firms with 100 or more workers are required by the regional air quality board to have an in-house transportation coordinator.)[15] Approximately half of the firms which were sent letters responded either by letter or telephone. These firms were then contacted and screened to determine whether a station-car program might have a reasonable chance of success with their workers. One screening factor was whether surface street connections between the workplace and nearest BART station were suitable to station cars — e.g., reasonably direct routing and safe driving conditions, alternatives to freeway access, and the existence of mixed land uses in the area (thus allowing short midday non-work trips by station cars). Other factors weighed in screening employers were the level of interest expressed by the transportation coordinator and their understanding of the station-car concept, the firm's previous commitment to commute alternatives (e.g., providing workers with transit vouchers, subsidizing vanpools), and proximity of the firm to BART stations.

An agreement was reached with ten East Bay companies to participate in the work-end station-car tests and surveys. The ten companies have offices near five BART stations — four existing stations (Concord, Pleasant Hill, Fremont, and McArthur) and one slated to open in 1996 (East Dublin/Pleasanton) (see Map 2.1). All five stations have over 600 park-and-ride spaces and are well-served by surface streets connecting BART.[16] The planned East Dublin/Pleasanton station was considered a particularly promising candidate for station cars because of its proximity to the Hacienda Business Park, one of the largest employment centers in the Bay Area, with over 12,000 workers within a 0.5-1.5 mile radius of the soon-to-open BART station. The existence of undeveloped land between the planned BART station and the Hacienda complex might also allow specialized infrastructure, such as dedicated pathways, to be easily built in the future to accommodate EVs.

[14]Most employers in San Francisco, Daly City, Oakland, Berkeley, Richmond, and other fairly urbanized parts of the East Bay were not contacted because we consider these areas to be less viable station-car markets, mainly because they have fairly intensive existing bus services. Concerns over busier traffic volumes and higher crime levels in these areas might also deter some workers from using station cars.

[15]Regulation 13, passed by the Bay Area Air Quality Management District in 1991, requires all firms with over 100 workers to introduce measures, including designating a company transportation coordinator, that will result in the company's average vehicle occupancy level to 1.5 or more.

[16]The following number of parking spaces are (or will be) available at each station: Concord (1,975); Pleasant Hill (3,245); Fremont (2,494); MacArthur (609); and East Dublin/Pleasanton (2,400 planned).



Map 2.1. Location of BART Stations where Station-Car Test Drives were Conducted

The ten employers recruited to participate in the survey are listed in Table 2.1, along with the time period when in-field tests were conducted and the number of company employees who test-drove the Kewet. All except one (city of Fremont) are private firms whose workforce is involved predominantly in office and service functions. In most instances, we personally met with each firm's transportation coordinators prior to actual field tests to further explain the research project and station-car concept, to guide coordinators in recruiting a representative cross-section of company employees to participate in the field tests, to schedule field tests, and to work out other logistics (e.g., whether the Kewet could be securally parked and recharged at the company premises overnight).

Table 2.1. Companies Whose Workers Participated in the Work-End Station-Car Tests and Surveys

Employer	Nearest BART Station	Survey Month	Number of Surveys
Payco America	E. Dublin/Pleasanton	March-May 1994	21
BASS Tickets	Concord	April 1994	22
Bank of America	E. Dublin/Pleasanton, Pleasant Hill	April 1994	14
Chevron	Concord	April 1994	4
Paragon	Concord	April 1994	15
Aetna Insurance	Pleasant Hill	April 1994	7
Lucky Stores	E. Dublin/Pleasanton	May 1994	6
AT&T	E. Dublin/Pleasanton	May 1994	15
Kaiser Permanente	MacArthur	May 1994	6
City of Fremont	Fremont	June 1994	8
TOTAL			118

Recruiting Participants for Home-End Tests

Participants for the home-end tests were recruited directly at two BART stations: Lafayette and Fremont in June and July 1994 (see Map 2.1). These two stations were chosen because they have predominantly residential land uses within a one-half- to four-mile range (the range best suited for station-car access trips) and a significant share of their employed residents earn relatively high wages and work in professional occupations (and thus might be able to afford to lease a station car). Several other factors weighed in in choosing these two stations. Based on 1990 journey-to-work census statistics, an estimated one-half of Lafayette's employed residents work in downtown San Francisco or Oakland; thus, many are regular BART users. In addition, at the time of the field tests, the Lafayette station was the site of an electric van commuter program for PG&E employees. There was already a large display on EVs at the Lafayette station, so regular BART riders from the area were probably already somewhat familiar with the electric vehicle concept. Fremont is a terminal station, and thus draws commuters from a fairly large catchment, including both southern Alameda County and Santa Clara County to the south. Moreover, compared to Lafayette, Fremont residents have more diversity in incomes, ethnicity, occupations, and presumably commuting and patterns, and was thus viewed as representing a broader cross-section of residential settings in the Bay Area.

Participants for home-end station-car simulations were recruited directly at the main BART station entrances of the Lafayette and Fremont stations in June 1994. We received written permission from BART to set up booths, post large signs, and hand out flyers for signing up BART customers to test-drive the Kewet at an agreed-upon date and time.[17] (Appendix A shows examples of advertisements used in recruiting participants.) The Kewet test car was also parked inside the station next to our booth, and clearly attracted the interest of passers-by more than anything. Recruiting took place in the afternoon when many residents were returning home from work on BART[18]; in most cases, station-car tests were scheduled for the following afternoon or several days after people signed up.[19] Every 10 to 20 minutes when a BART train arrived and disembarking customers passed through the fare gates, two to three researchers would announce: "Free test drives of an electric car. Non-polluting commuting." We attempted to hand out fliers to everyone willing to accept them, but mainly relied on BART customers to approach us or express an interest in participating.[20] To anyone even vaguely intrigued by the idea, we explained the purpose of our research and the station-car concept and urged them to participate. While this approach unlikely produced a truly statistically random group of participants, it did serve to limit the field tests to BART users who seemed most interested in the concept and thus might be likely candidates for home-end station-car usage.[21]

2.2.3. Designing a Questionnaire

A survey instrument was designed and pre-tested that elicited the following information from station-car participants: socio-demographic (e.g., age, gender, occupation); characteristics of their present commute, midday travel patterns, and transportation expenses; and a series of post-test questions

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[17]To advertise about our study and recruit participants, we handed out small handbill flyers that provided general background information. A more detailed letter discussing our research project was also made available to interested parties. Two six-foot-high announcement boards were also placed on easels near the recruitment desk.

[18]We believed that Thursday would be the best day to advertise because workers were more likely to take Friday off from work, especially during the late spring and summer. We advertised in the evening because people returning home from work would have more time to linger and discuss our project than would people hurrying off to work in the morning.

[19]We made follow-up telephone calls the evening before people were scheduled to test-drive the Kewet to confirm the appointments.

[20]We tried both active and passive "sells." One researcher would stay at the booth to answer questions by people who walked over to check out the Kewet. Two other researchers would pass out handbills and invite those showing any degree of interest in the project to participate.

[21]Compared to the work-end station-car tests, those recruited to participate tended to be middle-aged men. Far fewer women wandered over to check out and discuss the Kewet with us.

that allowed participants to evaluate the station-car concept and the many attributes of the Kewet test car.[22] Appendix B contains a copy of the questionnaire used for the work-end station-car field tests.[23]

2.2.4. Scheduling and Conducting Field Tests

Carrying out the field tests posed a number of logistical challenges. Field tests had to be coordinated to fit employer schedule preferences and also to allow the Kewet to be efficiently transported from site to site. The Kewet had to be towed between stations and test sites because most distances were outside the range limit of the Kewet and in some cases there were few good alternatives to freeways in getting between locations.[24] Another reason for towing was that we were concerned that long-distance usage of the Kewet in a concentrated period of time might affect its performance and thus bias survey evaluations. For work-end tests, we also had to arrange for overnight parking of the Kewet in a secure location where the vehicle could be slowly recharged. In some instances, the Kewet was parked overnight at a work site, whereas in other cases it was parked at a BART station or a municipally owned lot.[25] For home-end surveys, the Kewet was parked overnight inside the Lafayette and Fremont BART stations. All parking locations had to be within reach of a 110-volt electrical outlet so that the Kewet could be fully charged overnight to allow between six and eight tests the following day.

Work-End Field Tests

The day of field tests, we typically arrived at the employer site in the morning to work out any remaining logistical matters with transportation coordinators. Transportation coordinators usually had a list of people who were cleared by company management to participate in the test and who had been assigned to 30- to 45-minute time slots. Most participants had already received some background information on the study and the station-car concept. Normally, one to two researchers conducted field tests.

When participants first arrived, we introduced ourselves and invited people to ask any questions about the research project or station-car concept. Participants then signed an "Indemnification and Release" form wherein they assumed all risks associated with participating in the research. Next, we collected background information on each participant and then proceed to explain and briefly demonstrate how the Kewet EV operates. This was followed by a test drive where participants drove a circuit between

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[22]Pre-tests did not involve actual in-field tests, but rather having people complete the questionnaires based on verbal descriptions of the station-car concept. This was necessary because we had not received the Kewet vehicle at the time the survey instrument was being designed and refined.

[23]Questions were virtually identical for the surveys administered at home-end field tests, though reference was made to operating the station car between their residence and a BART station rather than at the work-end of their commute.

[24]BART operations personnel provided towing services between stations and test sites.

[25]In the case of the Pleasanton test sites, for instance, the Kewet was parked overnight at the city of Pleasanton corporation yard, where most municipal vehicles are parked, because the East Dublin/Pleasanton BART station is not yet constructed.

their worksite and the nearest BART station and back.[26] (See Photos 2.1 and 2.2.) Maps 2.2 through 2.5 show the locations of the 10 surveyed sites in relation to the nearest BART station.[27] A researcher sat in the passenger seat and generally only talked when responding to questions (Photo 2.3). Most driving tours took 10 to 15 minutes. Upon returning to the worksite, the participant would park the car, turn off the battery, and proceed to complete the remainder of the questionnaire, evaluating the station-car concept and the Kewet performance (Photo 2.4). After completing and returning a questionnaire, participants were thanked and given $10 for their time and involvement. In total, 118 people field-tested the work-end station car and returned completed questionnaires.

Home-End Field Tests

Home-end tests of people recruited directly at BART stations were carried out similarly to work-end tests. Each test period ran from 3 to 7 p.m. at both the Lafayette and Fremont stations. Participants signed up for a 30-minute time slot on one of the four days that home-end tests were conducted at each station. On average, five to seven people field-tested the home-end station car on a given afternoon.

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[26]For Pleasanton field tests, employees drove to and from the site of the planned East Dublin/Pleasanton BART station.

[27]In general, drivers followed similar routes between work sites and the nearest BART station, though a handful of drivers preferred taking alternative routes. The following were the most common routes from each work site to the nearest BART station.

Pleasant Hill

Aetna Route: L. on Civic Drive/Oak Road, drive through Pleasant Hill BART, L. on Oak Road/Civic Drive, R. on Pine: Distance: 2.2 mi.

Bank of America Route: Ellinwood Drive to Contra Costa Blvd., L. on Contra Costa Blvd., L. on Treat Blvd., drive through Pleasant Hill BART Station, R. on Treat Blvd., R. on Contra Costa Blvd., R. on Ellinwood Drive: Distance: 3.0 mi.

Concord BART Station

Bass Tickets Route: R. on Gateway Blvd., L. on Clayton Blvd., R. on Grant Ave., L. through Concord BART station, R. on Grant Ave., L. on Clayton Blvd., R. on Gateway Blvd.: Distance: 1.6 mi.

Chevron Route: R. on Diamond Blvd., L. on Willow Pass Rd., R. on Grant Ave., drive through Concord BART, R. on Grant Ave., L. on Willow Pass Rd., R. on Diamond Blvd.: Distance: 4.4 mi.

Paragon Route: R. on Sutter Street, R. on Willow Pass Rd., R. on Grant Ave., drive through Concord BART, R. on Grant Ave., L. on Willow Pass Rd., L. on Sutter St.: Distance: 1.4 mi.

E. Dublin BART

AT&T Route: R. on Owens Drive, U-Turn on Owens Drive at Willow Road, L. on Rosewood: Distance: 2.1 mi.

Lucky Stores Route: L. on Clark, R. on Dublin Blvd., continue to end of Scarlett Court, return to Dublin Blvd. and turn right, L. on Clark: Distance: 3.2 mi.

Payco America Route: L. on Coronado Ln., L. on W. Las Positas Blvd., L. on Owens Dr., L. on Willow Rd., R. on W. Las Positas Blvd., R. on Coronado Ln.: Distance: 3.0 mi.

Fremont BART

City of Fremont Route: R. on Liberty, L. on Walnut Ave., L. on Civic Center, drive through Fremont BART, R. on Civic Center, L. on Mowry Ave., L. on Paseo Padre Pkwy., R. on Capitol Ave., L. on Liberty: Distance: 2.2 mi.

MacArthur BART

Kaiser Permanente Route: L. on Howe, L. on 40th Street, drive through Macarthur BART Station, L. under Highway 24, L. on Macarthur Blvd.: Distance: 2.1 mi.

Source: IURD Station Car Survey

Photo 2.1 Field-Test Drive of the Kewet El-Jet Near the Lafayette BART Station

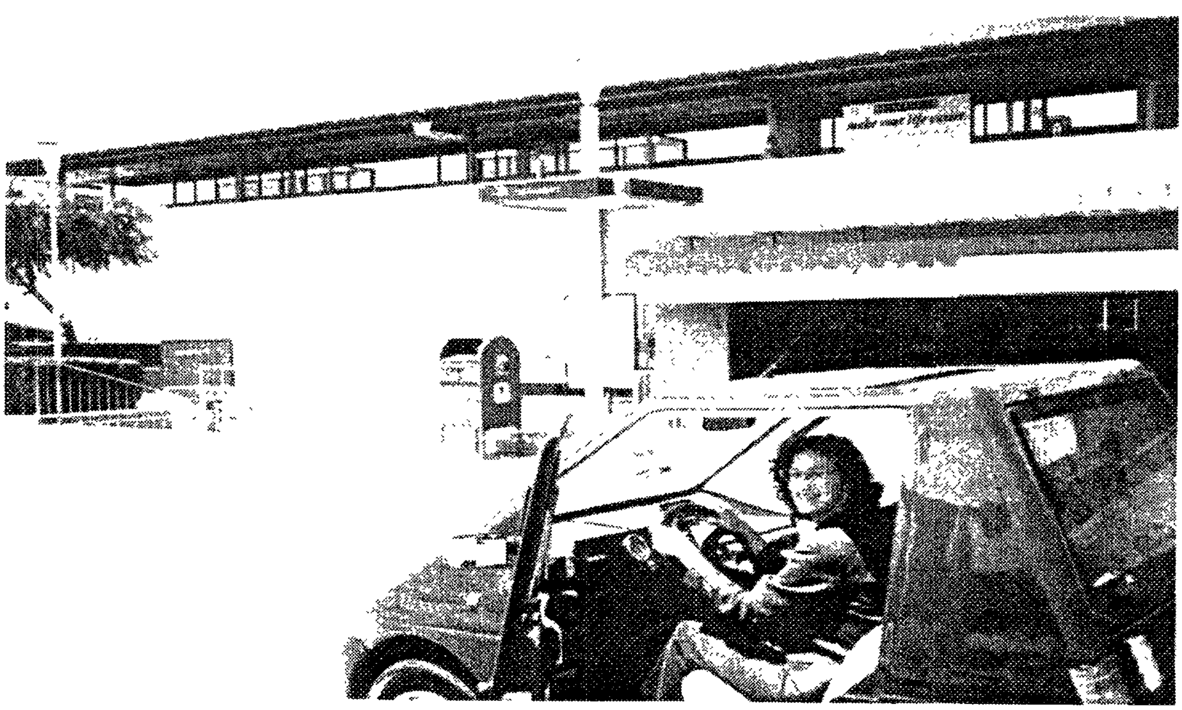
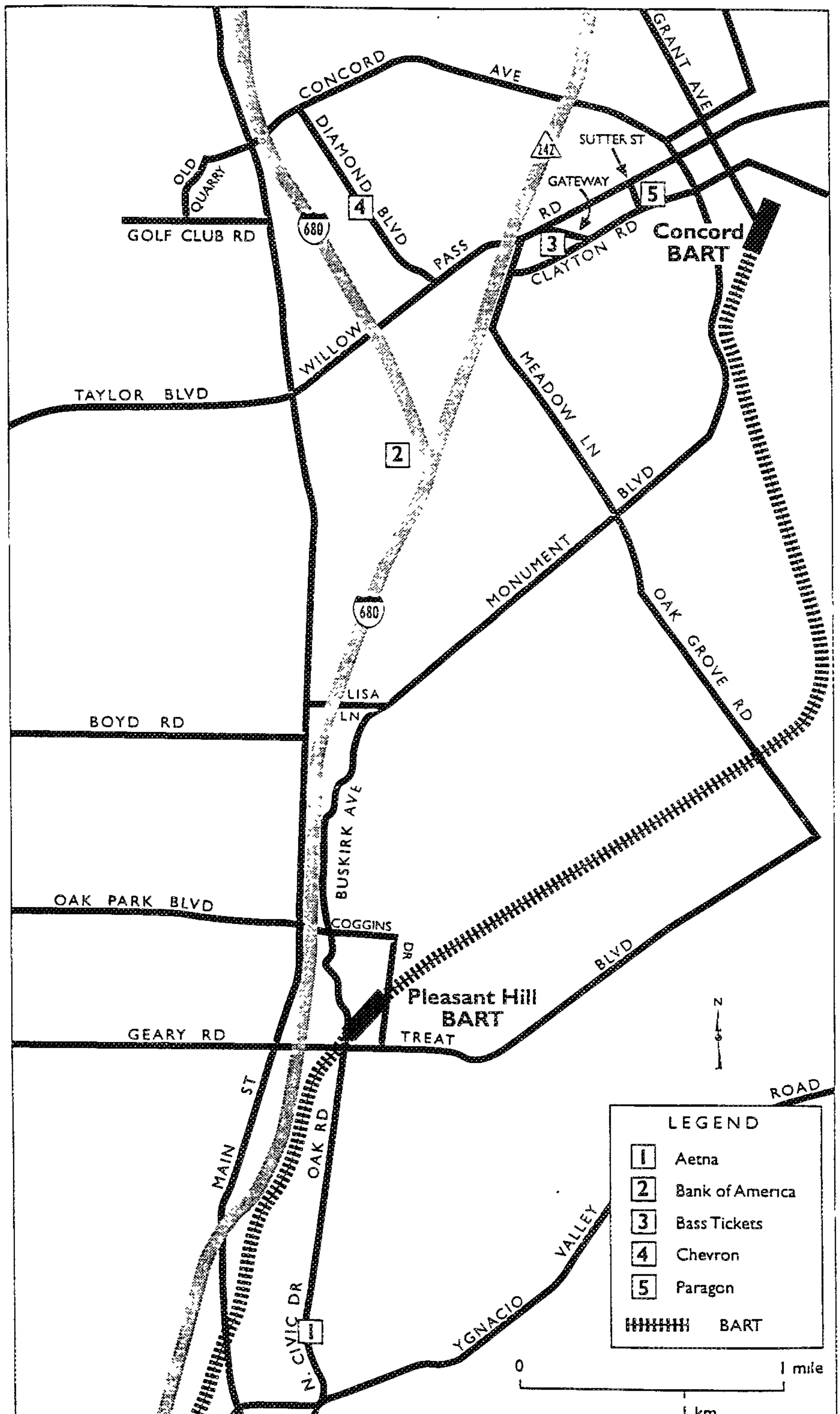
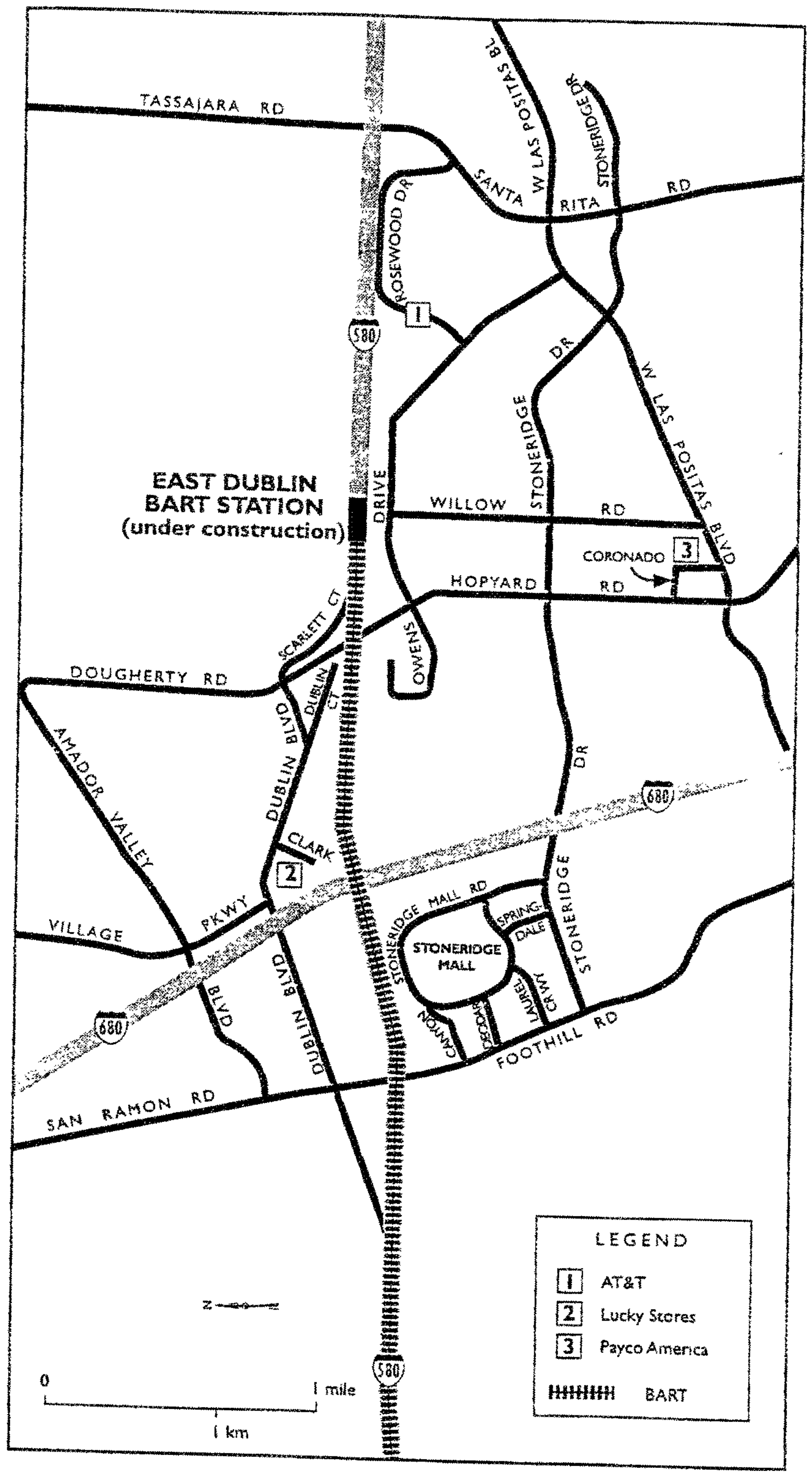


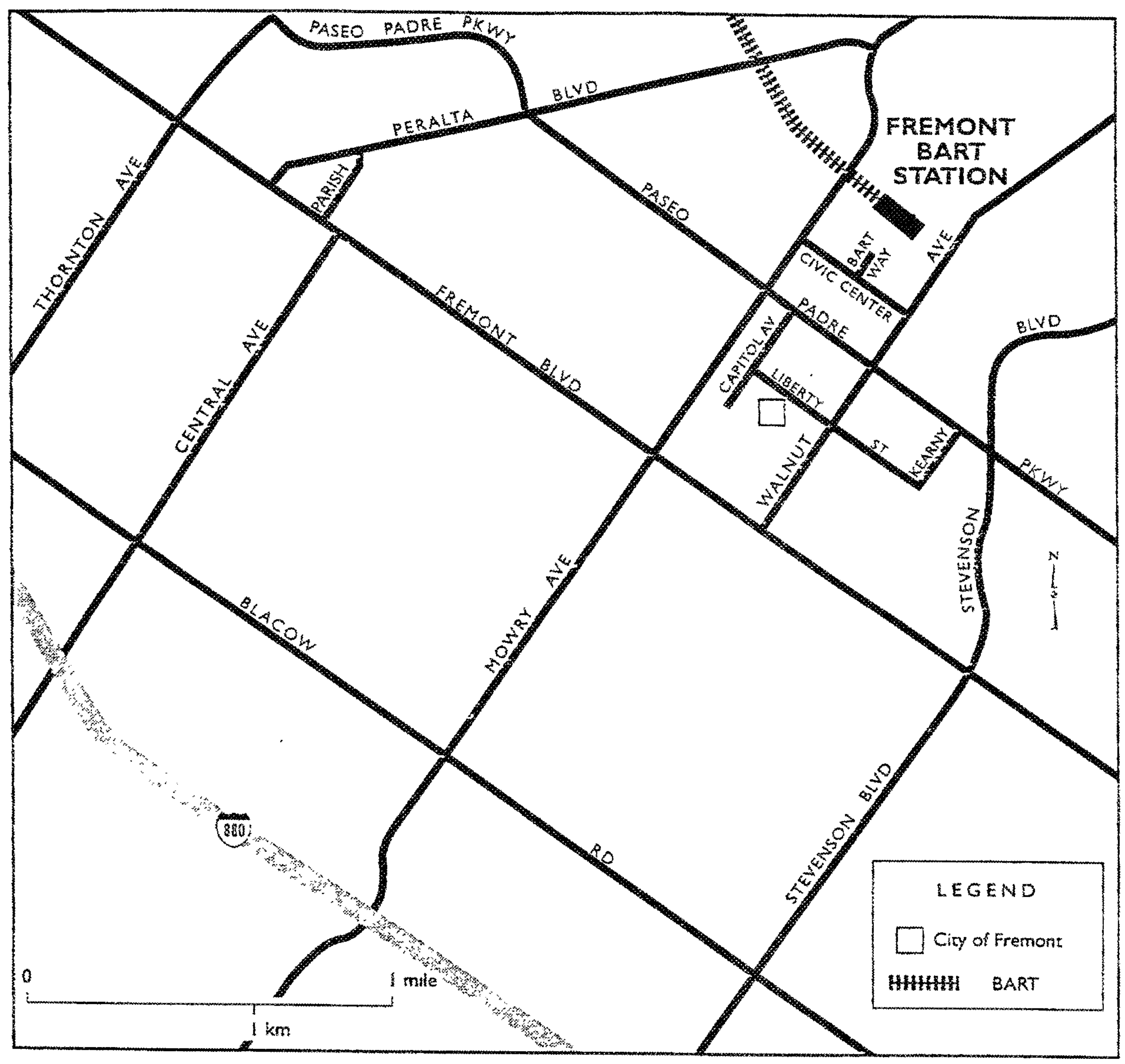
Photo 2.2 Arrival of Survey Participant at the Fremont BART Station



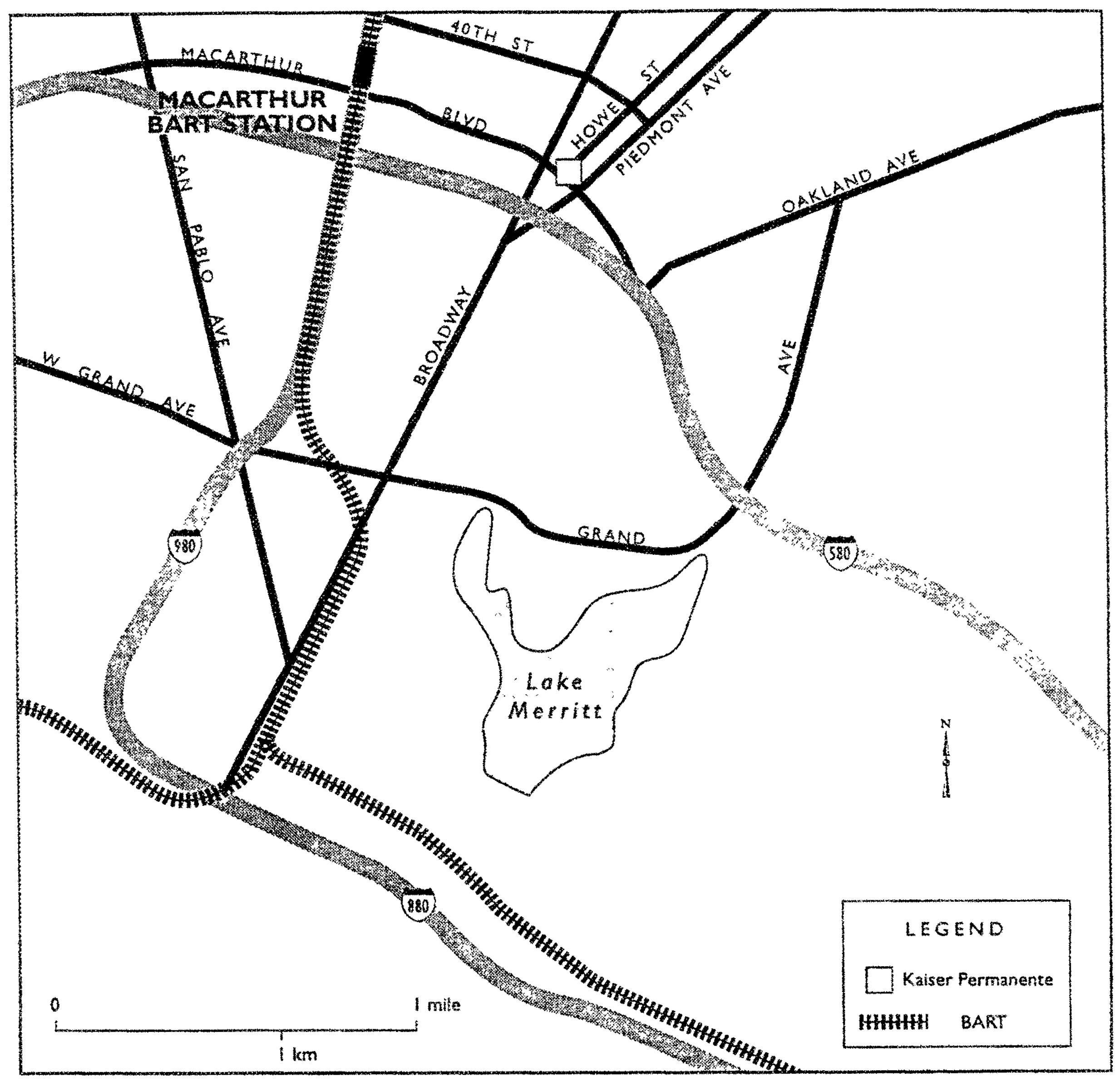
Map 2.2. Five Surveyed Work Sites Near the Concord and Pleasant Hill BART Stations



Map 2.3. Three Surveyed Work Sites Near the Planned East Dublin BART Station



Map 2.4. City of Fremont Work Site in Relation to the Fremont BART Station



Map 2.5. Kaiser Work Site in Relation to the MacArthur BART Station

Photo 2.3 Researcher Discussing Test Drive with Survey Participant at the Lafayette BART Station

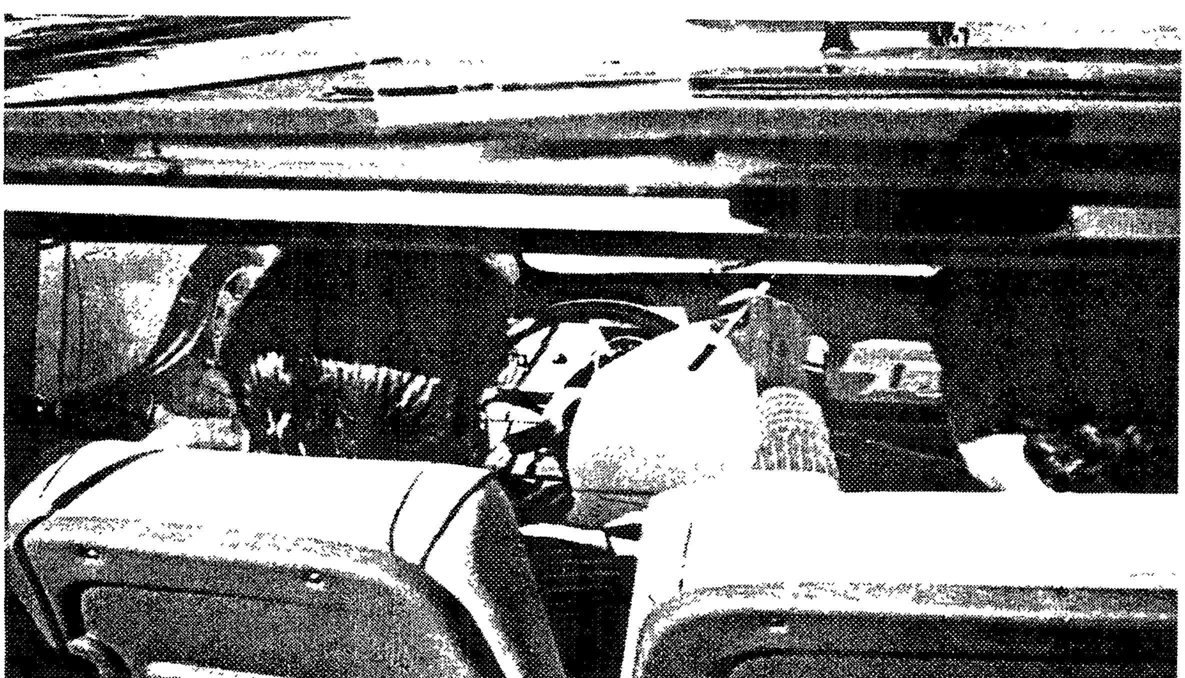


Photo 2.4 Participant Filling out Questionnaire Inside the Kewet upon Completing the Test Drive

Instead of having participants drive the Kewet from the BART station to their residence, we had them drive a designated circuit of around three miles. This was preferable to having them drive home for several reasons. One, routes to peoples' residences would have varied in terms of traffic levels and topography, which would have no doubt influenced the Kewet's performance and peoples' rating of the vehicle. Using a standard route at each station controlled for differences in driving environment. Second, adopting a standard route allowed us to better predict ahead of time how many field tests might be scheduled in an afternoon.[28] If a participant lived relatively far from the BART station or in an area with lots of stop-and-go traffic, this might have reduced the number of field tests before recharging, thus making advanced scheduling difficult. Last, we expected that once participants reached their home by the station car they would not want to return to the BART station; thus, unlike the work-end field tests, it would not have been possible to have people evaluate the Kewet based on driving a complete circuit.

For tests conducted at the Lafayette station, the three-mile circuit took drivers along a collector street, a wide and busy arterial, and on several local streets with gentle to moderate slopes (Map 2.6). At the Fremont station, drivers were taken on a similar type of tour, though because of the flat topography around the station, drivers encountered no significant grade changes.

In all, 45 individuals participated in the home-end field tests — 24 at Lafayette and 21 at Fremont. Three-quarters of those who initially signed up actually showed up and test-drove the vehicle. Last, those participating in the home-end tests received no money for their time because many earlier participants told us they would have gladly participated even if they were not paid.[29]

2.3. Estimating Market Demand Potential

Survey results provided a barometer on how receptive Bay Area workers are to the station-car concept. To address the question of how many people are making the kinds of commutes where a mini-EV might effectively be used to access stations required us to turn to another data source: the 1990 Bay Area Travel Survey (BATS), prepared by the Metropolitan Transportation Commission (Rodenborn and Purvis, 1991).

BATS is a 1990 random survey of 10,900 regional households with telephone exchanges in the San Francisco Bay Area, representing around 0.5 percent of the region's households. BATS contains

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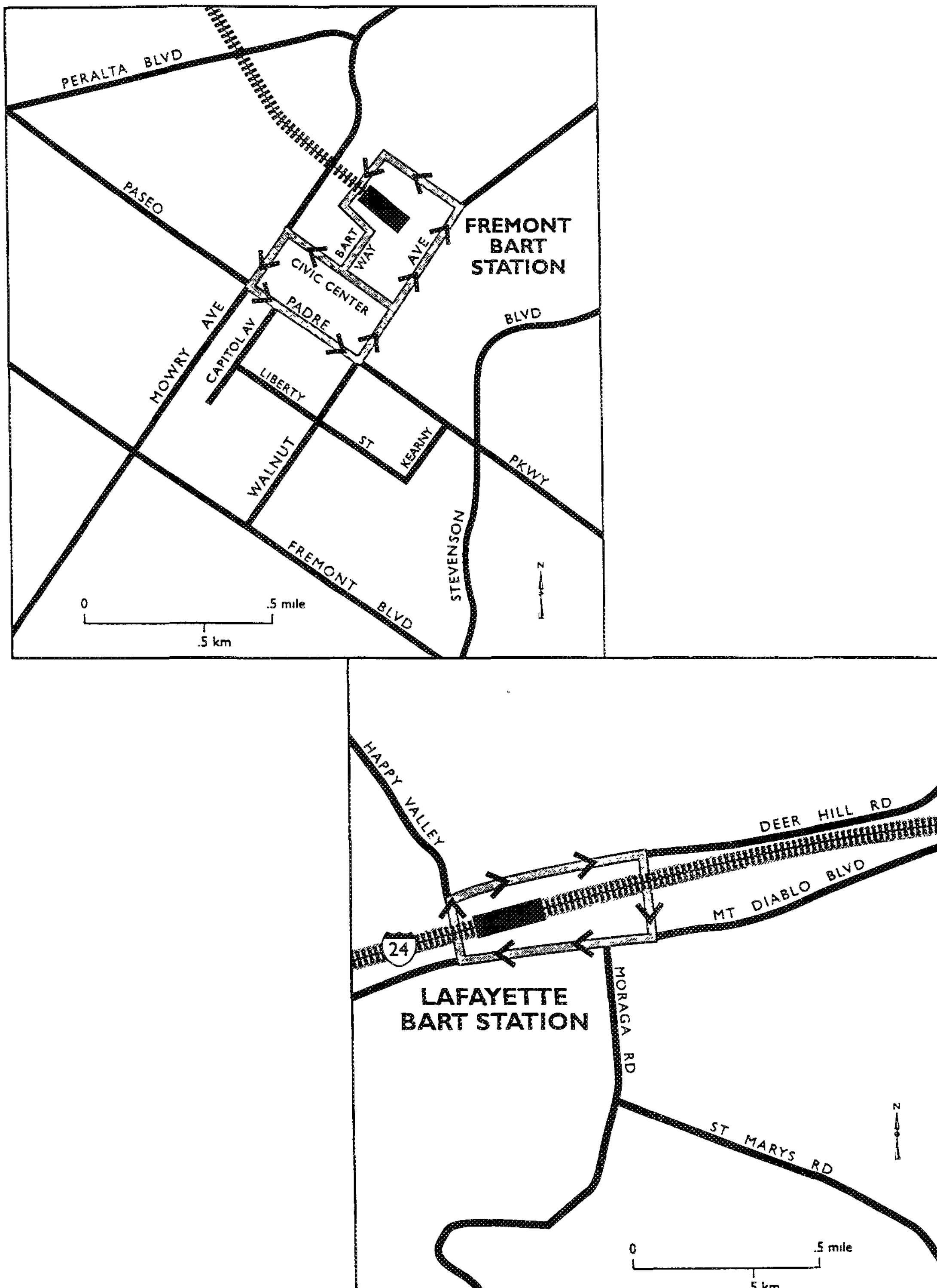
[28]Based on our experiences with work-end field tests of the station car, we knew that the Kewet could go about 30 miles before recharge. This is around one-quarter less than the vehicle specifications, and could be attributed to the fact that a lot of different people, with different driving styles, were test-driving the car, typically in stop-and-go traffic. With an assumed 30-mile range, we felt confident we could have up to eight people field-test the vehicle over a three-mile drive on a given afternoon.

[29]After several days of work-end field testing, we were finding some individuals were hesitant and almost embarrassed to receive payment for participating. Some actually did not accept the money offered. Since we had already told transportation coordinators we would pay participants $10 for their involvement, we could not renege on this promise, so we continued to offer $10 to each participant. We decided, however, that it would not be necessary to offer payment when recruiting for participants in the future, including people for home-end field tests.



Map 2.6. Circuit Routes Driven by Survey Participants at the Fremont and Lafayette BART Stations

complete travel diaries for all members of the 10,900 households above six years of age: 9,400 reported one-day travel diaries and 1,500 multiple-weekday travel diaries. For all trip purposes as well as each leg of multi-leg (linked) trips, BATS contains data on travel mode, travel times, origins and destinations (at the census block group level), and such other sundries as parking availability and parking prices. GIS techniques were used to provide more precise estimates of the distances and orgin-destination patterns of Bay Area work trips. We opted to use BATS data instead of the 1990 Census Transportation Planning Package (CTPP) for the Bay Area because BATS contained data for all trip purposes, not just work trips, and more detailed information on mode of access to rail stops.

As mentioned, the estimate of the market demand potential for station cars involved simple mathematics: the number of daily Bay Area rail commute trips whose distance and origin-destination profiles were considered well suited to station-car usage multiplied by the percent of people field-testing the Kewet who rated it very high for station-car functions. While this simple formula likely understates station-car numbers, for reasons discussed in Chapter Four, we nonetheless feel that this approach provides reasonable "order of magnitude" numbers on the future market demand for station-car travel. Using data on existing modes of travel, we further stratified the estimates by the share of combined station-car and BART trips made up of former drive-alone commuters to examine environmental implications. Based primarily on field-test survey results, preliminary estimates of the effects of station cars on midday travel and non-work trip-making are addressed. Survey results were likewise used to examine how much people might be willing to pay to lease station cars.

2.4. Summary

A combination of evaluative survey responses from field tests and regional travel data are used in this study to estimate the market penetration potential of station cars as access modes to BART stations. In the absence of any large-scale programs of station cars using mini-EVs in the U.S., we opted to simulate the station-car experience and elicit attitudinal responses from participants. The research segments station-car usage into two markets: work-end trips (between rail stations and work sites) and home-end trips (between residences and park-and-ride lots).

Obtaining attitudinal ratings of the station-car concept required four steps: acquiring a mini-EV, recruiting employers and participants, designing and pre-testing a questionnaire, and scheduling and conducting field tests. Field-testing of station cars posed a number of logistical challenges, such as transporting the limited-range vehicle between regional sites and scheduling the right number of participants to drive along a designated route before requiring an overnight recharge. While our means of recruiting participants relied heavily on good will, field tests of 163 individuals were carried out without any serious incidents, and, for the most part, many people who appear to be good candidates for station-car usage participated in the study.

BATS data on the modes, distances, and origin-destination patterns of Bay Area commutes allowed us to expand field test results into regional estimates of possible daily station-car trips. While estimates might best be viewed as "ballparks," they do provide some initial insights into the potential scale of station-car operations that might be expected under admittedly ideal conditions.

It is to the question of "what might be the demand for station cars on the BART system?" that we now turn. Chapter Three presents and evaluates the results of the field tests of station cars. This is followed by Chapter Four, which combines these survey results with regional travel data to derive daily station-car demand estimates.

Chapter Three

Evaluation of the Station-Car Concept by Bay Area Workers and Residents

3.1. Introduction

The results of how Bay Area workers and residents responded to the station car following field tests are presented in this chapter. Most survey results are stratified by the two station-car market niches: work-end and home-end. In most of the tables that follow, respondents are identified as belonging to either an employment site (representing the work-end market) or home-end survey (at the Lafayette or Fremont stations). Initially, the background characteristics of survey respondents are summarized. This is followed by summary statistics on how respondents evaluated both the mini-EV (Kewet) and larger station-car concept. Ratings are cross-tabulated by such factors as how respondents currently commute and levels of midday trip-making. Survey results are then used to examine the feasibility of station cars with regard to willingness to pay and travel time impacts. The chapter ends with a summary of the key findings.

3.2. Background Characteristics of Survey Respondents

3.2.1. Demographic and Occupation Profiles

Most participants in the station-car simulation were male: 58 percent of participants surveyed at the work-end and 76 percent of those surveyed at the home-end.[30] Around three-quarters of those surveyed at employment sites were white, compared to around 60 percent of those field testing the home-end station car at the Lafayette and Fremont stations.[31] Respondents were mostly middle-aged (and slightly older in the residential sample than the employment sample). Last, Table 3.1 shows that most respondents worked in professional fields.[32]

3.2.2. Transportation Characteristics

How different is the rail-station-car combination from respondents' current commute? Currently, two-thirds of those surveyed at employment sites usually drive alone to work (Table 3.2). Just 10 percent

[30]The large share of male respondents at the residential sites stemmed, in part, because the sign-up procedure depended more upon peoples' willingness to talk to unintroduced strangers. For the Lafayette site, 83 percent of respondents were men, compared to just 49 percent of Lafayette's citywide population.

[31]For the home-end tests, slightly higher shares of African American and Asian respondents were surveyed than currently reside in the two surrounding communities, Lafayette and Fremont.

[32]This reflects the white-collar character of the employment sites surveyed. Also, many participants recruited at the Lafayette and Fremont stations for the home-end tests worked in professional offices in downtown San Francisco and Oakland.

Table 3.1. Occupations of Survey Respondents

Occupation	Respondents at: Employment Sites	Respondents at: Home-End BART	All Respondents
Professional	53.3%	67.4%	59.2%
Technical, Administrative	26.7%	14.0%	21.4%
Sales	16.7%	2.3%	10.7%
Craft	0.0%	4.7%	1.9%
Operators/Laborers	3.3%	2.3%	2.9%
Students	0.0%	9.3%	3.9%
TOTAL	100.0%	100.0%	100.0%

Source: IURD Station Car Survey, 1994.

Table 3.2. Typical Commute Modes of Survey Respondents

Commute Mode	Employment Sites		Residential Sites		TOTAL	
BART	10%		75%		28%	
Drive alone to station		3%		52%		16%
Carpool or public transport to station		5%		15%		8%
Walk/bike to station		2%		8%		4%
Bus	3%		2%		3%	
Drive alone	67%		15%		54%	
Carpool (driver or passenger)	15%		8%		13%	
Other*	4%		0%		3%	
All trips reported	100%		100%		100%	

Source: IURD Station Car Survey, 1994.

*Includes walk or bike.

take BART to work; most of the surveyed BART users reach stations by carpools or public transit.[33] By contrast, three-quarters of those field-testing the "home-end" station car usually commute by BART, most of whom park-and-ride. This high share, of course, reflects the fact that most participants for the home-end tests were recruited directly at the Lafayette and Fremont BART stations.

Respondents who do not currently commute by BART were asked why. At the employment sites where BART usage is sparse, poor access was cited as the main deterrent: BART stations are either too far from the place of work (15.3 percent) or home (22 percent). Since station cars aim to bridge the gap between rail stops and work sites with on-call, flexible services, they would seem well suited to responding to the most frequent complaint of rail service in the suburbs — poor access to destinations. In general, rea-

[33]Overall, the commute trip modal splits of survey respondents closely matched the 1990 average for residents of Alameda and Contra Costa counties.

sons cited for not taking BART do not present formidable obstacles to the station-car concept, and in fact underscore the need for efficient, seamless connections between rail stations and work destinations.[34]

A major reason why many Americans drive alone to work is the availability of free parking at the workplace (Shoup, 1994; Cervero, 1994). Table 3.3 shows the vast majority of survey respondents can park for free at their work site — 95 percent of those surveyed at employment sites and 41 percent of those surveyed at a home-end station. The very reason why home-end participants took BART was probably because they had to pay to park at their workplace, which can be upwards of $15 per day for those working in downtown San Francisco. Table 3.3 also shows that respondents who must pay for parking tend to live or work close to BART stations. This likely reflects the tendency for neighborhoods near BART to be relatively dense and urbanized, with commercial rates charged for parking, whereas areas farther from BART often allow free on-street parking.

Table 3.3. Free Parking and Work-Place Distance from BART

Respondents	Employment Sites	Residential Sites	ALL
Percent with free parking at workplace	95%	41%	85%
Mean distance (miles) to or from BART station for respondents:			
with free parking	2.3	4.9	2.5
without free parking	0.8	0.3	0.4

Source: IURD Station Car Survey, 1994.

3.2.3. Midday and Extra-Work Trip-Making

Today, many suburban workers are compelled to solo-commute because they need access to a car for midday trips and after-work, or extra-work, trips (Cervero, 1989). For example, if a worker wants to meet a friend during lunch or stop off at a grocery store on the way home, current land use patterns and pricing policies encourage many to drive alone to work. By providing automobility between rail stops and worksites, station cars allow rail users to easily access shops and other non-work destinations during the midday and after work. Work-related and, to a lesser extent, child-care-related trips are likely the purposes least suited to station-car use.

Table 3.4 shows how employment site respondents currently make non-work trips. For home-based trips (typically en route to home from one's workplace), 95 percent were by automobile. For non-home-based trips (typically during the midday while at work), 87 percent were by private car. Mass transit plays a negligible role in serving midday and extra-commute trips of the suburban workers surveyed. Larger shares of those surveyed at home-end BART stations were able to fulfill their midday

[34]Other reasons cited for not using BART by respondents from employment sites were: work and personal schedule is too varied (9.3 percent); and they need car during the day (5.9 percent). Among home-end survey participants, the most frequently cited reason for not commuting by BART was that the nearest station was too far from their home.

trips needs by non-auto modes, mainly by walking (Table 3.5). This high incidence of midday walk trips reflect the large share of home-end survey respondents who work in downtown San Francisco where the built environment is more supportive of foot travel.[35]

Table 3.4. Modes Taken for Non-Work Trips: Employment Site Respondents

Travel Mode	Percent of Non-Work Trips: Home-Based*	Non-Home-Based**	All Trips
Automobile	95.5%	87.4%	88.9%
Public Transit	0.0%	1.1%	0.9%
Walk	4.5%	9.5%	8.5%
Bike	0.0%	2.1%	1.7%
TOTAL	100.0%	100.0%	100.0%

Source: IURD Station Car Survey, 1994.

* One end of the trip includes the traveler's residence.
**Neither end of the trip includes the traveler's residence.

Table 3.5. Modes Taken for Non-Work Trips: Home-End Respondents

Travel Mode	Percent of Non-Work Trips: Home-Based*	Non-Home-Based**	All Trips
Automobile	66.7%	54.5%	56.3%
Public Transit	33.3%	4.5%	8.7%
Walk	0.0%	40.9%	34.9%
Bike	0.0%	0.0%	0.0%
TOTAL	100.0%	100.0%	100.0%

Source: IURD Station Car Survey, 1994

* One end of the trip includes the traveler's residence.
**Neither end of the trip includes the traveler's residence.

The restricted range of the Kewet station car limits distance allowed for midday trips of around 15 to 20 miles.[36] Tables 3.6 and 3.7 show that the station car could easily serve most of the midday and extra-work trips of survey respondents. The most regularly taken trip, by those who take it, is for child care — 0.84 trips per day among employment site respondents, and 1.29 trips per day among home-end respondents.[37] Over half of employment site respondents also make work-related trips each day. These

[35]The relatively high level of automobile travel for non-home-based, non-work trips among home-end respondents could be skewed by the relatively small sample size for this subset of trips. Most of these midday automobile trips are probably taken as passengers or by using a company car.

[36]This assumes that 10 to 15 miles would be driven each day between rail stops and workplaces or residences, and 10 to 15 miles are reserved for emergencies. Netting this from the 35- to 40-mile range for a fully charged Kewet EV leaves around 20 to 25 miles for midday trip-making.

[37]Because most child-care trips are home-based (73 percent), they would probably be taken on the home side of a BART-station-car trip —i.e., between home and BART rather than between BART and work.

Table 3.6. Extra-Work Characteristics of Respondents' Trips: Employment Sites

Trip purpose	Trips: Average Trips Per Day* (#/day)	Trips: Average Distance Per Trip (miles)	Trips: Home-Based (%)	Trips: Non-Home-Based (%)	Respondents: Respondents Making at least One of Trip Type (%)	Respondents: Average Trip Distance/Day* (miles/day)
Grocery shopping	0.38	2.55	41%	59%	42%	1.08
Other shopping	0.37	2.62	16%	84%	31%	1.01
Child care	0.84	4.20	73%	27%	12%	3.64
Meals/restaurant	0.48	1.77	0%	100%	52%	1.03
Appointments (doctor, etc.)	0.24	5.41	89%	11%	11%	1.19
Recreational	0.30	6.60	53%	47%	8%	3.19
Bank services	0.57	1.05	6%	94%	36%	0.26
Other services	0.22	4.58	20%	80%	5%	1.38
Work-related	0.61	43.07	45%	55%	19%	26.29
Other	0.27	5.43	0%	100%	5%	1.52
TOTAL	1.10	7.39	22%	78%	87%	8.59
Total without work-related trips	0.96	2.40				2.77

Source: IURD Station Car Survey, 1994.

* Only for those who reported at least one of trip type.

Table 3.7. Extra-Work Characteristics of Respondents' Trips: Home-End BART Sites

Trip purpose	Trips: Average Trips Per Day* (#/day)	Trips: Average Distance Per Trip (miles)	Trips: Home-Based (%)	Trips: Non-Home-Based (%)	Respondents: Respondents Making at least One of Trip Type (%)	Respondents: Average Trip Distance/Day* (miles/day)
Grocery shopping	0.28	2.66	41%	59%	22%	0.72
Other shopping	0.20	6.67	35%	65%	22%	1.33
Child care	1.29	4.35	78%	22%	11%	5.92
Meals/restaurant	0.53	2.27	0%	100%	36%	1.29
Appointments (doctor, etc.)	0.21	3.14	0%	100%	13%	0.67
Recreational	0.48	3.33	0%	100%	11%	1.60
Bank services	0.23	2.25	0%	100%	16%	0.51
Other services	0.40	3.00	0%	100%	2%	1.20
Work-related	0.35	7.76	0%	100%	13%	2.72
Other	0.30	1.00	33%	67%	4%	0.40
TOTAL	0.94	5.68	27%	73%	67%	3.22
Total without work-related trips	0.98	3.22				3.09

Source: IURD Station Car Survey, 1994.

* Only for those who reported at least one of trip type.

two trip purposes are also among the most lengthy — on average, 4.2 miles for child care and 43 miles for work-related trips. Only the range needed for work-related trips clearly exceeds the station-car's capabilities. Only one in five of employment site respondents, however, made any work-related trips.

Moreover, a company car is often available for making relatively long midday work-related trips, so such travel might not always be a deterrent to station-car usage. None of the other extra-work trip purposes present distance obstacles to the station car. In fact, the average distance traveled by employment site respondents for midday trips (when omitting work-related trips) is 2.77 miles. Even if an entire week's extra-work trips were taken in a single day, the resulting average of 14 miles would easily be within the range of the Kewet station car.

3.3. Overall Evaluation of the Station-Car Concept

This section summarizes how participants rated the station car. While our research focuses on the market potential of station cars generically, since we used in-field tests to elicit survey responses it was difficult to get people to separate their views toward the station-car concept from how they felt about the specific test vehicle, the Kewet El-Jet. The responses presented in this section likely reflect attitudes toward both the test vehicle itself and the concept of an "all-electric" rail/station-car commute.

3.3.1. Three Best and Worst Features of the Kewet Station Car

When asked to list the best qualities of the Kewet station car, most people cited the environmental benefits of no air pollution and reduced fuel consumption (Table 3.8). Third on the list was the belief that the Kewet station car would help reduce traffic congestion, presumably because of its small size and because it would win over former motorists. Specific features of the vehicle itself, such as being "easy to drive" or "easy to park," were cited less frequently.

In contrast, when asked to identify characteristics of the station car that they liked least, respondents most often chose features that are specific to the Kewet or any other mini-EV. Liked least was the vehicle's limited range, followed by minimum top speed, inability to operate on freeways (closely related to "top speed"), and need for frequent recharging. These concerns underscore the challenge of initiating a new technology into peoples' everyday lives which is supposed to substitute for what has become the mobility standard of most Americans: the private automobile. In general, vehicles used to access transit stations do not need to go long distances or go fast, yet many expect high performance regardless of the vehicle's propulsion system. For those who cited "limited range" as a shortcoming of the Kewet station car, the average acceptable range of 97 miles is around twice as far as the vehicle can go before recharge. The average top speed acceptable to those who expressed reservations about the vehicle is 53 mph, a speed which would allow freeway driving.

The acceptable average range and speed differed considerably by gender: men generally demanded higher performance from the Kewet station car than women. For example, the average acceptable range

Table 3.8. Three Best and Three Worst Features of Station Car Cited by Survey Respondents

Station-Car (Kewet) Features	Percent Selected by Respondents at: Employment Sites*	Residential Sites**	All Sites
Cited as one of three best qualities			
No air pollution	30%	30%	30%
Less fuel and energy consumption	27%	28%	27%
Less traffic congestion	16%	12%	15%
Easy to drive	8%	7%	8%
Fun to drive	8%	8%	8%
Easy to park	6%	8%	6%
Other	5%	8%	6%
TOTAL	100%	100%	100%
Cited as one of three worst qualities			
Range	21%	23%	22%
average acceptable:	*93 miles*	*99 miles*	*95 miles*
Top speed	18%	19%	18%
average acceptable:	*52 mph*	*54 mph*	*53 mph*
No freeway driving	16%	15%	15%
Frequent recharging	14%	9%	13%
Safety	12%	14%	12%
Average speed	11%	14%	12%
average acceptable:	*44 mph*	*53 mph*	*47 mph*
Other	8%	6%	8%
TOTAL	100%	100%	100%

Source: IURD Station Car Survey, 1994.

*Survey for trips between a BART station and the respondent's work site.
**Survey for trips between a BART station and the respondent's residential neighborhood.

among women respondents was 66 miles, compared to 100 miles for men, and the average top speed acceptable to women was 48 mph, compared to 54 mph for men.[38]

3.3.2. Rating of Kewet Station-Car Features

In addition to listing the best and worst qualities, respondents also rated eleven features of the Kewet station car on a -3 to +3 scale. Table 3.9 is arranged so that those features given positive ratings most frequently are listed first. Participants responded very positively to the vehicle's maneuverability and visibility (both from the inside and outside). They also generally liked the vehicle's deceleration, and were fairly neutral in their rating of the car's acceleration, safety, vibration, and comfort level. Ratings were fairly evenly split, pro and con, in terms of the car's noise level and average speed. Negative ratings outnumbered positive ratings only with regard to the vehicle's top speed and range.

Responses were fairly similar for both work-end and home-end tests, with one exception. Those testing the Kewet as a home-end station car were more critical of the vehicle's range limitations. This

[38]Additionally, "ease of parking" was more highly valued by men (9 percent) than women (2 percent), whereas "easy or fun driving" was selected more often by women (21 percent) than men (11 percent).

Table 3.9. Ratings of Kewet Station Car: Employment vs. Residential Sites

Station-Car Features	Respondents' Reactions* Negative Employment (%)	Negative Residential (%)	Neutral Employment (%)	Neutral Residential (%)	Positive Employment (%)	Positive Residential (%)	Total Employment (%)	Total Residential (%)
Maneuverability	3	2	25	22	72	76	100	100
Visibility	4	0	22	33	74	67	100	100
Deceleration	2	2	49	56	49	42	100	100
Comfort level	10	14	42	48	48	38	100	100
Vibration	4	12	58	55	39	33	100	100
Noise level	25	32	44	42	31	27	100	100
Acceleration	17	12	53	67	30	21	100	100
Average Speed	16	22	60	56	24	22	100	100
Safety	17	20	62	68	21	13	100	100
Range	24	38	55	55	21	8	100	100
Top Speed	36	43	52	48	13	10	100	100

Source: IURD Station Car Survey, 1994.

*Respondents rated qualities on a scale from -3 to +3. Here, "negative" signifies a score of -3 or -2, "neutral" means a score from -1 to +1, and "positive" means a score of +2 or +3.

could reflect the preference of those testing the Kewet at the home-end to own a more versatile, general-purpose neighborhood vehicle.

3.4. Likelihood of Using Station Car

Weighing both the characteristics of their daily trips and their road experiences with the Kewet station car, respondents were also asked to indicate the likelihood they would lease a station car as part of a BART trip (on a -3 to +3 scale). Participants were also asked to rate the likelihood of using the station car for just one side versus both sides (home-end and work-end) of a BART trip.

Figure 3.1 shows that nearly one-half of respondents were very enthusiastic about using station cars for one end of their trips, giving the Kewet station car a +3 rating. Five times more people gave the Kewet station car a positive than a negative rating. The strongest enthusiasm for the single-end station car was by those testing the Kewet at the home-end (i.e., Lafayette and Fremont stations). This suggests that most people interested in driving a station car between their residences and a rail station would not be inclined to do so between their exit station and job sites. Around 40 percent of all respondents gave the station car a +3 rating as an access mode on both ends of a rail trip (Figure 3.2). The strongest support for the two-end station car was among those surveyed at their job sites. Far fewer survey respondents gave the station car a +3 rating as an access mode on *both* one end and two ends of a rail trip — just 21.9 percent.

For predictive purposes (see Section 3.4.3), those rating the likelihood as 2 or 3 were considered "likely" candidates for station cars.[39] Table 3.10 shows that, overall, two-thirds of participants were likely

[39]The initial version of the survey asked participants how many days a week they would use the station car. In these cases, responses of four or five days per week were considered to represent "likely" usage.

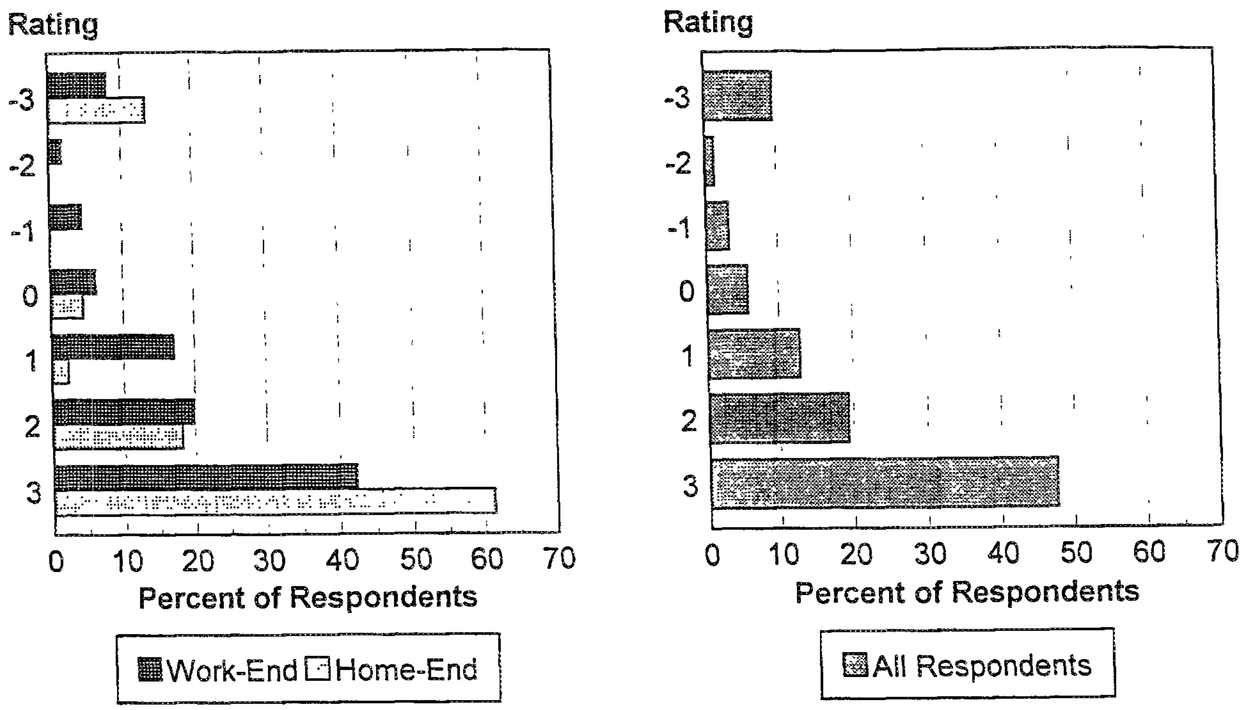


Figure 3.1. Ratings of Station Cars for One End of a Rail Commute

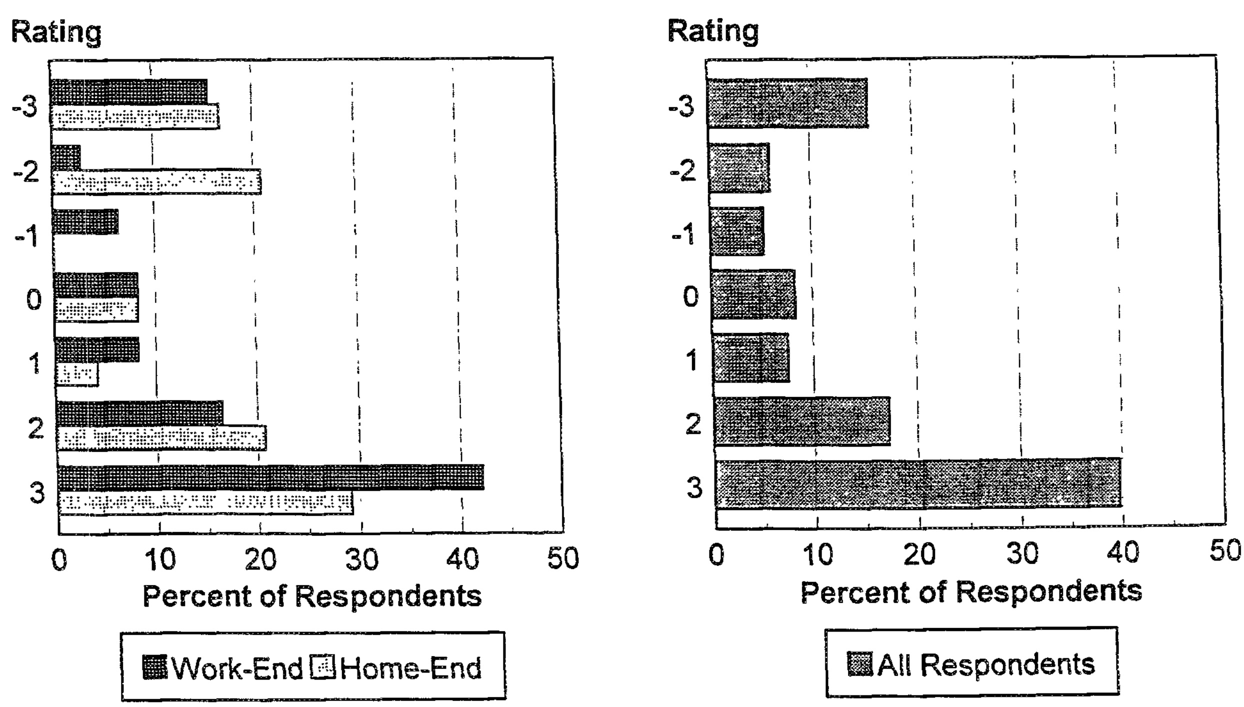


Figure 3.2. Ratings of Station Cars for Two Ends of a Rail Commute

Table 3.10. Likelihood of Using Station Car

	Respondents at: Employment Sites	Respondents at: Home-Station Sites	Total
All respondents answering question			
...who are likely to use the station car for one side of BART commute*, **	62%	80%	67%
...who are likely to use the station car for both sides of BART commute*	59%	50%	57%

Source: IURD Station Car Survey, 1994.

* Some respondents were asked to rate their likelihood of using the station car. Included here are respondents who, on a scale from -3 to 3, stated their likelihood was 2 or 3. Other respondents were asked how many days a week they would use the station car. Included here are those who responded 4 or 5 days a week.
**For employment sites, "one side" means the BART-to-work leg. For residential sites, "one side" means the BART-to-home leg.

station-car patrons. Around 60 percent of employment site respondents who test-drove the Kewet station car were receptive to using it for one side (the work end) or two sides of their commute. As noted, those testing the Kewet at the Lafayette and Fremont BART stations (as a home-end vehicle), however, were primarily interested in using it for only one side of their commute (the home side). This again reflects the fact that many of BART's present commuters work in downtown San Francisco and Oakland office buildings that are easily accessible by foot.

Overall, the degree of positive ratings was surprisingly high, but should be interpreted with caution. Some self-selection biases unavoidably influenced ratings. That is, those who were most likely attracted to or favorably predisposed toward the station-car concept probably agreed to participate in the study. The novelty of an electric vehicle and perhaps even the desire of the participants to appease the researchers also likely influenced ratings. The relative effects of such factors cannot be determined; however, it likely is the case that survey responses overstate the degree of public receptiveness toward the station-car concept.

3.4.1. Interest in Station Cars by Participant Characteristics

There was little association between respondents' overall rating of the Kewet station car and their gender, occupation, age, or race. Non-professionals were more interested in using station cars on both ends of a trip than those working in professional and technical fields — 70 percent of non-professionals gave the Kewet station car a +2 or +3 rating versus 50 percent of professionals.[40] Moreover, over one-quarter of professionals gave the station car a negative rating (-2 or -3) as an access mode on both ends of

[40]Some occupations rely heavily on ease of midday access and would likely show little interest in either transit commuting or station-car access. For instance, those working in business sales often need a high-performance vehicle to reach midday appointments throughout a region and would not be expected to show much enthusiasm for station cars. Because of the small sample size, our survey was not able to discern differences in ratings between specific occupations.

a rail trip, compared to just 6 percent of non-professionals. Ratings across occupational groups were nearly identical for single-end station-car services.

The only notable difference in station-car ratings between men and women was for single-end access. Three-quarters of women gave the Kewet station car a +2 or +3 rating as an access mode from home to a BART station, compared to 64 percent of men. In terms of race of the respondents, ratings were virtually identical between whites and non-whites. Ratings were likewise very similar by respondent age.

3.4.2. Interest in Station Car by Travel Distance

In this study, a distance between 0.5 and 4.0 miles from a rail station is considered feasible for station-car use. Thus, the station-car "shed" is donut-shaped. For many, a distance up to one-half a mile from a station, represented by the hole of the donut, would be just as easy to walk as to transfer to and drive an EV. A distance beyond four miles, on the other hand, might become cumbersome without freeway access or be viewed as too far for a limited-performance vehicle.

Among those surveyed at employment sites, if their workplace was within a station-car shed, around 60 percent were "likely" candidates for station-car services, either for one or two ends (Table 3.11). Only 4 percent of this group, however, live close enough to a BART station (< 0.5 miles) to walk. Over half live in the 0.5- to 4.0-mile ring of a BART station. This leg of the BART commute could be accommodated by a station car or some motorized mode, be it automobile or bus.

Table 3.11 also reveals that "home-end" respondents living within the station-car shed of the Lafayette and Fremont stations were even more receptive to using station cars, though overwhelming for just one side of the BART access trip. This reflects the fact that four out of five of these respondents work within walking distance of a BART station and therefore would have little use for an EV at the work-end. For home-end station-car users, the target population is likely suburbanites working downtown who currently access park-and-ride lots with ICE vehicles.

3.4.3. Predictive Model of Likelihood of Station-Car Use

Discrete choice models were estimated in order to identify those factors most strongly associated with respondents giving the Kewet station car a high "likelihood of using" rating.[41] Table 3.12 presents a binomial logit model that estimates the probability of workers using a station car for access between their job sites and a rail station — wherein likelihood is defined, as before, by an overall rating of +2 or +3. The likelihood rises if a person's work site lies within the 0.5- to 4.0-mile range of a station and he or she is sensitive to levels of comfort and convenience (reflected by ratings of the Kewet in terms of driver

[41]A rating of +2 or +3 was used to signify the respondent would likely patronize station cars. For modeling purposes, these values were recoded to 1. All other ratings assigned by respondents were treated as low marks, signifying unlikely participation in a station-car program.

Table 3.11. Likelihood of Using Station Car and Distance from BART Station

Characteristics	Respondents at: Employment Sites	Respondents at: Home-End Stations	Total
Those who work from .5 to 4.0 mi. from BART	92%***	24%***	80%***
...and are likely to use the station car for one side of BART commute*, **	63%	100%	65%
...and are likely to use the station car for both sides of BART commute*	59%	33%	58%
...and live .5 mi. or less from BART	4%	0%	4%
...and live from .5 to 4 mi. from BART	57%	83%	58%
Those who live from .5 to 4.0 mi. from BART	56%*	47%*	53%*
...and are likely to use the station car for one side of BART commute*, **	60%	81%	68%
...and are likely to use the station car for both sides of BART commute*	58%	50%	58%
...and work .5 mi. or less from BART	0%	64%	9%
...and work from .5 to 4 mi. from BART	93%	24%	87%

Source: IURD Station Car Survey, 1994.

* Some respondents were asked to rate their likelihood of using the station car. Included here are respondents who, on a scale from -3 to 3, stated their likelihood was 2 or 3. Other respondents were asked how many days a week they would use the station car. Included here are those who responded 4 or 5 days a week.
** For employment sites, "one side" means the BART-to-work leg. For residential sites, "one side" means the BART-to-home leg.
***These percentages are of all valid cases. Percentages below in this section are of valid cases in this geographic category only.

Table 3.12. Binomial Logit Model for Predicting the Likelihood of Station-Car Use

Model	Variable	β coefficient	Significance	Overall % Correct	ρ2
Work-End Model	BART-Work distance .5 to 3.5 miles	0.87	0.04	66.4%	0.12*
	Driver Comfort (-3 to +3 scale)	0.39	0.01		
	Noise Level (-3 to +3 scale)	0.36	0.01		
	Vibration (-3 to +3 scale)	0.26	0.17		
	Drive Alone (0=No, 1=Yes)	-0.57	0.29		
	Constant	-0.34	0.55		
Home-End Model	Manager/Specialty Occupation (0=No, 1=Yes)	-1.91	0.07	77.5%	0.33**
	Range (-3 to +3 scale)	0.57	0.10		
	Midday recreation trip (0=No, 1=Yes)	2.85	0.03		
	Constant	-0.05	0.94		

Source: IURD Station Car Survey.

* Chi-square = 18.715, probability = .0022.
**Chi-square = 15.580, probability = .0014.

comfort, noise levels, and vibration). Presently driving alone to work reduces the likelihood of patronizing station cars.

Among the participants testing the Kewet at the home end, Table 3.12 shows that the probability for using station cars declines for those in management and specialty occupations, and increases among those making more midday recreational trips and who are most sensitive to the vehicle's limited operating range. This model correctly predicted how over three-quarters of the home-end respondents rated their likelihood of participation.

Overall, factors like travel distance, occupations, and perceptions of vehicle performance are most strongly correlated with peoples' likelihood of patronizing station cars. To the degree trip-ends are within an easy operating range of station cars and vehicle performance can be maintained or improved, these results would appear to bode favorably for the future of station cars.

3.5. Willingness to Pay for Station-Car Services

After the test drives were completed, respondents were asked how much they would be willing to pay for their entire commute if they could take BART and use the station car on either one or two ends of the BART commute. Table 3.13 shows, on average, respondents were willing to pay $5.22 per day for a combined BART fare and station-car services on one end. For access to station cars on both ends of rail trips, respondents were willing to pay $1.50 more — or $6.74 in total. Willingness to pay was fairly similar regardless if a respondent was testing the vehicle on the work-end or home-end.

Table 3.13. Results on Willingness to Pay for Round-Trip BART/Station-Car "Package"

	Respondents at:		
	Employment Sites	Home-End Stations	All Sites
Station Car on One End			
Percent of Respondents Willing to Pay:			
...$3.00 or less	29%	34%	31%
...$3.01 to $5.00	36%	27%	33%
...more than $5.00	35%	39%	36%
TOTAL	100%	100%	100%
Mean amount willing to pay	**$5.32**	**$4.96**	**$5.22**
Station Car on Both Ends			
Percent of Respondents Willing to Pay:			
...$3.00 or less	13%	25%	16%
...$3.01 to $5.00	32%	10%	28%
...more than $5.00	55%	65%	57%
TOTAL	100%	100%	100%
Mean amount willing to pay	**$6.76**	**$6.62**	**$6.74**

Source: IURD Station Car Survey, 1994

To estimate how much each respondent valued the station car itself monetarily, we netted out the cost of a round-trip BART fare, based on the person's stations of origin and destination, from the person's willingness-to-pay for the BART/station-car package.[42] Table 3.14 shows the resulting esti-

[42]Respondents recorded the intersection to which they reside closest. From this information, we were able to assign each respondent to both origin and destination BART stations for their combined BART/station-car trip. Since BART applies distance-based fares, we were able to calculate a total two-way fare if each respondent had commuted by BART.

Table 3.14. Difference Between Respondents' Willingness to Pay for Round-Trip Station-Car/BART "Package" and Round-Trip BART Fare

Difference*	Respondents at: Employment Sites	Home-End Stations	All Sites
Station Car on One End**			
Percent Respondents with Difference of:			
...less than $0/day	20%	43%	26%
...$0 to $1/day	19%	13%	17%
...more than $1 day	61%	43%	57%
TOTAL	100%	100%	100%
Average Difference	$2.00	$1.12	$1.78
Station Car on Both Ends			
Percent Respondents with Difference of:			
...less than $0/day	8%	22%	10%
...$0 to $1/day	18%	0%	15%
...more than $1 day	74%	78%	75%
TOTAL	100%	100%	100%
Average Difference	$3.30	$2.90	$3.25

Source: IURD Station Car Survey, 1994.

* Difference = Amount willing to pay for round-trip "package" minus round-trip BART fare.
**For employment sites this means station cars on the employment end of BART commute only. For residential sites this means station cars on the residential side of BART commute only.

mates of willingess-to-pay for station cars on one and both ends of rail trips. Respondents from employment sites were generally willing to pay more for station cars — on average, $2.00 per day for one-end and $3.30 for both-end services. Among those field-testing the station car on the home-end, 43 percent seem inclined to use a station car between their homes and stations only if it was free (i.e., cost $0 per day, or less). If people were able to forego owning a second or third car as a result of leasing station cars, some might very well be willing to pay more than what they indicated in the survey.

Another way to discern whether station cars might generate sufficient revenues is to compare what people currently pay for their commute versus what they are willing to pay for the BART/station-car package. People estimated their daily costs of commuting subjectively, and, from the responses, appeared to understate the true cost of car commuting.[43] Table 3.15 shows that the average estimated daily cost for commuting was $4.61 among all respondents.[44] Taking the difference between what respon-

[43]The 1993 estimated cost per mile of a new American-made compact car, amortized over five years, is around $0.42 per mile. These are unpublished rates used by national rental car agencies. With the 1993 average round-trip commute distance of 29 miles for Bay Area residents, this yields a daily commute cost estimate of $12.18. This suggests repondents were underestimating their personal commuting costs by at least a factor of two. Of course, these estimates do not reflect full social costs, which could be much higher.

[44]Respondents were asked three questions on the cost of their round trip commute. First, they were asked how they usually pay for their commute. The responses given were estimated based on whatever respondents thought appropriate, which is often the visible, out-of-pocket expenditures, like cost of gasoline and tolls, and very seldom factored in vehicle depreciation costs. Some of the fixed cost of vehicle ownership are likely perceived as "subscription fees" that most people pay to fully participate in American society. Regardless, it was clear from the responses that people did not consider full costs of owning and operating a vehicle.

dents were willing to pay for the BART/station-car package and what they estimated their current commuting expenses to be resulted in the estimates shown in Table 3.16. In general, the combined package would add to their current "perceived" commuting bill just $0.65 for using station cars on one end, and around $2 for both ends. Among those testing the home-end station car, around one-third currently pay more for commuting than what they would be willing to pay for the BART/station-car package.

Table 3.15. What Respondents Estimate They Currently Pay for Round-Trip Commute

	Respondents at:		
Amount	Employment Sites	Home-End Stations	All Sites
Estimated current commute cost*			
$3.00 or less	39%	45%	41%
$3.01 to $5.00	34%	12%	28%
more than $5.00	27%	43%	31%
TOTAL	100%	100%	100%
Mean amount estimated	**$4.62**	**$4.60**	**$4.61**

Source: IURD Station Car Survey, 1994.

*Estimated by respondents.

Table 3.16. Difference Between Respondents' Willingness to Pay for Round-Trip Station Car/BART "Package" and Estimated Current Round-Trip Commute Cost

	Respondents at:		
Difference*	Employment Sites	Home-End Stations	All Sites
Station Car on One End**			
Percent Respondents with Difference of:			
...less than $0/day	26%	34%	28%
...$0 to $1/day	38%	23%	34%
...more than $1 day	36%	43%	38%
TOTAL	100%	100%	100%
Average Difference	**$0.69**	**$0.55**	**$0.65**
Station Car on Both Ends			
Percent Respondents with Difference of:			
...less than $0/day	16%	18%	16%
...$0 to $1/day	22%	13%	20%
...more than $1 day	63%	69%	64%
TOTAL	100%	99%	100%
Average Difference	**$2.09**	**$2.05**	**$2.08**

Source: IURD Station Car Survey, 1994.

* Difference = Amount willing to pay for "package" minus estimated current commute cost.
**For employment sites this means station car on the employment end of BART commute only. For residential sites this means station car on the residential side of BART commute only.

Based on these willingness-to-pay estimates, it is doubtful that a station-car program using a mini-EV similar to the Kewet would be financially self-supporting. As noted, the Kewet El-Jet costs around $16,000 new. Assume that maintenance, insurance, battery replacement, and administration would add

50 percent, or $8,000, to the cost of a vehicle over an assumed service life of five years. Amortizing the $16,000 cost over five years at an 8 percent interest rate, and pro-rating all additional costs over five years, yields an average annual cost of $5,600.[45] Assuming each vehicle is used an average of five days a week over an entire year, or 260 days in total, results in a daily estimated cost of over $21. This is around ten times more than the estimated average amount study participants were willing to pay. It is also more than four times higher than what participants estimate their current daily commute costs to be.

Clearly, in order to be financially viable, a station-car program will require substantial subsidies at the outset. Quite simply, this enterprise must be treated as a fledgling infant industry that needs an injection of public support if it is ever to achieve sufficient economies of scale. As noted in Chapter One, a Kewet-type station car could probably be mass-produced at a cost as low as $5,000 (in 1993 dollars). Making the same assumptions on maintenance and overhead costs (50 percent of purchase price), service life (five years), and interest rate (8 percent), the annualized cost of a mass-produced station car could be as low as around $1,750. Under this scenario, a station-car program would be able to recover costs at a daily lease rate of around $6.75. If the station cars could be leased during weekends under a car co-op arrangement (allowing annualized costs to be spread over more days), daily lease rates could be as low as $5.00.[46]

3.6. Travel Time Differential

Besides monetary costs, whether people might opt for rail/station-car travel over drive-alone commuting also likely depends on expected differences in travel times. We were able to estimate whether the BART/station-car "package" would generally increase the travel time of the survey respondents, and if so, by how much. In the questionnaire, we asked participants to record the amount of time their current commute takes, round-trip. Based on information on where participants live, we were able to estimate how long their existing commute would take if they used a BART/station-car combination on both ends.[47] The difference between the two values revealed the time savings or loss that participants would experience if they switched to an all-electric BART/station-car commute.

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[45]The capital costs were amortized using a capital recovery factor at an 8 percent interest rate over five years. The estimated ongoing maintenance, insurance, and administrative costs of $8,000 per vehicle was pro-rated at $1,600 per year.

[46]This estimate is based on the assumption of 360 daily leases each year. This higher intensity of leasing could raise maintenance costs and reduce the useful service life of the vehicle.

[47]First, we identified the BART stations closest to each person's place of residence and place of employment. The average peak-period travel times from the two stations were estimated using BART's current timetables. Road distances were then measured between each person's residence and the nearest BART station, as well as between their workplace and the nearest BART station. We assumed that every mile of station access would take three minutes. If respondents lived or worked less than a half mile from a BART station, a flat five minutes was used as the estimated access time for reaching the station by foot. A five-minute average wait and transfer time was also added to the time of a BART/station-car trip. The projected times for the participants of the home-end survey should be interpreted with caution because of the small number of participants surveyed at the Lafayette and Fremont stations.

Table 3.17 shows that switching over to the BART/station-car combination would, on average, add nearly ten minutes to participants' commutes. Among the 163 study participants, the BART/station-car commute would take an average of about 55 minutes each way, compared to the participants' average of around 40 minutes.[48] We note that the participants already average fairly long commutes, given that the average 1990 one-way commute time for residents of Alameda and Contra Costa counties was 27.2 minutes (Metropolitan Transportation Commission, 1992).

Table 3.17. Comparison Between Current One-Way Commute Time and Projected One-Way BART/Station-Car "Package" Time

	Time for One-Way Commute			
Sample	BART + Station Car (Projected*) (minutes)	Current Commute Time (Respondents' Estimates) (minutes)	Paired Difference of Means** (minutes)	Average Commute for Census place (1990) (minutes)
All Respondents	55.2	40.5	-12.6	...
Employment Sites	54.2	35.5	-14.3	...
Home-End Stations	58.3	49.3	-9.3	...
Lafayette	56.9	47.7	-9.7	27.7
Fremont	63.7	51.6	-6.0	27.5

Source: IURD Station Car Survey, 1994, and 1990 US Census.

* Time was estimated by adding: (1) BART trip time between stations closest to home and work sites; (2) three minutes for every mile respondent either worked or lived from BART for BART access, however, if respondent lived or worked less than a half mile from a BART station, a flat five minutes was added to account for the likelihood respondent would walk this shorter distance; and (3) three minutes' transfer time from station car to BART train.
**Current commute time - "Package" commute time.

The biggest increase in travel from switching to a combined BART/station-car commute would be experienced among those who tested the station car at the work end. This reflects the likelihood that riding BART and leasing station cars would add the most time to those working in the suburbs. While this added time might at first glance be expected to dissuade many from making an all-electric commute, the perceived cost of commuting longer might be offset by an increase in "quality" or more productively used time. When seated in a rail car, it is possible to read, work, and even take a short nap, as opposed to spending one's commute time concentrating on driving. Perhaps those perceiving the benefits of having more time freed up to read or relax would be suburban workers who are reverse commuting in less crowded conditions.[49]

[48]Thus, the group mean difference was around 11 minutes. However, the average of paired differences was 9.4 minutes.

[49]Whether the availability of more time for reading or other more productive activities is a benefit is, of course, highly subjective. It would likely only be perceived as a benefit if people are able to get a seat, which is usually not the case for those boarding a BART train at most intermediate stations and heading toward downtown San

3.7. Summary

Overall, the survey results reveal a general receptiveness to the station-car concept and Kewet vehicle. Around two-thirds of the study participants expressed a strong interest in using a station car on at least one end of their commute. People liked the Kewet's maneuverability and visibility and generally liked the station-car concept for the contributions it would take toward improving air quality and conserving fuels. The most disliked feature of the Kewet EV was its limited top speed (40 mph) and operating range (about 40 miles). This was despite the fact that for nearly all access trips to and from stations, a limited performance EV would adequately accommodate travel needs. This includes those related to midday and extra-work travel. Based on survey results, the Kewet EV would be able to serve virtually all trips made from one's workplace during the midday and after work. Only in the case of work-related midday trips were average distances traveled beyond the operating range of a Kewet EV. However, since a company car is often available for long work-related trips, this would likely not be a serious deterrent to using a station car.

We estimate that participants would be willing to spend around $2 per day to lease a station car for one end of an access trip, in addition to their BART fare. This averages out to around $0.65 less than what they currently pay, or at least perceive they pay, for gasoline, tolls, parking, and other out-of-pocket expenses. This amount is substantially below what the actual costs would be of providing and maintaining a station car, meaning a station-car program would require substantial subsidies, at least initially. Under a scenario where station cars were mass-produced in sufficient numbers to drive the purchase price down to around $5,000, the daily cost of a station-car lease could be as low as $6.75. If people were able to forego owning a second or third car as a result of using the BART/station-car combination, some might very well be willing to pay more than they indicated. An all-electric commute would likely add to peoples' commute times, especially those working in the suburbs — on average, around 30 minutes per day. However, the perceived added time commuting would likely be partly offset by the freeing of time to read or relax while riding BART, especially for suburban workers riding BART in the reverse-commute direction when trains are less crowded.

Francisco during the peak period. However, those using BART to reach suburban job sites would likely be mainly reverse-commuting, and in most cases would be able to find a seat. Thus, the ability to enjoy more quality or productive time would likely accrue the most to those who would likely experience the greatest increase in commute time from switching to the BART/station-car combination — suburban workers.

Chapter Four

Estimate of the Market Demand for Station Cars on the Bay Area Rapid Transit System

4.1. Introduction

This chapter combines empirical commuting data with the survey results presented in Chapter Three to estimate the overall market demand for combined BART/station-car commuting. Estimates are also broken down by trips that would be converted from drive-alone commutes and other modes. This breakdown provides insights into the possible air quality benefits of station cars. For the most part, air quality benefits would accrue to the degree that station-car patrons are former drive-alone ICE commuters or BART park-and-riders.[50]

Market demand estimates are limited to station-car work trips associated with BART travel. While station cars would no doubt be leased for other purposes, we believe its greatest market potential lies with work trips for several reasons. One, an all-electric commute would be easiest to make during peak periods because rail services are more frequent during those hours. Second, the rail/station-car combination would find it difficult to compete with the private automobile for other trip purposes, like shopping. In general, lower levels of congestion during non-commute hours and the availability of free parking at non-work destinations make it tough for any other mode to compete with the private automobile for any trips beyond walking distance. Third, we expect that some large employers who are required under clean air mandates to initiate alternative transportation programs would be willing to help support a station-car program. This might take the form of providing workers a transit voucher that could be used to lease a station car in lieu of free parking. For all of these reasons, we feel that the greatest market demand for station cars would be, by far, for journeys to work.

Three key steps went into deriving market demand estimates for station-car trips on the BART system. First, criteria were established for determining whether an existing commute would be a candidate for being converted to a combined BART/station-car commute. Second, these criteria are applied to journey-to-work data obtained from the 1990 Bay Area Travel Survey (BATS), and generalized to derive an initial estimate of candidate trips. Last, these candidate trips are adjusted based on the findings, summarized in Chapter Three, on the share of those test-driving the Kewet station car who expressed a strong willingness to patronize station cars. The reliance on stated preference data unavoidably adds a

[50]The air quality benefits of converting trips from carpools, vanpools, and buses would be lowered to the degree that people previously commuted in high occupancy vehicles. The conversion of BART trips that previously involved park-and-ride to station-car-and-ride trips would yield air quality benefits to the degree that people drove alone to rail stations. This benefit would be roughly equivalent to substituting for solo-commute trips.

subjective dimension to these estimates. The absence of an existing station-car market from which to gauge demand leaves little other choice. Still, we believe the numbers presented provide a reasonable order of magnitude estimate that should be useful in planning for an eventual full-scale implementation of a regional station-car program.

4.2. Criteria for Estimating Candidates Trips for BART/Station-Car Commuting

As discussed in Chapter Two, BATS contains 1990 travel diary data for all members over six years of age for 10,900 randomly sampled households in the San Francisco Bay Area. For purposes of identifying commute trips with origin-destination patterns and other characteristics that are seemingly well-suited to BART/station-car travel, the following four criteria were used.

> *Location.* A work trip was excluded as a candidate for station cars if either its origin or destination is in San Francisco. San Francisco is an unlikely candidate for station-car trip-making for two related reasons. One, none of the downtown stations and only one other station in the city has any on-site parking.[51] Second, because the city is so compact, most residents and workers can easily reach stations by foot or a mix of available feeder services, including trolley bus, motor bus, light-rail transit, streetcars, cable cars, and even jitneys.[52] It is in large part because of the city's built form and excellent array of feeder services that hardly any San Francisco BART stations have parking lots.
>
> *Spatial Relationship of Trip Ends to BART stations.* The station-car shed was defined as a distance of 0.5 to 4 miles from each of the 25 non-San Francisco BART stations. Two circles of radii 0.5 and 4 miles were drawn around each of these stations. A trip end was considered to be in the station-car shed, or "donut," if it was located in the area between the two circles. A trip end was considered to be outside the shed if it was inside the inner circle (the "donut hole") or outside the outer circle. To be considered a candidate station-car trip, each trip must have met one of three spatial criteria: (a) both the origin (home-end) and destination (work-end) were in a "donut"; (b) the home-end is in a "hole" and the work-end is in a "donut"; and (c) the home-end is in a "donut" and the work end is in a "hole." The "donut" and "hole" distinctions are made for two reasons. One, it is unlikely that a commuter who lives or works within a 0.5-mile radius of a BART station would need any mechanized transportation to access a station and would instead walk. Two, the likelihood of a commuter who lives or workers more than four miles from a BART station would use a station car is thought to be low, because the time spent making intermediate or longer-distance trips in a mini-EV becomes relatively long and such distances are often difficult to travel on suburban surface streets alone (since mini-EVs are banned from freeways).[53]

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[51]The only station in San Francisco with parking facilities is Glen Park, which only has 55 parking stalls. Daly City, the existing western terminus of the BART system, has 2,228 parking spaces; however, because it lies in a rolling terrain, is relatively isolated from other cities to the south and is well-served by feeder services from the San Francisco Municipal Railway (Muni) and San Mateo County Transportation Agency (SamTrans), it is not considered a good candidate for station-car trip-making.

[52]A jitney currently operates along Mission Street between downtown and the city's Mission district (largely an Hispanic community). In the early 1980s, 15 jitney operators plied their trade along Mission Street, however today only one operator remains.

[53]One-way distances of upwards of 20 miles are within the operating range of mini-EVs like the Kewet, so some station-car access trips would no doubt be from origins and to destinations beyond four miles of a rail station. We believe these would constitute a relatively small share of station-car trips, however.

Parking Facilities. Station cars would be parked and potentially recharged at BART parking lots, and cars used for work-end access would likely be stored overnight at stations. Thus, the use of a station car implies access to only BART stations with parking. Specifically, for case (a) above, both the home-end and work-end BART stations must have parking. For cases (b) and (c), the BART station serving the trip-end that lies within the "donut" must have parking. (It is irrelevant whether the BART station serving the trip beginning or ending in the "hole" has parking, since commuters will likely access it by foot or bicycle.)

Minimum Distance. A combined BART/station-car trip would likely be made only relatively long distances where the BART leg is the biggest portion of the trip. The effort of leasing station cars and transferring to and from BART stations would likely only be perceived to be worthwhile for commutes that are at least as long as the regional average, estimated by RIDES (1994) to be around 14.4 miles in 1993. To be a station-car candidate, a commute would have to traverse at least three BART stations, not including the origin and destination stations. For commutes to or from suburban stations, this would generally produce trips that exceed 10 miles.[54] If there are five consecutive stations A, B, C, D, and E, then a trip from home station A to work station E would meet this criterion, but a trip from home station A to work station D would not.

4.3. Initial Estimates of Candidate Station-Car Work Trips

If a trip recorded in the 1990 BATS database met all four criteria, it was considered a potential all-electric commute. Weights developed by the Metropolitan Transportation Commission were then used to expand sample trips to total daily regional trips. Applying these weights yielded an estimate of total daily trips that were candidates for BART/station-car commutes.

In total, around 200,000 daily work trips are made in the BART-served region that meet all four criteria, and thus are considered candidates for combined BART/station-car commuting. Around 60 percent of the candidate trips would have both an origin and destination within the station-car shed of both home-end and work-end BART stations — what we call a "donut-to-donut" station-car trip. For these trips, station cars could be used for both home-end access (to a station) and work-end egress (to a workplace) — that is, both ends of the commute trip.[55] The next largest market share, involving around 34 percent of the candidate trips, would be by those using the station car on the home-end only — what we call a "donut-to-hole" station-car trip. Here, people would drive the station car from their homes to a rail station, but because their workplaces lie within the "donut hole" around a station, would generally reach their job sites by foot. The remaining 6 percent of candidate trips would involve station-car use at

[54]Station spacing along BART's suburban corridors is generally two to four miles. For a reverse-commute by BART, for instance, the distance from an origin (which could be in a more urbanized area where station spacings are sometimes less than a mile) to a suburban destination that is four stations away would in many cases be around ten miles. From the Ashby Station in Berkeley to the Lafayette station, for instance, would cover a distance of around 10 miles (covering short distances from the Ashby-Mac Arthur-Rockridge stations, and long distances from the Rockridge-Orinda-Lafayette stations). Adding several miles for station-car access at at least one end of the trip would produce a trip distance comparable to the regional average.

[55]Under the most ambitious scenario, people could drive a station car from their homes to the nearest rail station. At their exit station, they could then obtain a different station car to reach their workplaces. For such a program to work, balanced flows would be necessary —i.e., the number of station-car users entering and exiting a station each morning or afternoon would need to be fairly similar.

the work-end only — a "hole-to-donut" station-car trip. For this submarket, their homes are generally close enough to rail stations that they would generally walk to reach a station at the home end. Tables C.1 to C.4 in Appendix C present matrices to show the number of candidate station-car trips at the origin and destination BART stations, broken down by these three spatial submarkets — donut-to-donut, donut-to-hole, and hole-to- donut, as well as for the three combined.

Pooling the total number of home-end and work-end trips made to and from each station produced estimates of the total number of candidate station-car trips at each station, shown in Table 4.1.

Table 4.1. Number of Station-Car Trips per Day: Access to Home Stations, Egress from Work Stations, and Total Trips

BART Name	Home Station Access Trips	Work Station Egress Trips	Total Trips
Fruitvale	10,384	4,825	30,417
Lake Merritt	6,495	7,832	28,653
Macarthur	5,663	7,780	26,885
Rockridge	8,694	3,463	24,313
Coliseum	7,350	4,552	23,805
Richmond	8,003	2,650	21,307
Concord	7,210	3,122	20,664
San Leandro	4,562	5,135	19,393
Fremont	7,076	2,464	19,080
Ashby	4,369	4,903	18,544
Walnut Creek	7,916	1,339	18,510
Hayward	7,231	1,720	17,901
Daly City	7,493	1,278	17,542
North Berkeley	3,788	4,945	17,465
El Cerrito del Norte	5,861	1,797	15,315
Pleasant Hill	4,938	2,249	14,374
Bayfair	5,806	844	13,302
South Hayward	3,891	2,151	12,084
West Oakland	289	5,598	11,773
El Cerrito Plaza	3,234	1,087	8,642
Union City	3,557	693	8,499
Lafayette	3,801	373	8,350
Orinda	1,333	249	3,164
Berkeley	0	0	0
19th St.	0	0	0
12th St.	0	0	0
Embarcadero	0	0	0
Montgomery	0	0	0
Powell St.	0	0	0
Civic Center	0	0	0
16th & Mission	0	0	0
24th & Mission	0	0	0
Glen Park	0	0	0
Balboa	0	0	0
TOTAL	128,942	71,049	199,991

The table, sorted by total number of candidate trips, shows that the Fruitvale BART station has the potential to be the busiest BART station for total station-car trips. Most of the station-car use would be in the form of people using station cars to access the Fruitvale station from their homes. Oakland's Lake Merritt station has the highest number of candidate work-end station-car trips. BART stations with fairly good balance of candidate home-end and work-end station-car trips are Lake Merritt, San Leandro, and Ashby. These three stations, in particular, would appear to have a good enough directional balance of usage that there would be relatively few station cars parked at these stations for any length of time. Instead, they would tend to be parked at peoples' residences overnight and their workplaces during the day.

The origin/destination patterns of candidate station-car trips were also analyzed across six classes of BART stations. The six classes are:

Terminal/Near Terminal: Richmond, El Cerrito del Norte, Fremont, Concord, Pleasant Hill, Daly City
Non-Terminal Suburban: Fruitvale, Coliseum, San Leandro, Bayfair, Hayward, South Hayward, Union City, Walnut Creek, Lafayette, Orinda
East Bay Urban: El Cerrito, North Berkeley, Ashby, MacArthur, Lake Merritt, Rockridge, West Oakland
San Francisco Intermediate: Mission-16th, Mission-24th, Glen Park, Balboa
Oakland/Berkeley CBD: Berkeley, Oakland-12th, Oakland-19th
SF CBD: Embarcadero, Montgomery, Powell Stret, Civic Center

In general, these six classes represent different levels of urbanization, geographic location, and park-and-ride facilities. The terminal/near-terminal stations tend to be the most suburbanized, be the farthest from the metropolitan core, and have the most parking spots.[56] Stations near downtown San Francisco, at the other extreme, have by far the densest surrounding land uses and no special BART parking.

Figure 4.1 shows the distribution of candidate station-car trips between these six classes of stations. The figure shows that the East Bay Urban stations will, by far, generate the most home-end station-car trips. The stations that would likely receive the most station-car activity at the work end are the non-terminal suburban ones. The single largest geographic submarket of candidate station-car trips are from East Bay Urban stations to Non-Terminal Suburban stations — accounting for around 44,000 candidate station-car trips. (These would consist of station-car trips made at either or both ends. A station-car trip, for instance, might be made from one's home to the Ashby station, followed by a bus trip from the Hayward station to one's work place; in Figure 4.1, this trip would be treated as one of the 44,000 East Bay Urban home-end to Non-Terminal Suburban work-end trips.) These geographic profiles of candidate station-car trips are also broken down in Figures D.1 to D.3 in Appendix D for the three submarkets: donut-to-donut, donut-to-hole, and hole-to-donut.

4.4. Adjusted Estimate of Station-Car Trips

The "candidate" trips identified above are based on meeting four criteria. These criteria, however, do not weigh the degree to which these candidates are likely to: (1) patronize rail transit to get to

[56]The distinction of near-terminal is made because the terminal stations do not in all cases have the most parking spaces for any single corridor. Along the Richmond line, for instance, the second-to-last station on the line, El Cerrito del Norte, has more parking spaces (2,516) than Richmond, the terminal station with 796 spaces.

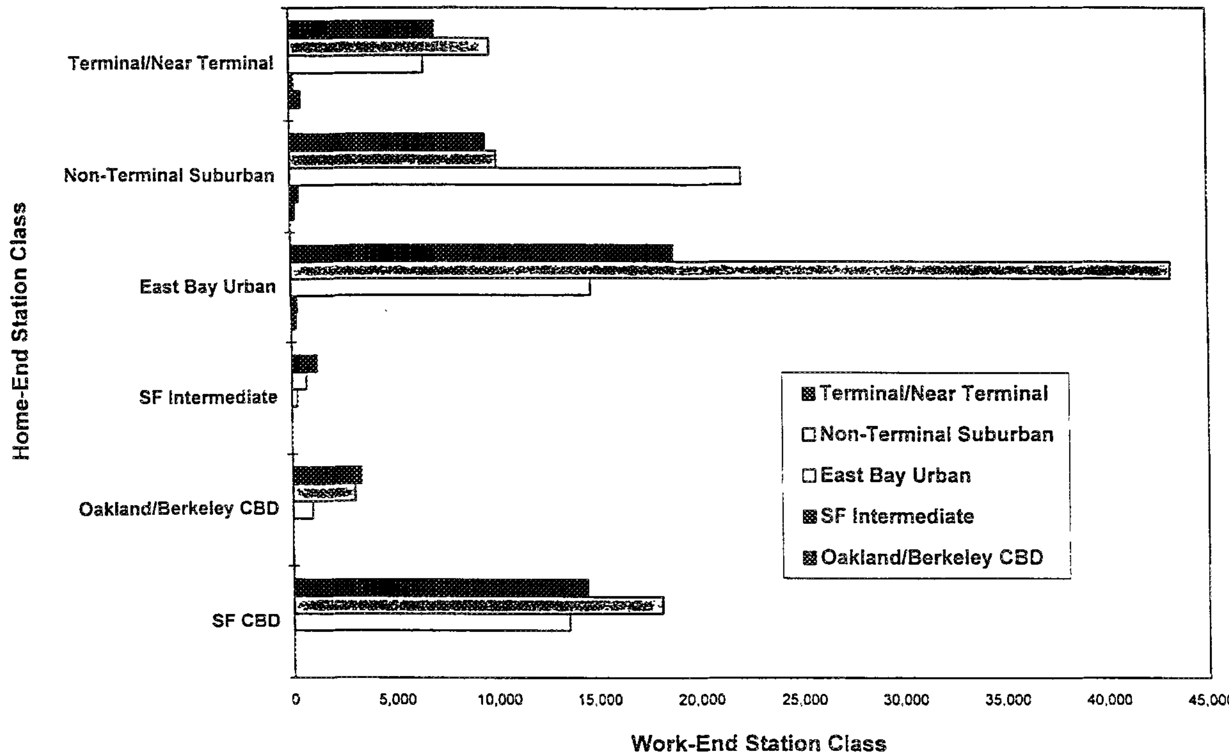


Figure 4.1. Distribution of Station-Car Trips Between Station Classes, Home-End to Work-End Stations

work; and (2) if they do commute rail, whether they like a Kewet-type station car sufficiently to patronize it. The adjusted estimate of station-car trips weighs in these factors. A simple formula used for estimating the market demand for station-car round trips in the BART-served area is:

Daily Station-Car Round Trips = A x B x C,
where:
A = Candidate station-car trips
B = Percent commutes by rail for all commutes with an origin or destination within a station-car shed
C = Percent of respondents expressing a very strong interest in patronizing station cars

These are round-trips, in the sense that they represent a lease made by one person, such as for using a station car from an exit-BART station to their workplace and back to the station again.

The simple three-factor equation combines: (1) the candidate trips estimated by the four criteria; (2) existing rail modal splits for work trips that lie within a station-car shed, as defined; and (3) the willingness to patronize station cars based on the survey evaluations (from Chapter Three). While this formula is simple, it likely errs on the conservative side (of showing less market demand than might actually exist). This is because existing rail modal splits are based on the existing quality of access modes to predominantly suburban BART stations. If station cars were to become popular, rail commuting would likely increase as a result, upping the share of future trips in the marketshed likely to be made by station cars. Also, in calculating "willingess," people were considered only likely to patronize station cars if they rated them as a "+3" on a -3 to +3 scale. That is, people had to be unequivocal and strongly supportive of the concept to be counted as expressing a "willingness" to commute by a BART/station-car combination.

From the 1990 BATS survey, 24.8 percent of those making trips within station-car sheds, as defined, were by BART. Also, as noted in Chapter Three, 21.9 percent of those who test drove and evaluated the Kewet station car gave it a +3 rating (for both one end and two ends of a rail trip), signifying a high likelihood of patronizing the service. Combining these figures yields the following estimate of overall daily leases, or round trips, for station cars in the BART-served area:

Daily Station-Car Round Trips = 199,991 x 0.248 x 0.219 = 10,860

In total, we estimate that there is currently a market demand in excess of 10,000 daily station-car round-trips in a single day. This represents around 5 percent of all daily BART trips, meaning that if the market potential was fully met, station cars would take on a major presence at many stations, relieving the BART district of the pressure to expand parking facilities while also potentially producing such environmental benefits as cleaner air. It is to this latter question that we now briefly turn.

4.5. Potential Environmental Benefits of Station Cars

As discussed in Chapter One, the potential of station cars to substitute for current drive-alone auto trips and park-and-ride journeys could yield important air quality benefits. To explore this question, the likely distribution of existing modes of commuting for the 10,000-plus combined BART/station-car trips was examined. This was done by simply identifying the "predominant" mode for all commute trips in the 1990 BATS survey with origins and destinations that fell into the station-car shed. The most serious shortcoming of this database is the fact that it only records predominant modes, thus ignoring the relative roles of different modes for intermodal trips, such as park-and-ride. In most instances, a park-and-ride trip was recorded as a BART rail journey.

Table 4.2 shows the likely former modes of the estimated 10,860 trips won over to BART/station-car commuting. Nearly half of the projected all-electric commuters would likely be former drive-alone commuters. The environmental benefits of attracting the other half to a combined BART/station-car commute would be considerably less because this group formerly commuted by high-occupancy modes, like buses, vanpools, and rail. A significant share of the projected all-electric commuters currently ride BART and probably rely upon park-and-ride or kiss-and-ride to reach stations. Converting these BART trips from park-and-ride to EV-and-ride would yield air quality benefits. Overall, it appears that on the order of 65 to 70 percent of station-car trips would be converted from former modes associated with high per capita levels of emissions. If the projected 10,860 daily station-car round trips were achieved, this would mean cutting out around 7,500 daily round commute trips associated with significant polluting.

Table 4.2. Estimated Prior Modes of Commuting for Station-Car Trips

Current Predominant Commute Mode	Percent of Projected All-Electric Commutes Currently Made by Mode	Estimated Daily Station-Car Round Trips Converted from Mode
Drive Alone	47.8	5,190
Share Ride	19.6	2,130
Bus Transit	4.5	490
BART	24.9	2,700
Other	3.2	350
TOTAL	100.0	10,860

Using the average daily round-trip commute distance of 29 miles in the San Francisco Bay Area, assuming three-quarters of converted BART trips formerly involved park-and-ride or kiss-and-ride access, and assuming typical peak-period occupancy loads for non-drive-alone modes, we estimate that the projected 10,860 daily station-car round trips would substitute for 183,600 daily vehicle miles traveled in ICE vehicles.[57] While this is a small fraction of daily travel within the nine-county Bay Area, station cars could be counted on to provide positive environmental benefits that, when combined with other complementary programs, could have meaningful impacts over the long run.

4.6. Conclusion

In this chapter, we estimate that there is a substantial latent demand for station-car commuting in the San Francisco Bay Area — representing over 10,000 daily round trips in all. These station-car trips would reduce the amount of daily travel in ICE vehicles by somewhere in the neighborhood of 180,000 vehicle miles. We believe the benefits that would accrue in the way of reduced parking demands at stations, reduced air quality and energy consumption levels, and improved access to and from rail stations could be substantial. It is for these reasons that we believe there is credible grounds for launching a substantial station-car pilot program in the San Francisco Bay Area that is designed around mini-EVs like Kewets. Only by implementing such a program can we begin to understand the true market demand for station cars and gain an appreciation for the kinds of public policies that can help incubate station cars from an infant industry to a fully developed, self-supporting one.

[57]In making the estimate, the following was assumed. Average vehicle occupancies during commuter hours would be: share-ride vehicles (e.g., carpools, vanpools) = 3 passengers; bus transit = 40 passengers; and BART park-and-ride = 1 drive-alone occupant. Average round-trip commutes by all modes, except park-and-ride, are assumed to be 29 miles (RIDES, 1994). Average round trips by drive-alone park-and-ride are assumed to be 6 miles. Park-and-ride is assumed to constitute three-quarters of all access trips to BART stations within the defined station-car sheds. All "other" trips were assumed to be park-and-ride, and thus would not yield any reductions in ICE vehicle miles traveled. The estimated reduction in daily ICE vehicle miles traveled was calculated as: [(5,190 drive-alone trips x 29 miles) + ((2,130 shared ride trips/3 persons per shared ride vehicle) x 29 miles) + ((490 bus trips/40 persons per bus) x 29 miles) + ((2,700 BART trips x 0.75 park-and-ride share) x 6 miles)] = 183,600.

Chapter Five
Towards Station-Car Implementation

5.1. Summary

Electric station cars have the potential of filling an important market niche — namely, providing on-call, door-to-door access to and from rail transit stations as well as midday automobility for those who patronize transit. They would make getting from home to work via rail transit virtually seamless. Their greatest promise is likely in the suburbs. Throughout the East Bay, there are thousands of jobs beyond walking distance of BART stations. Given the choice of driving from home to work or taking BART and transferring to a bus to reach jobs, most suburban workers choose the former. The availability of free parking at the workplace and the generally poor quality of many suburban bus services reinforce this overwhelming preference for solo-commuting.

Station cars would yield important environmental benefits by both luring solo-commuters to rail transit and converting existing park-and-ride trips to electric-vehicle-and-ride trips. Since electrified station cars produce no direct tailpipe emissions and have no catalyst or hot-cold distinction, they would improve air quality to the degree they replace large numbers of ICE trips. Because station cars are small and many would be away from rail stations during the day, they would also relieve transit agencies of the need to build more parking lots. Station cars would also help conserve energy and, because they are human-scale, would complement new urbanism design schemes.

Because there are currently no large-scale station-car programs in the U.S. designed around mini-EVs, we simulated station-car services by having East Bay residents and workers drive a Kewet EV to and from BART stations. Based on survey responses from 163 East Bay residents and workers who participated in the field tests, there was considerable enthusiasm for the station-car concept. People liked the Kewet station car for its environmental benefits and ease of driving and parking. Liked least was the Kewet station car's limited range and top speeds. Overall, five times more people gave the Kewet station car a positive than a negative rating. Factors like travel distance, occupations, and perceptions of vehicle performance were most strongly correlated with peoples' likelihood of leasing station cars.

On average, survey respondents were willing to pay around $2 per day for station-car access at one of their commute trip and $3.30 for both ends. This is around $2 more than what respondents perceive as their current commuting bill. It is considerably less, however, than the over $20 per day that would have to be recouped to fully recover the cost of providing and maintaining an EV station car. If station cars could be mass-produced so as to cut the purchase cost in half and leased on weekends as well (as part of a car co-op program), daily lease rates could be as low as around $6.75. Still, it is clear a station-car program will require some level of subsidy support to be financially sustainable. Logically, support should come from those benefitting the most — such as rail agencies and large employers who face less demands for parking spaces as well as the larger public, which benefits from cleaner air and reduced fossil fuel consumption. It follows that some form of cost-sharing between station-car users, employers, transit agencies, and taxpayers will be necessary if station cars are to be financially feasible.

Combining survey results with 1990 commuting statistics, we estimate that there is currently a market demand for over 10,000 daily station-car leases in the San Francisco Bay Area. We also estimate that these 10,000+ station-car round-trips would substitute for over 180,000 daily vehicle miles traveled in ICE vehicles.

5.2. Initiating a Demonstration Program

An important step toward implementing station cars on a large scale is to mount a successful demonstration program. If a demand for station cars can be empirically demonstrated, we believe market forces will eventually allow full-scale implementation of station cars. Once the industry achieves economies of scale, station cars could eventually become self-supporting. Efficiency would be maximized to the extent that station cars are leased for both home-end and work-end access trips.

A number of criteria might be considered in choosing one or more sites for a large-scale station-car demonstration:

- *Limited existing shuttle services.* Station cars will likely work the best where existing bus connections and shuttle runs are limited or non-existent. This characterizes many suburban areas of the U.S.
- *Work sites and residences within the station-car shed.* There must be sufficient numbers of workers or residents within the 0.5-4 mile catchment of rail stations to sustain a station-car program.
- *Parking capacity.* There should be sufficient capacity to accommodate between 50-100 station cars on a trial demonstration basis. To the degree that station cars replace automobiles, the availability of parking would probably not be a serious constraint on developing a station-car demonstration.
- *Corporate interest.* Ideally, there should be one or more large firms within a station-car shed willing to help support a station-car demonstration. Support might come in the form of subsidies (e.g., station-car vouchers), providing staff assistance (e.g., transportation coordinators), and marketing the station-car concept among employees.
- *Local interest.* Equally important, local elected officials should also support the initiation of station-car services in their community. Having a political champion for station cars would help ensure that there is a receptive local policy environment.
- *Balanced flows.* To ensure EVs are used efficiently, stations that are good candidates for demonstrations should have a reasonable balance of both residences and jobs within the 0.5- to 4-mile station-car shed. This would allow EVs to be used for both home-end and work-end station-car trips each day. As noted in Chapter Four, BART stations like Lake Merritt, San Leandro, and Ashby meet this criterion.

Other criteria might also be considered. For example, to make even more efficient use of station cars, a station may be viewed as a good demonstration site candidate if there are many nearby residents who could lease the EVs on weekends. The Pleasant Hill BART station is an example, wherein over

1,600 housing units lie within a quarter-mile distance of the station. A station-car demonstration at the Pleasant Hill station, for instance, would allow EVs to be leased to BART commuters on weekdays and possibly nearby residents on weekends. This would effectively make station cars part of a week-long EV co-op program. Alternately, a new rail station might be a good candidate for a full-fledged station-car program because various provisions could be designed into the station area (e.g., specialized parking, dedicated lanes, and recharging stations). On the BART system, the East Dublin/Pleasanton station, which is slated to begin construction in 1995, is an attractive site for station cars in part because it is currently surrounded by open fields as well as thousands of workers. One of the largest employment centers in the East Bay, Hacienda Business Park, contains some 14,000 workers who are within a 0.5- to 1.5-mile range of the East Dublin/Pleasant Hill station. Additionally, several retail centers and a large shopping mall lie within 1-2 miles of Hacienda Business Park. A Kewet-type EV that could be used to travel between BART and Hacienda as well as to nearby retail centers in the midday would appear to be a natural for the East Dublin/Pleasanton site.

5.3. Close

The time is ripe for developing a large-scale station-car program in the San Francisco Bay Area as well as possibly other large rail cities in the U.S. With California's ZEV requirements on the horizon, growing environmental awareness, continued suburbanization, and, we believe, a latent demand for station-car access to rail, stakeholders should move quickly, though carefully, to mount one or more significant-scale demonstration programs in the San Francisco Bay Area. Among the stakeholders are rail agencies like BART, large employers facing TDM mandates, local governments concerned with congestion management, electric utility companies, and a host of others with a vested interest in developing environmentally sound and economically viable forms of transportation, including EV manufacturers and vendors such as Green Motorworks, Inc., CalStart, air quality districts, the National Station Car Association (NSCA), and research organizations, like UC Berkeley's National Transit Access Center (NTRAC). Working together, these groups would form a strong station-car coalition. By forging a concensus on how to develop a large-scale pilot program of mini-EVs leased to rail users, station cars could quickly move from concept to implementation in the San Francisco Bay Area. A successful Bay Area demonstration program, we believe, would open the door for similar initiatives in rail cities throughout the U.S.

References

BART (Bay Area Rapid Transit District). 1993. *1992 BART Passenger Profile Survey.* Oakland: BART.

BART Planning Office. 1993. *1992 Passenger Profile Survey: Summary Report.* Oakland, California: San Francisco Bay Area Rapid Transit District, Office of Strategic Research.

Begg, S., and S. Cardell. 1980. "Choice of Smallest Car by Multi-Vehicle Households and the Demand for Electric Vehicles." *Transportation Research* 14A(4): 389-404.

____. 1981. "Assessing the Potential Demand for Electric Vehicles." *Journal of Econometrics* 16(1): 2-19.

Bernard, M. 1994. *Station Cars: Concept Paper.* Oakland, California: National Station Car Association, Bevilacqua-Knight, Inc.

Calthorpe, P. 1993. *The Next American Metropolis.* Princeton: Princeton Architectural Press.

Cervero, R. 1982. *Intergovernmental Responsibilities for Financing Urban Transit Services.* Washington, D.C.: U.S. Department of Transportation, Urban Mass Transportation Administration.

____. 1993a. *Ridership Impacts of Transit-Focused Development in California.* Berkeley: Institute of Urban and Regional Development, Monograph No. 45.

____. 1993b. "Surviving in the Suburbs: Transit's Untapped Frontier." *Access* 1(2): 30-35.

____. 1994. "Transit-Based Housing in California: Evidence on Ridership Impacts." *Transport Policy* 1(3): 174-183.

Cervero, R., M. Bernick, and J. Gilbert. 1994. *Market Opportunities and Barriers to Transit-Oriented Development.* Berkeley: Institute of Urban and Regional Development, Working Paper No. 621.

Garrison, W., and J. Clarke. 1977. *Studies of the Neighborhood Car Concept.* Berkeley: Univeristy of California, Institute of Transportation Studies, Report 78-4.

Greene, D. 1985. "Estimating Daily Vehicle Usage Distributions and the Implicatons for Limited Range Vehicles." *Transportation Research* 19B(4): 287-301.

JHK and Associates. 1989. *Development Related Ridership Survey.* Washington, D.C.: Washington Metropolitan Transit Authority.

Katz, P. 1993. *The New Urbanism: Toward an Architecture of Community.* New York: McGraw-Hill.

Knack, R. 1992. "Plug In and Commute." *Planning* 58(10): 26.

LaFond, M. 1994. "Cooperative Transport: Berlin's Stattauto (Instead of Cars)." *Rain* 14(4): 2-6.

MacCready, P. 1994. "Small and Electric Vehicles with a Future." Washington, D.C.: Paper presented at the 73rd Annual Meeting of the Transportation Research Board, paper number 940947.

Meldgin, M. 1992. "PG&E's Plans to Meet Electric Vehicle Demand." Boston: U.S. Department of Energy, Solar and Electric Vehicles Conference Proceedings.

Metropolitan Transportation Commission. 1992. *Bay Area Travel and Mobility Characteristics: 1990 Census.* Oakland: Metropolitan Transportation Commission, Working Paper No. 2.

Nesbitt, K., K. Kurani, and M. DeLuchi. 1992. "Household Electric Vehicle Market: A Near Term Constraints Analysis." Davis: Institute of Transportation Studies, Working Paper.

Pisarski, A. 1992. *New Perspectives in Commuting.* Washington, D.C.: U.S. Department of Transportation, Federal Highway Administration.

RIDES. 1994. *Commute Profile '94.* San Francisco: RIDES for Bay Area Commuters.

Rodenborn, S., and C. Purvis. 1991. "1990 Bay Area Travel Surveys: Data Collection and Data Analysis." Washington, D.C.: Paper presented at the 70th Annual Meeting of the Transportation Research Board.

Rutherford, G., D. Niemeier, and C. Kooperberg. 1994. Washington, D.C.: Paper presented at the 73rd Annual Meeting of the Transportation Research Board, paper number 940151.

Scott, A. 1993. *Electric Vehicle Manufacturing in Southern California: Current Developments, Future Prospects.* Berkeley: The University of California Transportation Center, Working Paper 170.

Shoup, D. 1994. "Cashing in on Curb Parking." *Access* 4: 20-26

Solomon, D. 1992. *ReBuilding.* Princeton: Princeton Architectural Press.

Sperling, D. 1994. "Electric Cars and the Future." *ITS Review* 17(3): 1-8.

____. 1994. "Prospects for Neighborhood Electric Vehicles." Washington, D.C.: Paper presented at the 73rd Annual Meeting of the Transportation Research Board, paper number 940911.

Stein, A., K. Kurani, and D. Sperling. 1994. "Roadway Infrastructure for Low Speed, Mini-Vehicles: Processes and Design Concepts." Washington, D.C.: Paper presented at the 73rd Annual Meeting of the Transportation Research Board, paper number 940913.

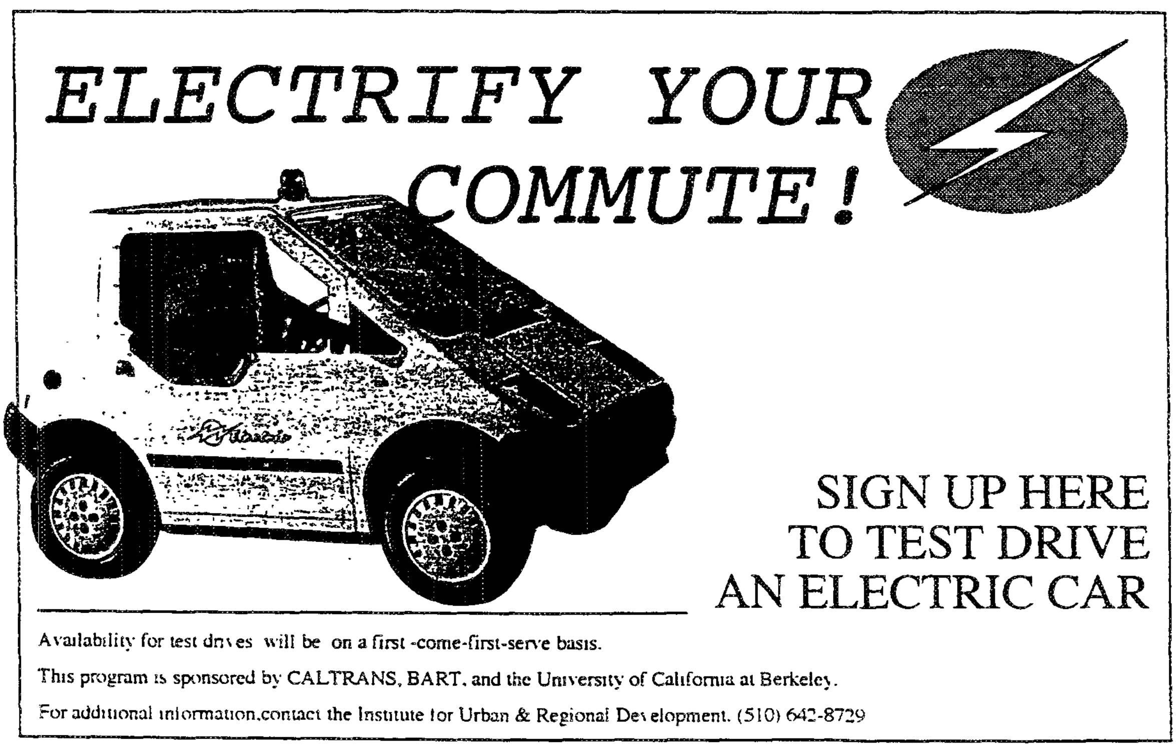
Stringham, M. 1982. "Travel Behavior Associated with Land Adjacent to Rapid Transit Stations." *ITE Journal* 52(4): 18-22.

Vuchic, V. 1992. "Urban Passenger Transportation Modes." In *Public Transportation in the U.S.*, Englewood Cliffs, N.J.: Prentice-Hall, 2nd edition: 79-113.

Wolff, G., D. Rigby, D. Gauthier, and M. Cenzatti. 1993. "The Potential Impacts of an Electric Vehicle Manufacturing Complex on the Los Angeles Economy." In *Electric Vehicle Manufacturing in Southern California: Current Developments, Future Prospects*, A. Scott, ed., Berkeley: The University of California Transportation Center, Working Paper 170.

Appendix A

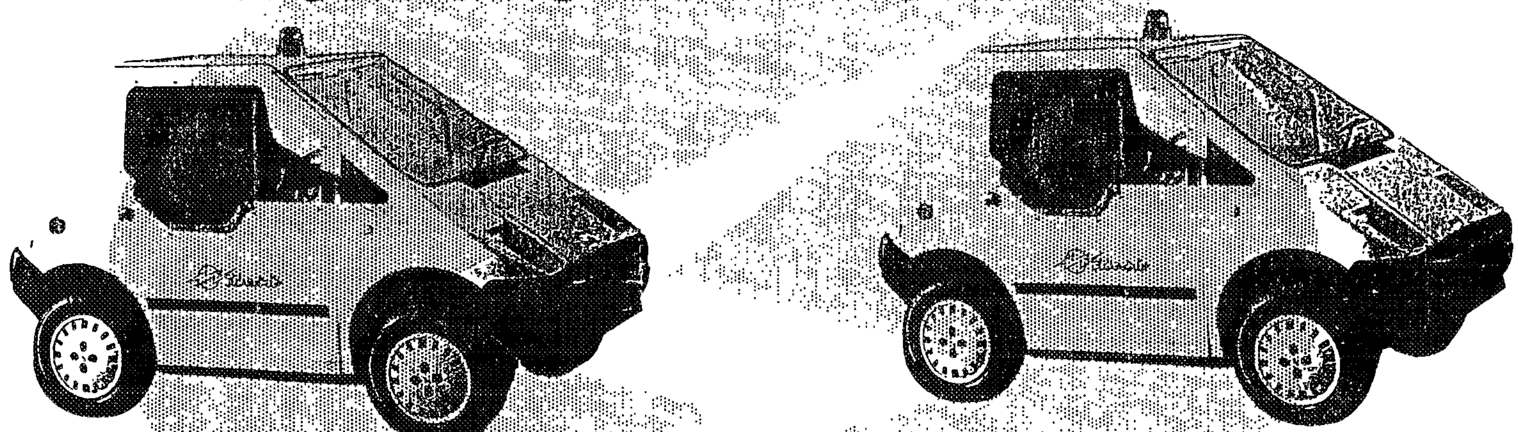
Advertisements Used in Recruiting Participants



Part 1

Sign up for a 30 minute test-drive!

Test drives will leave and return from this BART station. . .



Tuesday, June 21 - Friday June 24 ONLY!

<u>Sponsored by</u> :
University of California at Berkeley,
BART, and CalTrans

Part 2

Appendix B

Copy of the Station-Car Survey Instrument

Test ID # _________

Date of Test _________________________

BART Station ____________________________

Station Car Survey

I. PRELIMINARY INFORMATION

Fill out the following for all scheduled participants in a given round of testing before arriving at the worksite:

Name of Employer ____

Type of Business ____

Address of Employer ____

Nearest Intersection of Employer ____

Route between worksite and BART Station ____

____

____

Miles on vehicle at start of current charge ______________

ID Numbers for This Round of Testing _________

II. PARTICIPANT BACKGROUND

Fill out the following for each test drive before administering the oral part of the survey:

Estimated Age of Participant	**Gender**	**Race**
1) 18 - 29	1) Male	1) Caucasian
2) 30 - 39	2) Female	2) African-American
3) 40 - 49		3) Asian
4) 50 - 59		4) Hispanic
5) 60 +		5) Other ________________
6) can't guess		6) can't guess

Current Occupation:

1) Accounting/Financial	4) Laborer	7) Sales Worker
2) Clerical/Secretarial	5) Manager/Administrator	8) Service Worker (waiter, clerk)
3) Craftsman (mechanic, builder)	6) Professional (consultant, engineer)	9) Other (specify)

Start Time of Test Drive ______________________

Odometer reading at start of this test ______________ miles.

III. PARTICIPANT PRE-DRIVE QUESTIONNAIRE

"Hello, my name is _____________ from the University of California - Berkeley. We are working in conjunction with BART to determine whether a small electric vehicle like the one you see here is feasible as a commute vehicle between worksites and nearby BART stations. This vehicle is called a Kewet. It weights about 1,600 pounds and operates on four 12-volt batteries. The car has a range of about 25 miles before it has to be recharged. You drive it like a regular car, except that it can't go faster than about 35 mph. Before we get started, I'd like to ask you a few questions."

Questions 1 through 9 are orally asked to the driver before starting the vehicle.

1) What is your home zip code? ________________

2) What is the nearest intersection to your home? ____________________________________

3) Which is the closest BART station to your home? ____________________________________

4) How far do you live from this BART station? (miles) ________________________________

If the driver is not going to a BART station during the test (e.g. as in the case of East Dublin), ask 4a and 4b; otherwise, go to 5:

4a) Which is the closest BART station to your place of work? ______________________

4b) How far do you work from this BART station? _____________________________

For questions 5 and 6, fill in the link as a number (1, 2, or 3 for trips 1, 2, and 3, respectively) and a letter (for the link within the trip). For example, suppose the driver does the following three days a week: walk to BART, take BART, take shuttle to work. These three links would be labeled a under column 1, b under column 1, and c under column 1, respectively. Suppose the driver takes a carpool the other two days of the week. This link would be labeled a under column 2. Also, if the driver takes BART, fill in the name of the station.

5. For your trip from **home to work**, what form of transportation do you use?

Form of Transportation	Link Number 1	2	3	Time in Minutes 1	2	3	Days per Week
1) Drive Alone	___	___	___	___	___	___	1.
2) Carpool	___	___	___	___	___	___	2.
3) Vanpool/Shuttle	___	___	___	___	___	___	3.
4) BART ________	___	___	___	___	___	___	
5) Bus	___	___	___	___	___	___	
6) Walk	___	___	___	___	___	___	
7) Bicycle	___	___	___	___	___	___	
8) Other ____________	___	___	___	___	___	___	

6 For your trip from **work to home**, what form of transportation do you use?

Form of Transportation	Link Number 1	2	3	Time in Minutes 1	2	3	Days per Week
1) Drive Alone	___	___	___	___	___	___	1.
2) Carpool	___	___	___	___	___	___	2.
3) Vanpool/Shuttle	___	___	___	___	___	___	3.
4) BART ________	___	___	___	___	___	___	
5) Bus	___	___	___	___	___	___	
6) Walk	___	___	___	___	___	___	
7) Bicycle	___	___	___	___	___	___	
8) Other	___	___	___	___	___	___	

If the driver does not use BART for any links in answer to 5 and 6, ask 6a; otherwise, go to 7:

6a. Why do you not use BART for commute trips?

a) not close enough to my home
b) not close enough to my worksite
c) service is too infrequent
d) my schedule is too flexible
e) I need my car during the day
f) too expensive
g) I like to commute by myself
h) Other ______________________________________

7. Between the time you leave for work in the morning and arrive at home in the evening, what other trips do you typically make? **Note: Circle one of N or H for each type of trip: N = Non-Home Based, H = Home Based.**

Type of Trip	Times Per Week		Mode	Distance (miles)
a) Grocery Shopping	______	N H	________	_____
b) Other Shopping	______	N H	________	_____
c) Child Care	______	N H	________	_____
d) Meals/Restaurants	______	N H	________	_____
e) Appointments (e.g., doctor, haircut)	______	N H	________	_____
f) Recreation	______	N H	________	_____
g) Banking Services (e.g., ATM)	______	N H	________	_____
h) Other Services (e.g., photocopying)	______	N H	________	_____
i) Work-Related	______	N H	________	_____
i) Other	______	N H	________	_____
____________________				

8. How much does it cost you for your entire round trip, on the average? $ __________.

8a. How did you arrive at this figure?

9. Do you park for free at your workplace?

1) yes
2) no

If the answer to 9 is no, ask 9a; otherwise skip 9a and continue.

9a. If no, how much do you typically pay

______ per day
______ per week
______ per month

IV. POST-TEST EVALUATION

Fill out the following once the driver has completed the test:

End Time of Test Drive ________________________

Odometer Reading at End of Test __________ miles.

Verbally ask the driver questions 10 - 13 after completing the test.

10. How likely is it that you would use station cars if they were available between the worksite and the nearest BART station?

-3	-2	-1	0	1	2	3
very unlikely			neutral			very likely

11. Suppose that for the morning commute you somehow get to the BART station nearest home, then take BART to the station nearest work and drive a station car to the worksite. For the evening commute, you reverse the pattern. What total round-trip fare (BART plus station car) would make it worth it for you to commute this way? $ ______________

12. How likely is it that you would use station cars if they were available at both the home and the work ends of the BART trip?

-3	-2	-1	0	1	2	3
very unlikely			neutral			very likely

13. Suppose now that for the morning commute you drive a station car from home to the nearest BART station, then take BART to the station nearest work and drive a station car to the worksite. For the evening commute, you reverse the pattern. What total round-trip fare (BART plus station car on both ends) would make it worth it for you to commute this way? $ ______________

Now ask the driver to fill in the answers to questions 14 - 18. Give the driver the following three sheets of paper so that he/she can answer these questions.

14. What three features do you like **most** about the station car? (Please label 1, 2, and 3 in spaces below).

___ 1) produces no air pollution

___ 2) helps reduce traffic congestion

___ 3) reduces fuel and energy consumption

___ 4) is fun to drive

___ 5) is easy to drive

___ 6) is easy to park

___ 7) other ________________________________

___ 8) other ________________________________

___ 9) other ________________________________

15. What three features do you like **least** about the station car? (Please label 1, 2, and 3 in spaces below).

___ 1) range
1a) if you selected this, what is an acceptable range? ______ miles.

___ 2) average speed
2a) if you selected this, what is an acceptable average speed? ______ mph.

___ 3) top speed
3a) if you selected this, what is an acceptable top speed? ______ mph.

___ 4) safety
4a) if you selected this, what changes to the car would be needed to make it more safe? ________________________________ .

___ 5) car can't be driven on freeways

___ 6) car requires frequent recharging

___ 7) other ________________________________

___ 8) other ________________________________

___ 9) other ________________________________

16. Please rate the station car in terms of:

	very poor			neutral			excellent
1) acceleration	-3	-2	-1	0	1	2	3
2) deceleration	-3	-2	-1	0	1	2	3
3) average speed	-3	-2	-1	0	1	2	3
4) maximum speed	-3	-2	-1	0	1	2	3
5) maneuverability/ ease of turning	-3	-2	-1	0	1	2	3
6) safety	-3	-2	-1	0	1	2	3
7) ability to climb hills	-3	-2	-1	0	1	2	3
8) visibility	-3	-2	-1	0	1	2	3
9) range	-3	-2	-1	0	1	2	3
10) vibration	-3	-2	-1	0	1	2	3
11) noise level	-3	-2	-1	0	1	2	3
12) driver comfort	-3	-2	-1	0	1	2	3
13) Other ______________________	-3	-2	-1	0	1	2	3

17. How might the station car be improved?

18. Would you like to participate in a follow-up test?

a) yes
b) no

If you answered "yes", please write the following contact information:

Name ______________________________

Address ______________________________

Phone ____________

Appendix C

Table C.1. Origin-Destination Matrix of Donut-to-Donut Station-Car Trips

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destinations)

		Richmond	El Cerrito Plaza	El Cerrito del Norte	North Berkeley	Berkeley	Ashby	Macarthur	19th St.	12th St.	Lake Merritt	Fruitvale	Coliseum	San Leandro	Bayfair	Hayward	South Hayward
1	Richmond	0	0	0	0	0	195	215	0	0	214	0	1,101	0	0	0	0
2	El Cerrito Plaza	0	0	0	0	0	446	227	0	0	387	0	0	0	0	0	0
3	El Cerrito del Norte	0	0	0	0	0	0	1,415	0	0	920	0	550	135	0	345	0
4	North Berkeley	0	0	0	0	0	0	0	0	0	0	113	0	270	0	154	0
5	Berkeley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Ashby	0	0	0	0	0	0	0	0	0	698	143	160	292	0	0	130
7	Macarthur	273	0	273	0	0	0	0	0	0	0	0	1,222	224	0	0	0
8	19th St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	12th St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Lake Merritt	229	0	0	0	0	597	0	0	0	0	0	0	0	0	274	200
11	Fruitvale	215	430	261	488	0	455	1,389	0	0	0	0	0	0	0	0	592
12	Coliseum	0	200	0	583	0	802	0	0	0	0	0	0	0	0	0	224
13	San Leandro	0	0	0	0	0	675	683	0	0	0	0	0	0	0	0	0
14	Bayfair	274	0	421	223	0	214	444	0	0	728	0	0	0	0	0	0
15	Hayward	0	0	0	363	0	714	548	0	0	720	221	0	0	0	0	0
16	South Hayward	0	0	0	327	0	0	749	0	0	0	0	0	0	0	0	0
17	Union City	0	0	0	0	0	0	209	0	0	189	209	0	641	0	0	0
18	Fremont	756	0	0	320	0	0	273	0	0	220	139	314	1,063	273	0	0
19	Concord	0	0	0	0	0	0	205	0	0	600	0	0	0	0	262	166
20	Pleasant Hill	356	192	0	0	0	0	614	0	0	0	0	0	0	191	0	217
21	Walnut Creek	180	0	160	806	0	133	412	0	0	545	331	0	286	166	180	0
22	Lafayette	144	0	0	180	0	144	0	0	0	631	0	265	265	0	293	0
23	Orinda	0	0	0	0	0	0	0	0	0	0	133	0	0	0	0	0
24	Rockridge	224	0	0	1,084	0	0	0	0	0	430	727	517	570	215	210	476
25	West Oakland	0	0	0	0	0	0	0	0	0	0	0	289	0	0	0	0
26	Embarcadero	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	Powell St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Civic Center	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	16th & Mission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	24th & Mission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	Glen Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Balboa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Daly City	0	0	0	263	0	0	0	0	0	603	0	0	0	0	0	0
	TOTAL	2,650	822	1,116	4,636	0	4,374	7,385	0	0	6,885	2,016	4,418	3,745	844	1,720	2,006

Table C.1. Origin-Destination Matrix of Donut-to-Donut Station-Car Trips (continued)

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destinations)

Union City	Fremont	Concord	Pleasant Hill	Walnut Creek	Lafayette	Orinda	Rockridge	West Oakland	Embarcadero	Montgomery	Powell St.	Civic Center	16th & Mission	24th & Mission	Glen Park	Balboa	Daly City	TOTAL
0	0	0	1,047	253	0	0	0	1,289	0	0	0	0	0	0	0	0	357	4,672
0	0	0	0	0	0	0	0	422	0	0	0	0	0	0	0	0	0	1,483
0	251	0	0	0	0	0	450	0	0	0	0	0	0	0	0	0	0	4,066
0	0	0	296	130	0	0	0	133	0	0	0	0	0	0	0	0	0	1,096
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	135	374	0	427	135	0	0	0	0	0	0	0	0	0	0	0	0	2,494
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,993
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
693	0	373	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,566
0	0	377	0	0	239	0	453	0	0	0	0	0	0	0	0	0	0	4,898
0	215	0	0	281	0	0	610	476	0	0	0	0	0	0	0	0	0	3,390
0	221	214	0	0	0	0	829	0	0	0	0	0	0	0	0	0	0	2,623
0	454	0	0	248	0	0	258	911	0	0	0	0	0	0	0	0	229	4,404
0	0	0	383	0	0	0	0	274	0	0	0	0	0	0	0	0	0	3,223
0	0	0	0	0	0	0	274	221	0	0	0	0	0	0	0	0	0	1,572
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,249
0	0	523	0	0	0	0	0	633	0	0	0	0	0	0	0	0	0	4,512
0	0	0	0	0	0	0	214	0	0	0	0	0	0	0	0	0	222	1,669
0	0	0	0	0	0	0	250	444	0	0	0	0	0	0	0	0	0	2,265
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,200
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,924
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133
0	369	179	0	0	0	0	0	536	0	0	0	0	0	0	0	0	0	5,537
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	289
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	865
693	1,645	2,041	1,926	1,339	373	0	3,339	5,340	0	0	0	0	0	0	0	0	808	60,122

Table C.2. Origin-Destination Matrix of Hole-to-Donut Station-Car Trips

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destinations)

		Richmond	El Cerrito Plaza	El Cerrito del Norte	North Berkeley	Berkeley	Ashby	Macarthur	19th St.	12th St.	Lake Merritt	Fruitvale	Coliseum	San Leandro	Bayfair	Hayward	South Hayward
1	Richmond	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	El Cerrito Plaza	0	0	0	0	0	0	394	0	0	0	0	0	0	0	0	0
3	El Cerrito del Norte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	North Berkeley	0	0	0	0	0	0	0	0	0	0	145	0	855	0	0	0
5	Berkeley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Ashby	0	0	0	0	0	0	0	0	0	245	888	135	0	0	0	0
7	Macarthur	0	0	0	0	0	0	0	0	0	0	1,775	0	0	0	0	0
8	19th St.	0	0	238	0	0	0	0	0	0	0	0	0	238	0	0	0
9	12th St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Lake Merritt	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Fruitvale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Coliseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	San Leandro	0	0	0	0	0	221	0	0	0	0	0	0	0	0	0	0
14	Bayfair	0	0	443	0	0	0	0	0	0	248	0	0	0	0	0	0
15	Hayward	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	South Hayward	0	0	0	0	0	0	0	0	0	220	0	0	0	0	0	0
17	Union City	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Fremont	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Concord	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	Pleasant Hill	0	0	0	0	0	308	0	0	0	233	0	0	0	0	0	0
21	Walnut Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Lafayette	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Orinda	0	265	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	Rockridge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	West Oakland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	Embarcadero	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	Powell St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Civic Center	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	16th & Mission	0	0	0	308	0	0	0	0	0	0	0	0	297	0	0	0
31	24th & Mission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	145
32	Glen Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Balboa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Daly City	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	265	681	308	0	529	394	0	0	947	2,809	135	1,389	0	0	145

Table C.2. Origin-Destination Matrix of Hole-to-Donut Station-Car Trips (continued)

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destinations)

Union City	Fremont	Concord	Pleasant Hill	Walnut Creek	Lafayette	Orinda	Rockridge	West Oakland	Embarcadero	Montgomery	Powell St.	Civic Center	16th & Mission	24th & Mission	Glen Park	Balboa	Daly City	TOTAL
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	394
0	0	0	0	0	0	0	0	258	0	0	0	0	0	0	0	0	0	258
0	0	130	323	0	0	0	124	0	0	0	0	0	0	0	0	0	0	1,578
0	415	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	574
0	0	157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,425
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,775
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	476
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	443
0	221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	229	1,141
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	220
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	541
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	183
0	0	412	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	677
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	241	846
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	145
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	249	0	0	0	0	0	0	0	0	0	0	0	249
0	819	1,081	323	0	0	249	124	258	0	0	0	0	0	0	0	0	470	10,927

Table C.3. Origin-Destination Matrix of Donut-to-Hole Station-Car Trips

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destinations)

		Richmond	El Cerrito Plaza	El Cerrito del Norte	North Berkeley	Berkeley	Ashby	Macarthur	19th St.	12th St.	Lake Merritt	Fruitvale	Coliseum	San Leandro	Bayfair	Hayward	South Hayward
1	Richmond	0	0	0	0	0	0	0	215	1,063	0	0	0	256	0	0	0
2	El Cerrito Plaza	0	0	0	0	0	0	0	253	394	0	0	0	0	0	0	0
3	El Cerrito del Norte	0	0	0	0	0	0	124	0	160	0	0	0	0	0	0	0
4	North Berkeley	0	0	0	0	0	0	0	160	160	0	0	0	0	0	130	0
5	Berkeley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Ashby	0	0	0	0	0	0	0	0	0	407	160	157	0	0	0	0
7	Macarthur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	238	0
8	19th St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	12th St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Lake Merritt	0	0	0	0	488	0	0	0	0	0	0	0	0	307	0	0
11	Fruitvale	0	0	215	0	406	0	289	0	0	0	0	0	0	0	0	0
12	Coliseum	0	0	0	0	215	279	0	0	0	0	0	0	0	0	0	0
13	San Leandro	0	0	0	0	0	0	0	256	0	0	0	0	0	0	0	0
14	Bayfair	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Hayward	0	0	0	0	363	0	223	248	462	639	0	0	0	0	0	0
16	South Hayward	0	489	0	0	274	489	0	0	0	0	0	0	0	0	0	0
17	Union City	0	0	0	0	0	0	0	0	0	251	0	0	0	0	0	0
18	Fremont	0	0	0	0	0	0	320	199	490	570	0	0	0	0	0	0
19	Concord	0	0	0	0	0	0	147	392	0	147	0	0	0	0	0	170
20	Pleasant Hill	0	0	0	0	0	0	0	192	170	0	227	0	0	0	0	0
21	Walnut Creek	0	0	0	0	0	0	160	144	0	0	0	225	142	0	96	0
22	Lafayette	0	0	0	0	259	133	0	180	0	0	0	0	0	0	0	265
23	Orinda	0	0	0	0	251	0	0	0	0	0	0	0	0	0	0	0
24	Rockridge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	West Oakland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	Embarcadero	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	Powell St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Civic Center	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	16th & Mission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	24th & Mission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	Glen Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Balboa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Daly City	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	0	489	215	0	2,256	901	1,263	2,239	2,899	2,013	386	382	398	307	464	435

Table C.3. Origin-Destination Matrix of Donut-to-Hole Station-Car Trips (continued)

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destinations)

Union City	Fremont	Concord	Pleasant Hill	Walnut Creek	Lafayette	Orinda	Rockridge	West Oakland	Embarcadero	Montgomery	Powell St.	Civic Center	16th & Mission	24th & Mission	Glen Park	Balboa	Daly City	TOTAL
0	0	0	215	0	0	0	0	409	0	978	0	195	0	0	0	0	0	3,331
0	0	0	0	0	0	0	0	0	0	1,104	0	0	0	0	0	0	0	1,751
0	0	0	0	0	0	0	0	0	130	1,154	0	227	0	0	0	0	0	1,795
0	0	0	0	0	0	130	135	0	193	1,070	145	276	292	0	0	0	0	2,692
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1,020	130	0	0	0	0	0	0	1,875
0	0	0	0	0	0	0	0	0	623	2,370	0	439	0	0	0	0	0	3,670
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	373	0	0	2,357	224	179	0	0	0	0	0	3,929
0	0	0	0	0	0	238	830	0	978	2,530	0	0	0	0	0	0	0	5,485
0	0	0	0	0	0	0	0	581	943	1,790	0	0	153	0	0	0	0	3,960
0	0	0	0	0	0	0	0	223	0	877	0	0	327	256	0	0	0	1,939
0	489	223	0	0	0	0	0	443	0	248	0	0	0	0	0	0	0	1,403
0	0	0	0	0	0	0	0	324	0	1,052	0	696	0	0	0	0	0	4,008
0	0	0	0	0	0	0	0	0	0	868	0	199	0	0	0	0	0	2,319
0	0	0	0	0	0	0	0	0	263	1,596	0	199	0	0	0	0	0	2,308
0	0	0	0	0	0	0	0	0	0	984	0	0	0	0	0	0	0	2,564
0	0	0	0	0	0	170	0	235	637	2,922	262	222	238	0	0	0	0	5,541
0	0	0	0	0	0	0	0	0	222	1,863	0	0	0	0	0	0	0	2,673
0	0	0	0	0	0	0	0	0	366	3,418	0	166	0	0	0	0	0	4,716
0	0	0	0	0	0	0	0	0	207	833	0	0	0	0	0	0	0	1,877
0	0	0	0	0	0	0	0	0	0	949	0	0	0	0	0	0	0	1,200
0	0	0	142	0	0	0	0	0	0	3,015	0	0	0	0	0	0	0	3,157
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	212	319	0	0	0	637	3,972	0	469	1,017	0	0	0	0	6,627
0	489	223	357	212	319	538	1,338	2,214	5,200	36,971	762	3,268	2,027	256	0	0	0	68,820

Table C.4. Origin-Destination Matrix of Total Station-Car Trips

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destination)

		Richmond	El Cerrito Plaza	El Cerrito del Norte	North Berkeley	Berkeley	Ashby	Macarthur	19th St.	12th St.	Lake Merritt	Fruitvale	Coliseum	San Leandro	Bayfair	Hayward	South Hayward	Union City
1	Richmond	0	0	0	0	0	390	431	215	1,063	429	0	2,202	256	0	0	0	0
2	El Cerrito Plaza	0	0	0	0	0	892	849	253	394	775	0	0	0	0	0	0	0
3	El Cerrito del Norte	0	0	0	0	0	0	2,954	0	160	1,839	0	1,100	270	0	690	0	0
4	North Berkeley	0	0	0	0	0	0	0	160	160	0	371	0	1,394	0	439	0	0
5	Berkeley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Ashby	0	0	0	0	0	0	0	0	0	2,048	1,334	612	583	0	0	261	0
7	Macarthur	547	0	547	0	0	0	0	0	0	0	1,775	2,444	448	0	238	0	0
8	19th St.	0	0	238	0	0	0	0	0	0	0	0	0	238	0	0	0	0
9	12th St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Lake Merritt	457	0	0	0	488	1,193	0	0	0	0	0	0	0	307	549	400	1,386
11	Fruitvale	430	859	737	977	406	910	3,067	0	0	0	0	0	0	0	0	1,184	0
12	Coliseum	0	400	0	1,166	215	1,882	0	0	0	0	0	0	0	0	0	448	0
13	San Leandro	0	0	0	0	0	1,572	1,366	256	0	0	0	0	0	0	0	0	0
14	Bayfair	548	0	1,285	446	0	429	889	0	0	1,704	0	0	0	0	0	0	0
15	Hayward	0	0	0	726	363	1,428	1,319	248	462	2,079	443	0	0	0	0	0	0
16	South Hayward	0	489	0	655	274	489	1,499	0	0	220	0	0	0	0	0	0	0
17	Union City	0	0	0	0	0	0	419	0	0	628	419	0	1,282	0	0	0	0
18	Fremont	1,512	0	0	639	0	0	866	199	490	1,010	278	628	2,125	545	0	0	0
19	Concord	0	0	0	0	0	0	556	392	0	1,347	0	0	0	0	524	501	0
20	Pleasant Hill	711	384	0	0	0	308	1,229	192	170	233	227	0	0	383	0	435	0
21	Walnut Creek	361	0	320	1,612	0	265	984	144	0	1,091	663	225	713	331	456	0	0
22	Lafayette	289	0	0	361	259	421	0	180	0	1,263	0	530	530	0	587	265	0
23	Orinda	0	265	0	0	251	0	0	0	0	0	265	0	0	0	0	0	0
24	Rockridge	447	0	0	2,168	0	0	0	0	0	859	1,454	1,035	1,140	430	420	953	0
25	West Oakland	0	0	0	0	0	0	0	0	0	0	0	577	0	0	0	0	0
26	Embarcadero	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	Montgomery	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	Powell St.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Civic Center	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	16th & Mission	0	0	0	308	0	0	0	0	0	0	0	0	297	0	0	0	0
31	24th & Mission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	145	0
32	Glen Park	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	Balboa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Daly City	0	0	0	525	0	0	0	0	0	1,206	0	0	0	0	0	0	0
	TOTAL	5,301	2,398	3,127	9,581	2,256	10,179	16,427	2,239	2,899	16,730	7,227	9,352	9,278	1,996	3,903	4,592	1,386

Table C.4. Origin-Destination Matrix of Total Station-Car Trips (continued)

Rows = Home-End Stations (Origins)
Columns = Work-End Stations (Destination)

Fremont	Concord	Pleasant Hill	Walnut Creek	Lafayette	Orinda	Rockridge	West Oakland	Embarcadero	Montgomery	Powell St.	Civic Center	16th & Mission	24th & Mission	Glen Park	Balboa	Daly City	TOTAL
0	0	2,310	505	0	0	0	2,988	0	978	0	195	0	0	0	0	714	12,675
0	0	0	0	0	0	0	844	0	1,104	0	0	0	0	0	0	0	5,111
502	0	0	0	0	0	900	258	130	1,154	0	227	0	0	0	0	0	10,185
0	130	915	261	0	130	259	266	193	1,070	145	276	292	0	0	0	0	6,462
415	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	574
270	905	0	855	270	0	0	0	0	1,020	130	0	0	0	0	0	0	8,288
0	0	0	0	0	0	0	0	623	2,370	0	439	0	0	0	0	0	9,431
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	476
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	746	400	0	0	0	373	0	0	2,357	224	179	0	0	0	0	0	9,060
0	754	0	0	477	238	1,735	0	978	2,530	0	0	0	0	0	0	0	15,282
430	0	0	561	0	0	1,220	1,532	943	1,790	0	0	153	0	0	0	0	10,740
443	650	0	0	0	0	1,659	223	0	877	0	0	327	256	0	0	0	7,628
1,618	223	0	495	0	0	515	2,265	0	248	0	0	0	0	0	0	688	11,351
0	0	766	0	0	0	0	872	0	1,052	0	696	0	0	0	0	0	10,454
0	0	0	0	0	0	548	443	0	868	0	199	0	0	0	0	0	5,684
0	0	0	0	0	0	0	0	263	1,596	0	199	0	0	0	0	0	4,805
0	1,046	0	0	0	0	0	1,267	0	984	0	0	0	0	0	0	0	11,588
0	0	0	0	0	170	429	235	637	2,922	262	222	238	0	0	0	444	8,879
0	0	0	0	0	0	501	888	222	1,863	0	0	0	0	0	0	0	7,744
0	0	0	0	0	0	0	0	366	3,418	0	166	0	0	0	0	0	11,116
183	0	0	0	0	0	0	0	207	833	0	0	0	0	0	0	0	5,909
0	412	0	0	0	0	0	0	0	949	0	0	0	0	0	0	0	2,143
738	358	142	0	0	0	0	1,072	0	3,015	0	0	0	0	0	0	0	14,231
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	577
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	241	846
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	145
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	212	319	249	0	0	637	3,972	0	469	1,017	0	0	0	0	8,607
4,599	5,386	4,532	2,889	1,066	787	8,139	13,152	5,200	36,971	762	3,268	2,027	256	0	0	2,087	199,991

Appendix D

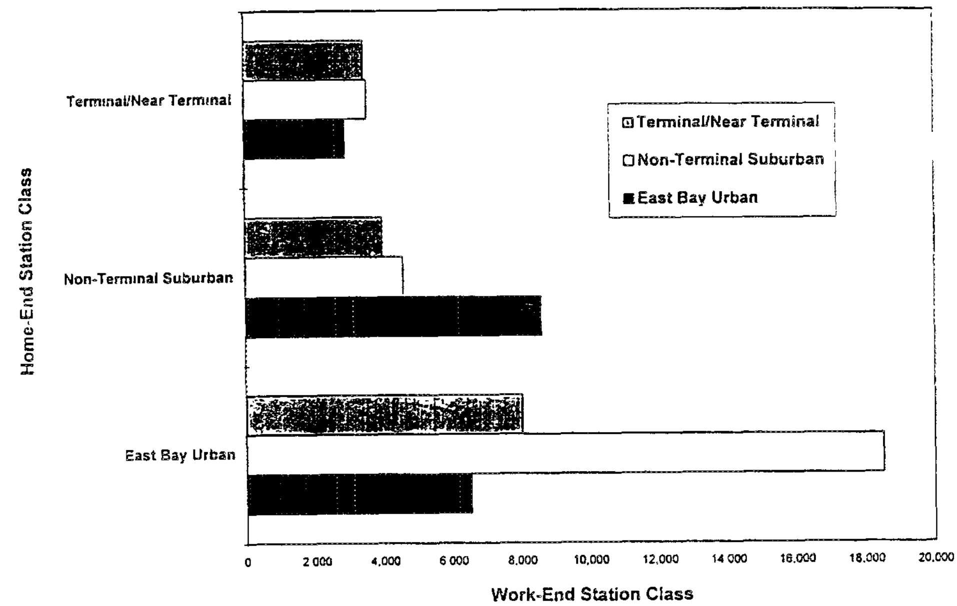


Figure D.1. Donut-to-Donut Station-Car Trips Between Station Classes, Home-End to Work-End Stations

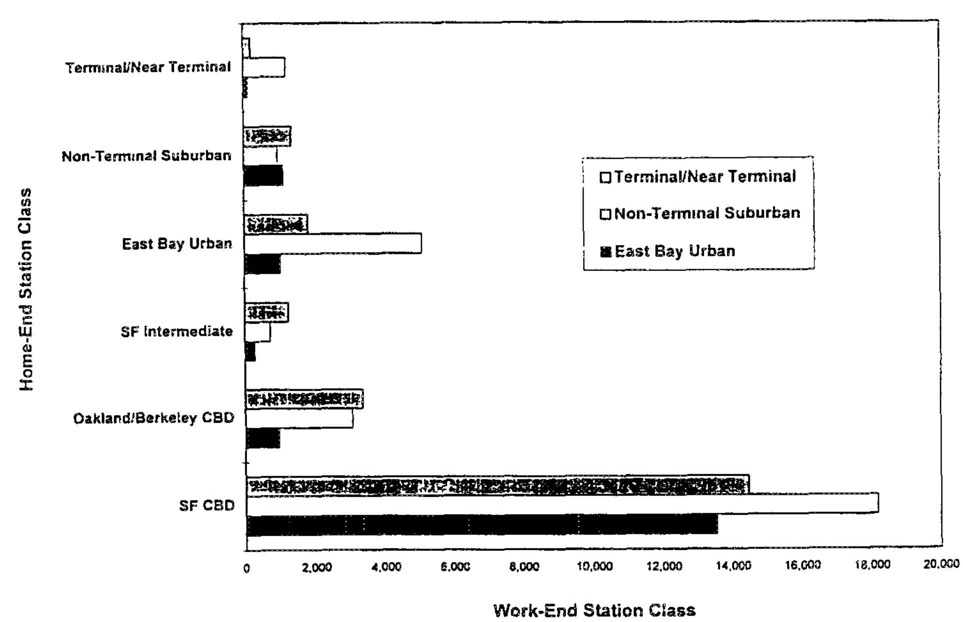


Figure D.2. Donut-to-Hole Station-Car Trips Between Station Classes, Home-End to Work-End Stations

Appendix D

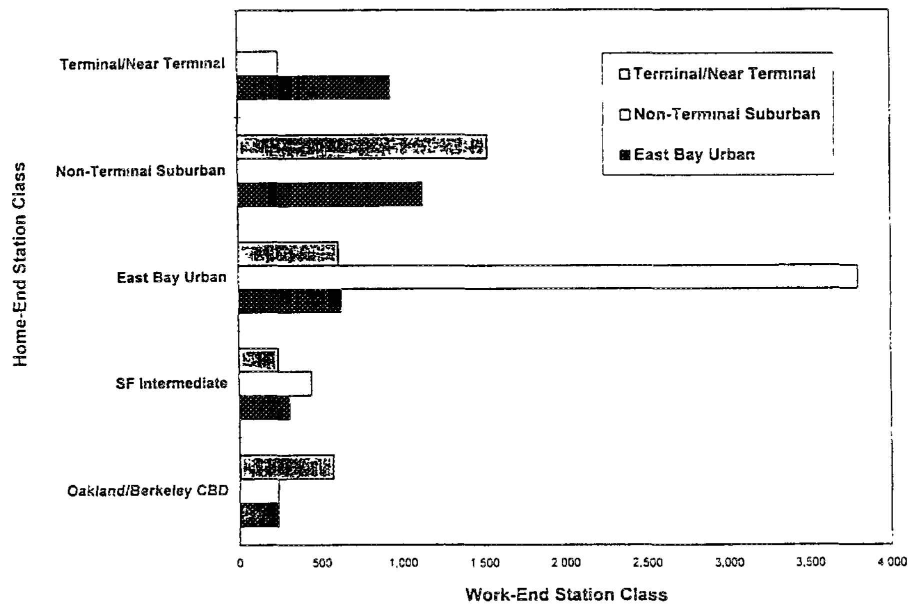


Figure D.3. Hole-to-Donut Station-Car Trips Between Station Classes, Home-End to Work-End Stations