10. Politics and Public Opinion

10.1 Overview

What are the chances that transportation pricing strategies of the sort considered in this study would be accepted by the public? In more general terms, can such changes in transportation pricing be implemented? To explore the issues and examine citizen reactions to the measures, we held nine consumer discussion groups ("focus groups") in the Bay Area, Los Angeles, San Diego, and Sacramento. In addition, we carried out a series of interviews and participated in a number of small group meetings to obtain feedback from state and local agency staff members, elected officials, and representatives of the private sector. The results indicate that some transportation pricing strategies would be more acceptable than others, that matching the strategy to local conditions will be important, and that clear commitments about uses of pricing revenues will be a necessary prerequisite to public support.

This chapter describes the approach utilized and the major findings from the focus groups and interviews, and identifies several issues that designers of transportation pricing measures and programs would need to address.

10.2 Focus Groups: Research Approach

Focus groups are a useful method for eliciting citizen opinions and preferences and obtaining reactions to proposals. (See, e.g., Krueger, 1994.) The method is widely used in marketing studies for consumer goods and as a preliminary step in the design of surveys and polls. The number of participants in each group is kept small so that in-depth discussion can take place. Usually, the sessions are held in small conference rooms with a one way mirror, behind which observers may watch the proceedings. The sessions also are

taped in most instances. Participants are informed that they are being observed and recorded, but the unobtrusive manner in which this is done rarely poses a problem. Only first names are used in the sessions themselves, and participants are informed that the results are for research purposes only and their anonymity will be preserved.

A focus group session typically begins with a brief presentation which is followed by open and participatory discussion of a set of questions (usually not more than 6-8). Open ended questions may be coupled with one or two "straw polls" or "votes", usually at the beginning of the session as a way of breaking the ice and getting the discussion going, and/or at the end of the session to sum up. The discussion leader or moderator's job is to keep the conversation going, assure that each question is addressed, encourage participation from all group members, and if necessary smooth over disagreements or redirect a discussion that begins to stray from the topic.

Most sessions are limited to 1 1/2 - 2 hours. With a few exceptions, the results are not statistically representative - the overall number of participants, even from a series of focus groups, is usually fairly small, and participants are not necessarily selected to be representative of the population as a whole. However, the material gathered from a successful focus group is richly informative and provides considerable insight on the way citizens think about the topic presented them.

For this project, eight focus groups were held in November 1993, two each in Sacramento, San Diego, Los Angeles (Encino), and the Bay Area (San Jose.) A ninth focus group was held later (in April 1994) in Berkeley. In total, 100 people participated in the sessions.

Each focus group consisted of 8-13 participants. The first eight focus groups were recruited at their homes using a telephone survey. The ninth focus group was recruited at San Francisco workplaces using flyers and intercept recruiting, and consisted of persons who worked in San Francisco and lived in the East Bay, crossing the Bay Bridge at least twice a week during peak periods.

For each focus group, the recruitment screening questions were designed to produce a group with experience in commuting and auto operation. Criteria included:

- no recent participation in a focus group
- a mix of men and women
- a mix of racial and ethnic groups
- a mix of incomes
- working age - no one under 18 or over 65
- must work at least three days a week
- must commute by car at least part of the time.

Respondents who met these criteria were invited to participate in a group discussion of transportation strategies for alleviating congestion, air pollution, and petroleum dependence, and if they agreed, arrangements were made for their attendance at a session. A modest honorarium was offered for participation.

Two hours were allotted for each session. During the first half hour, participants signed in and were offered a light meal. They then were seated, and the moderator began with introductions and a brief discussion of ground rules. The moderator then made a brief (10 min.) presentation on transportation problems and possible strategies to address those problems, including pricing. The ensuing group discussion lasted approximately 1 hr. 30 min.

Participants first discussed the importance of congestion, air pollution, and petroleum dependence as problems, to them personally and as social issues. Each group then spent about an hour discussing one of four strategies: congestion pricing, vehicle registration fees, fuel tax increases, or parking pricing.[1] The groups spent the final twenty minutes discussing the other pricing strategies and their overall reactions to these proposals.

1. At the time the focus groups were carried out, these four strategies were being considered. We later narrowed the vehicle registration fee strategy to focus on emissions, and added a VMT fee strategy.

Because of the complexity of the topic, a detailed script was prepared for moderator training and practice sessions. The moderators' presentations generally followed the script but were not tied to it word-for-word. A combination of story boards and graphics were used in the various sessions to illustrate the options being described. Moderators did explicitly utilize the list of questions prepared for the groups. (Both the presentation script and the set of questions are included in an appendix.)

10.3 Focus Group Findings

No consumer loves the idea of a price increase; still, many members of the public agree that good transportation and a better environment are worth paying for. Focus group members were no exception. Most were willing to consider higher transportation prices if they could be sure of two things: 1) that the funds raised would be devoted to transportation improvements, and not diverted to other uses; and 2) that the agencies in charge of the funds would be held accountable for providing real benefits to the public, and could have the funding taken away from them if they failed to do so.

A vocal minority was opposed to any increase in transportation prices. Members of this group argued that government is wasteful and indifferent to the needs of the working person, and that pricing policies would exacerbate both problems with little or nothing to show for it. At the opposite end of the spectrum, another minority felt that problems created by the automobile justified significant price increases as well as regulatory restrictions on auto use, and that such policies should be vigorously implemented. By far the most common reaction was a mild, somewhat grudging acceptance of the idea that price increases could help reduce congestion, air pollution, and fuel use, and would raise revenues for improving the overall transportation system. In addition, most thought that the funds could be used to provide important improvements if they were earmarked for such uses and expenditures had to be reported in detail.

Differences in the attitudes expressed by participants in the four metropolitan areas were notable. In particular, participants in Los Angeles and Sacramento expressed strong anti-tax sentiments and were cynical about the ability of government to manage programs efficiently or keep its promises. Participants in the Bay Area and in San Diego were more positively inclined toward government, more willing to pay taxes or fees for government programs, and more optimistic that government could deliver promised improvements using the taxes or fees wisely.

Severity of the Problems

Participants in all four metropolitan areas stated that air pollution is a serious problem both to them personally and for society. On a scale of 1-10, where 10 is a severe problem, the rankings were typically 9 or 10. Most also ranked congestion as a serious problem, although many felt it bothered others more than themselves (because they do not personally face much congestion on their work trips). Also, some who do travel under highly congested conditions say that they have become resigned to congestion and do not believe that anything will reduce it; this group rates congestion as less of a problem that do those who believe that congestion relief is possible.

There was considerably less concern expressed over petroleum dependence; this issue tended to be ranked in the 5-7 range. The global warming issue did not resonate with the participants and only one participant commented on it - to raise a question about whether this might not be a false alarm.

Fuel Tax Increases

Fuel tax increases were the most widely accepted of the strategies, although support for an increase was mixed. Most of the participants accepted the point that the gas tax had declined, in real terms, over the past several decades, and most felt that an increase would be acceptable, especially if implemented gradually. Some, however, characterized the gas tax as "just another way to gouge the middle class."

Some of the participants thought that an increase in fuel taxes would be an effective way to alter how much driving people do, in the short run, and what kind of cars they drive, in the longer run. However, most felt that a tax increase of less than 50 cents would have almost no effect on their own travel behavior, perhaps reducing a few discretionary trips off-peak.

Many of the participants thought that at-the-pump charges would be too blunt an instrument to be used for congestion relief or air pollution reduction. They saw only a small connection between fuel consumption and driving conditions or emissions, and felt that technologies to strengthen such a connection, e.g., on-board monitors or roadside sensors, were "Buck Roger-ish" - too futuristic and speculative to be considered seriously.Imost all felt that revenues from any gas tax increase should be earmarked for transportation. The most frequently supported use for the revenues was to greatly improve transit and/or speed planned transit improvements. Some did not want to see more money spent on highways; a smaller number felt that this would be an important use of the monies.

Vehicle Registration Fees

Vehicle registration fees reflecting VMT, vehicle emissions, or fuel consumption were hard for most people to understand, though once explained, the concept seemed reasonable to most. On the other hand, most felt that considerable effort would be needed, either in the form of technology improvements or in the form of greatly increased surveillance and enforcement, to implement such a registration fee.

Several argued that tying vehicle registration fees to odometer readings and emissions tests would lead to widespread odometer tampering and test fraud, and many felt that passing the smog check should suffice as a check on emissions. Similarly, many of the discussants felt that fuel consumption was already addressed by the fact that the more fuel used (whether via VMT or via gas guzzler), the more tax paid, and there was little enthusiasm for adding new government incentives or disincentives in this regard.

Participants who owned old cars worried that they could face sharply increased fees, and owners of cars that had barely passed their last smog check were alarmed by this option. Several participants expressed concern over how higher vehicle registration fees would affect low income owners of old vehicles, but there was mixed reaction to a possible subsidy to offset this impact. Some thought that help in buying a reasonable quality used car would be a pragmatic and humane response, while others objected that the costs would be excessive and that moderate-income participants would also be hurt but would not get any help.

Vehicle buy-back programs were viewed positively by some, but others expressed strong reservations because the buy-back prices were rarely high enough to pay for a "good" used car as a replacement. There also was some concern that vehicle buy-back would have an inflationary effect on used car prices.

Owners of "classic" cars and other "old favorites" worried that they would not be able to keep their cars if they were forced to pay emissions fees as part of vehicle registration. Some in this group felt that a possible compromise would be to limit old cars that could not meet modern emissions standards to perhaps 500 or 1000 miles a year. Others, however, use their old vehicles more than that and would prefer a blanket exemption for classic cars or no emissions fee at all. On the other hand, group members who do not own such old cars tended to react with some impatience to these concerns, arguing that if a car is dirty it should be cleaned up or not used.

There was solid agreement that a VMT, energy use, or emissions fee should be based on actual vehicle performance, not a "typical" rate for a vehicle of a particular type and age; but there also was a great deal of skepticism about the amount of bureaucracy this might require, as well as the potential for fraud. Indeed, each group had at least one member who gave examples of ways to get a car to (temporarily) pass an emissions test, to show a low odometer reading, and so on.

Finally, many participants felt strongly that the current policy of allowing cars that are heavy polluters to continue to operate under waivers should be changed.[2] Furthermore, many of the focus group members did not realize that the cutoff point for passing the smog check varied with vehicle age and type, and a substantial number felt this too was unfair, preferring a uniform pass/fail cutoff point. (Others argued that the current approach is both acceptable and practical given the differences in vehicle technology.) A number of participants in the discussion groups felt that an emissions fee, as well as a flat prohibition against operating vehicles that produce very high emissions levels, would be a more equitable policy than the current one, if a reasonable method of implementation could be devised.

Congestion Pricing

Reactions to congestion pricing varied with urban area; the strategy was seen as potentially effective in the Bay Area and Los Angeles, but of limited relevance (because congestion was thought to be serious on only a couple of routes) in Sacramento and San Diego. In all four urban areas some of the participants said that, at least some of the time, they would pay a fee to avoid congestion during peak periods; but almost no one would willingly pay it on a regular basis.

[2] Many focus group members were unaware that waivers were permitted at all, and while California now limits the availability of waivers, most focus group members did not approve of the practice in any form or thought that waivers should be limited to a very short period, e.g., 30-90 days.

A number of participants felt that congestion pricing was basically unfair because the well-off who could afford to pay the fee already have many privileges (e.g., set their own work hours, work at home, etc.) while others, perhaps more time-constrained but less affluent, would either be forced to use far inferior options or to pay a fee they could ill afford. Several participants blamed unnecessarily inflexible employer work scheduling policies for much of the congestion, and felt that government should address this first rather than hit workers with higher fees.

The use of the revenues to improve commute alternatives was seen as dubious in Los Angeles and, to a lesser extent, in Sacramento: participants in those cities opposed highway expansion, but also felt transit could never be competitive except, perhaps, to downtown. Many felt that the money would be wasted by incompetent bureaucracies or arrogant politicians. In contrast, in both the Bay Area and San Diego, many felt that useful transit improvements could be made and that other desirable projects could be implemented.

Congestion pricing was hard for most discussion group participants to understand, except for applications on bridges, toll roads, and special lanes. This is in part because few are familiar with toll tags or other automatic vehicle identification (AVI) and electronic toll collection (ETC) technologies, and imagined that toll booths would have to be added to collect the fees, but would make things worse. Once AVI/ETC was explained to the group, most saw it as by far the best way to implement congestion pricing. A small number worried about the government knowing who traveled where, but this was not a concern for most participants. Indeed, several scoffed at the issue, arguing that if government wanted to know the movements of particular individuals they could easily do so now using available technologies.

Parking Pricing

Policies which would charge for parking were the least supported by discussion group members. Most discussion group members felt that parking was already priced where it was most costly to provide, generally in downtowns and higher-density employment centers and shopping districts. Where parking is free and plentiful, the participants argued, it also is a necessity, because alternatives to driving and parking are too poor to be competitive; pricing such parking, they argued, would make little difference to the amount of driving people would do. In addition, few could imagine a government-imposed tax or fee on parking that would be substantial enough to alter behavior or fund significant improvements to commute alternatives; nor did they believe that employers or other private sector parking owners would make parking charge revenues available to improve commute alternatives. Finally, if a parking charge were imposed at their workplace, most thought they'd park elsewhere - on a nearby street or in a nearby shopping center, for example.

Asked to consider parking surcharges of the sort that might be implemented by local government or a regional agency, several participants voiced general concerns about another government regulation on business. Several expressed doubts that such surcharges would be implemented or enforced; they ventured that public officials would back off in the face of employer opposition, as had happened with trip reduction requirements. On the other hand, the participants who currently pay for parking thought that parking pricing should be employed more often, and that daily rates should be no higher than their proportionate share of monthly rates, to encourage part-time transit use.

10.4 Interviews with Local Officials and Interest Group Representatives

To further explore the acceptability of transportation pricing measures, we carried out a series of interviews with state and local government officials, legislative staff, and public and

private interests from all four metropolitan areas, with a greater number of interviews in the Bay Area and Sacramento. A total of twenty-eight individual interviews were completed. In addition, we participated in a number of small group meetings at which transportation pricing policies were discussed. Participants in the meetings included elected officials, planning and transportation staff members, representatives of business organizations, labor leaders, environmentalists, academics, staffers of organizations representing ethnic and racial minority groups, neighborhood activists, and realtors.

The interviews and meetings with officials and interest group members uncovered very similar reactions to those obtained from citizens in the discussion groups. Most of those interviewed believe that transportation pricing strategies could be effective in reducing congestion, emissions, and fuel use, if carefully implemented. However, there was a great deal of skepticism about the political viability of such strategies and government's ability to implement them effectively. Indeed, a number of those interviewed explicitly requested that not only their specific comments but their participation in the interviews be kept confidential, out of concern that their views might be misinterpreted.[3]

A number of those interviewed, both supporters of pricing approaches and skeptics, felt that this is a poor time to be discussing taxes and fees with a public that is trying to cope with a shaky economy, losses of military bases, and pockets of high unemployment. Some believe that widespread anti-tax sentiment would make open support for increased transportation prices and fees politically dangerous. Others feel that pricing measures might be accepted when the economy is strong, but that as long as the economy is seen as weak or only recovering, pricing measures would lose, resulting in a setback for policies that could do some good and might succeed if introduced at a better time.

Several of those interviewed argued that the state should not attempt to design uniform state-wide transportation policies. They argued that the need for revenues, congestion relief, and air pollution abatement vary widely in different parts of the state and the lack of

[3] Because of the requests for confidentiality, we have not included the names of those interviewed for this study.

need for action in many areas might undermine an attempt to get a state-wide policy implemented. They recommended instead that the state should authorize local government - counties and in some cases regional agencies - to implement emissions-based registration fees, higher gas taxes with earmarked funds, etc. One partial exception to this preference for local action was in areas that cannot meet state and/or federal air quality standards; there, some felt that the state should mandate policies such as emissions-based registration fees rather than merely authorize local action. Another partial exception is in the area of VMT fees; some felt that over the long run these fees might substitute for the current bundle of fuel taxes, sales taxes, property taxes, and the like used to pay for transportation facilities and services, and that statewide action would be the preferred way to proceed with such a revenue program.

Fuel Tax Increases

Most of the persons interviewed acknowledged that gas taxes are far lower than those of other developed countries and probably too low to adequately finance existing transportation infrastructure, let alone pay for improvements. On the other hand, most also felt that higher gas taxes are a political non-starter at the current time, at least on a statewide basis. Some would support regional gas tax approaches, where the state would authorize regions to put a tax increase and expenditure plan on the ballot.

A smaller number believe that a state gas tax increase could be introduced right away, with the funds are earmarked for transit, air pollution reduction strategies, and other transportation improvements (in order of priority.) They believe that such a tax increase could be sold to the public as a way to fund needed projects that will be good for the economy and produce jobs, as long as the projects are ones that have public support.

Vehicle Registration Fees

Interviewees were concerned about whether higher vehicle registration fees would have the desired effect on emissions or energy use. They argued that additional fees of more than a few hundred dollars maximum would be unlikely, but by the same token would be too low to substantially change auto ownership levels or auto type choices. Conversely some worried that fee increases of up to three or four hundred dollars could seriously impact low income households, who might then face sharp cutbacks in their mobility (being unable to afford a better vehicle). In some cases, they thought, people might simply decide to leave the offending vehicle unregistered.

In contrast to citizen-discussants, most public officials interviewed believed that it would make more sense to use CARB/EPA data on average vehicle emissions by vehicle type and model year, rather than to rely on emissions test results. A common reaction was that the latter approach would encourage "clean for a day" fix-ups to reduce emissions, or outright fraud of various sorts. The use of data for a typical vehicle, i.e., with the fee calculated based on registration data and listed on the mailed-out registration form, was felt to be simpler and hence more realistic than approaches that would require an elaborate measurement, monitoring, and reporting system. In addition, average emissions data were thought by several to be no less fair or accurate than many other commonly accepted fee calculation methods, such as using average trip rates (for example) to calculate traffic mitigation fees.

Wider use of vehicle buy-back programs would receive broad support from those interviewed, although several recommended a repair-or-retire approach rather than simply scrapping a vehicle. Support also ran high for programs that would get high-emissions vehicles off the road or limit their use (e.g., repair-or-retire requirements for all vehicle owners, policies that would disallow waivers for super-emitters after a specified date (e.g., two years following enactment) or limit the waiver to, e.g., six months, policies establishing a

high emissions and mileage fee for super-emitters after a specified date.) Some favor pricing strategies to encourage these latter actions; others suggest that regulations should do so.

Parking Pricing

Many local government officials argued that parking regulation was no business of the state's - that local governments were much better positioned to develop parking policies that made sense for their areas. Academics, environmentalists, and some business leaders, in contrast, argued that local governments' parking regulations tended to range from poorly conceived to downright irresponsible. Academics and environmentalists argued for a stronger state role in reducing mandatory parking requirements, whereas business people wanted less government involvement of any sort.

Several local government officials reported pressures to reduce impact fees due from developers and employers, and thought it very unlikely that parking pricing or similar strategies aimed at land owners and managers would be attempted or would succeed at this time, at least as a local initiative. The gradual elimination of tax benefits for employer-provided parking is an option that some would endorse, but others believe that anti-parking strategies will do more mischief than good, for example by leading to parking spillovers into residential neighborhoods.

Parking cash-out, the state policy that requires certain employers who purchase or subsidize parking for their employees to offer them the alternative of a cash equivalent, was known to only a few of those interviewed. To most, it seemed to be an interesting way to begin to rationalize parking requirements, but not a particularly efficient or "market-based" strategy.

Congestion Pricing

Congestion pricing made sense conceptually to most of those interviewed, but there was deep distrust among some about a policy that seems to reward the affluent and already privileged classes. One elected official took the position that policies that allowing the affluent to buy their way out of a problem reduced the probability that the problem would ever be addressed properly, and hence was socially irresponsible.

The details of implementing congestion pricing worry many. (E.g., what if people try to pull over and wait for the price to change? What if people avoid the fee by crowding onto the local streets?) In addition, equity issues were raised: the concern was for low and moderate income workers with little flexibility and no good alternative choices. Using the revenues to improve travel alternatives was generally felt to be a prerequisite to congestion pricing, but there also were doubts that this would in fact be done, or that improvements such as additional bus services or pass discounts would be maintained for long.

Several believed that some form of road pricing would be inevitable if a substantial number of alternate-fuel vehicles came into use, because then it would become clear that conventional fuel taxes were no longer working as a finance mechanism. They also felt that, when that time came, differential charges by time of day might be implemented more easily.

Enthusiasm for allowing solo drivers to buy into HOV lanes was decidedly mixed. Some felt that this would be a fine way to pay for HOV lanes and related programs and saw this as the main way congestion pricing would be implemented in the foreseeable future. Others felt that SOV buy-in would be unacceptable because it would violate agreements under which lane additions were approved on condition that they be restricted to HOVs during peak hours. Both supporters and doubters expressed concerns over the feasibility and practicality of enforcing an HOV lane in which some SOVs were permitted, except with a very heavy dose of technology (SOV buy-in only with toll tags, video recording of all

vehicles without a toll tag, and either real time monitoring or imaging to detect a violator and trigger enforcement, or tickets by mail.)

10.5 Overcoming Barriers

In both the focus groups and the interviews, many were skeptical that effective implementation of any significant change in transportation pricing would proceed, at least in the next few years. The barriers, in this view, are an apparent lack of broad-based support for action, the strength of the anti-tax movement, the high visibility of government action on most of the strategies, and the lack of clear precedent demonstrating overall benefits and an ability to offset inequities. On the other hand, many thought that these barriers could be overcome by a combination of public education, good planning, provision of safeguards to protect the public interest, and application of emerging technologies. Suggestions for overcoming the barriers included the following:

- If implementation is to proceed, business, environmental, and social justice communities must be willing to publicly advocate transportation pricing changes and to take on the effort needed to educate the public.

- Specific proposals must address the equity issues directly, and must offer concrete commitments for offsetting harm in an environmentally and socially acceptable way.

- The creation of public-private oversight committees and the use of independent audits to assure funds are being well used and programs are working as intended would help reduce, though not entirely dissipate, suspicions about government programs of this sort.

- Approaches that give local governments or regions authority to implement pricing programs matching their circumstances make more sense, for the most part, than uniform statewide approaches. Authorization for local action permits those communities that can build support for a measure to proceed without forcing the issue on those who are not prepared to act. In many cases a city- or county-level authority would be sufficient to avoid spillover problems; or a regional agency could be given implementation authority.

- Two possible exceptions to the general preference for local or regional control are for emissions fees in nonattainment areas (where direct legislative mandates were suggested) and VMT fees to be used for revenue purposes (where a statewide program was suggested.)

- Several transportation pricing measures may become more acceptable as new technologies are implemented. For example, AVI/ETC technologies will greatly aid in the implementation of road pricing, parking pricing, and perhaps vehicle registration fee policies; as consumers become more accustomed to the AVI/ETC technologies they may also become more accepting of pricing strategies which utilize these devices. New odometer designs will reduce the likelihood of tampering and make fees based on odometer readings easier to implement. On-board vehicle diagnostic equipment will help people keep their emissions equipment in good order. Experience with remote sensing should clarify the role of high-emitting vehicles in the overall pollution problem, and increase public acceptance of emissions-based fees.

- Finally, as low emission and zero emission vehicles become a realistic option for more people, public willingness to accept road pricing, higher fees for petroleum fuels, and emissions fees also should increase.

11. Legal Issues [1]

11.1 Introduction

A number of legal issues will have to be confronted as policy-makers consider the use of transportation pricing to relieve congestion, improve air quality, reduce energy consumption, and lower greenhouse gas emissions. This chapter outlines key legal issues which must be considered in designing transportation pricing strategies. It is designed to aid policy-makers in understanding what can be implemented under existing law and what legislative issues must be dealt with in order to accomplish desired policy goals. The topics are complex and this brief treatment of them cannot replace a detailed legal review of specific proposals. Nevertheless, the chapter should provide a start from which interested public officials can move forward.

Because the relevant law is largely state law, and because our four case study areas are all California regions, we focus on California legal issues. California policy-makers are faced with a legal structure not ideally suited to the implementation of transportation pricing innovations and reforms. While a few such pricing strategies have been "pushed through the system," and more are possible, not only are there a host of general legal issues affecting implementation, but enactments over the last 15 years restricting new taxes, fees and assessments impose additional hurdles.

A variety of transportation pricing measures already exist under California law - tolls, fuel taxes, vehicle registration fees, vehicle licensing fees, and parking fees and taxes among them. The availability of these measures means, of course, that there is established law concerning their utilization, use of revenues, and so on. We start with a summary of these

1 This chapter is based upon an outline developed by Geoffrey S. Yarema of Nossaman, Guthner, Knox and Elliott. Mr. Yarema was assisted by Winfield D. Wilson, Robert D. Thornton, Barney A. Allison, and Steven N. Roberts. Elizabeth Deakin prepared the final version of the chapter.

existing fees and taxes, to provide background for discussion of possible additional measures.

We then turn to general considerations in designing transportation pricing strategies. Generally, the biggest legal issue facing a transportation pricing measure is whether it will be classified as a "tax" or a "fee," since the two are implemented under separate authority and are subject to different procedural and substantive requirements. The California rules are particularly strenuous; in addition to the concerns shared with other states over due process and equal protection, adequate nexus and appropriate use of funds, California must comply with a number of citizen-enacted propositions limiting and constraining the enactment of taxes and fees and the uses of the revenues therefrom. Hence, in this chapter we distinguish between "taxes" and "fees" under California law and discuss the advantages and disadvantages of each classification.

A number of other federal and state constitutional provisions and statutes, as well as common law, also affect the implementability of transportation pricing strategies. The conditions under which these measures may be lawfully imposed are reviewed and provisions governing collection and disbursement of proceeds are discussed.

We then apply these legal considerations to the set of pricing measures being evaluated in this study: road pricing and its variants (including tolling mixed flow highway capacity and charging for use of high occupancy vehicle lanes by non-high occupancy vehicles); parking pricing; increased at-the-pump charges (fuel taxes or other); and emission-based or VMT-based registration fees.[2] While the discussion is necessarily general, it does indicate some of the issues that might arise and points out some options for dealing with them.

We conclude with a brief review of the legal aspects of such frequently raised issues as whether extensive monitoring would constitute an unlawful search or invasion of privacy,

2 The measures considered in this chapter are described in somewhat different terms than in preceding chapters, because here we focus on the implementation mechanisms that might be used and the legal issues surrounding them.

whether differential prices based on congestion levels, tolls, etc. violate equal protection guarantees, and whether transportation pricing measures might amount to improper double-charging. Brief reference also is made to the is made to some of the issues that new technologies for implementing pricing measures might raise.

11.2 Current Transportation Fees and Taxes

At the time this chapter was prepared,[3] a number of transportation fees and taxes are already in place or authorized under California law. At, the following:

-- Tolls

The Legislature has authorized the California Department of Transportation (Caltrans) and other public and private entities to impose tolls on a variety of transportation facilities, including bridges, highway crossings, tubes, tunnels, subways, underpasses and overpasses acquired or constructed pursuant to the California Toll Bridge Authority Act (Sts. & Hwys. Code § 30000). Tolls have been in place for some years on the San Francisco-Oakland Bay Bridge (Sts. & Hwys. Code § 30600), the San Pedro-Terminal Island Bridge (Sts. & Hwys. Code § 30680), bridges across Carquinez Straits (Sts. & Hwys. Code § 30750), the Antioch Bridge (Sts. & Hwys. Code § 30760), the San Francisco-Oakland Rapid Transit Tube (Sts. & Hwys. Code § 30771), the San Mateo-Hayward and Dumbarton Bridges (Sts. & Hwys. Code § 30790), and the San Diego-Coronado Bridge (Sts. & Hwys. Code § 30796). Recent legislative action authorized four demonstration projects selected by Caltrans to be developed by private entities (Sts. & Hwys. Code § 143): the tolled use by single-occupant vehicles of high-occupancy vehicle lanes on I-15 (AB 713); facilities constructed and tolled pursuant to the El Dorado County

3 The chapter was drafted in Fall 1993 and updated in June 1995. Legislative action and court decisions since that time may have altered certain provisions reported herein. The reader should confirm the current status of laws and regulations before utilizing this information.

Toll Tunnel Authority Act (Sts. & Hwys. Code § 31100); and bridge and major thoroughfare construction to be undertaken by the Orange County Transportation Corridor Agencies (Gov. Code § 66484.3). The latter organization has recently opened tolled segments of its highways.

Caltrans has general authority to grant toll franchises under certain specified conditions (Sts. & Hwys. Code §§ 30800, 30810), including public hearings on the toll rates to be established. It is unlikely that Caltrans or any other state agency could by itself authorize a local entity lacking police powers to levy a toll, whether in fact the toll was a "fee" or a "tax," since this would be exercising a legislative prerogative.

Boards of Supervisors have no authority to grant franchises or licenses to construct or collect tolls, but may construct or acquire a toll road, subject to restrictions imposed by any law authorizing the construction or acquisition of toll toads. (Sts. & Hwys. Code § 30810, 30812).

-- Vehicle License Fee (Rev. & Tax Code §§ 10701 et seq.).

The vehicle license fee law currently (1996) provides for a "fee" equal to 2 percent of the value of the vehicle. Proceeds are allocated in part to counties to fund health services programs (Rev. & Tax Code § 11001.5; Wel. and Instit. Code §§ 17600, 17604); in part to cities for lost property tax revenues (Rev. & Tax Code § 11005(b)); and the balance to cities and counties based on population. Monies disbursed to cities and counties may be used for any county or city purposes.

-- Motor Vehicle Fuel License Tax (Rev. & Tax Code §§ 7301 et seq.).

The tax rate currently (1996) is $.18 per gallon (Rev. & Tax Code § 7351), levied on distributors for the privilege of distributing motor vehicle fuel; i.e., an "excise" tax. Subject to the provisions of any budget bill, proceeds are deposited into the State Transportation Fund (Rev. & Tax Code §§ 8352, 8352.2, 8353). Once in the Transportation Fund, the money is allocated to a variety of state and local programs. (See, e.g., Sts. & Hwys. Code § 2104 et seq.)

-- Motor Fuel Use Tax (Rev. & Tax Code § 8601 et seq.)

The rate currently (1996) is $.18 per gallon, levied on the consumer. (Rev. & Tax Code § 8651.) Proceeds are deposited into the Highway Users Tax Account and the Transportation Tax Fund. (Rev. & Tax Code § 9302.)

-- Local Motor Vehicle Fuel Tax (Rev. & Tax Code § 9501 et seq.; PUC Code 99500 et seq.)

Counties may impose a motor vehicle fuel tax on a county-wide basis. This tax may be expended only for the purposes authorized by Article XIX of the California Constitution. Prior to imposition, the proposal must be approved by the Board of Supervisors, a majority of the city councils of the cities having a majority of the population in the incorporated areas of the county, and a majority of the voters. The county and the majority of the cities having a majority of the population in the incorporated areas of the county must also have a written agreement with respect to allocation of the revenues between the counties and the cities. (Rev. & Tax Code § 9502.)

-- Local Vehicle License Fees (Rev. & Tax Code § 11101 et seq.)

Counties which have adopted a general plan providing for a network of county expressways and financing the first phase of constructing such highways from a county bond issue totaling at least $70 million, may impose a county vehicle license fee not to exceed $10 per vehicle. This vehicle license fee is imposed on the privilege of operating the vehicle upon the public highways and hence is an excise tax. Revenue from this source is to be distributed to the county for the construction of the expressway system.

-- Parking Fees and Taxes

Cities and counties, as well as private entities, frequently provide parking and charge for its use. In addition, some charter cites and counties have imposed taxes on parking revenues from private facilities (see discussion which follows on charter city authority.)

11.3 General Considerations in Designing Transportation Pricing Strategies

In designing transportation pricing strategies, one of the most important legal issues is whether to structure the charge as a fee or a tax, an issue which has serious procedural consequences, particularly in California. Other considerations stem from restrictions on the use of funds depending on the nature of the charges levied and the entity imposing the charges.

Classification of Charges as "Taxes" or "Fees"

In general, a monetary charge can be formulated as either a "tax" or a "fee". Whether a charge is classified as a "tax" or a "fee" depends upon the governmental entity's power and ability to impose the charge, as well as its amount in relationship to benefits received or burdens imposed. In addition, the classification determines the permissible use of the funds raised and, in California, may determine whether the charge is subject to voter approval.

"Fees" are considered to be charges (exactions) which compensate the government for a service rendered, a benefit conferred or a burden created by the payor. "Taxes" encompass exactions other than fees. Certain exactions may be properly classified as either a fee or tax. For example, persons using a segment of highway might be levied a fee for the benefit of using the highway; conversely, they might be charged an excise "tax" for the privilege of using the highway. (See Associated Homebuilders v. City of Livermore (1961) 56 Cal.2d 847, 852-853; Westfield-Palos Verdes Co. v. City of Rancho Palos Verdes (1977) 73 Cal.App.3d 486.)

The classification, if necessary, of exactions as fees or taxes may depend upon legislative intent, or constitutional or statutory proscriptions against one or the other which cannot be avoided simply through a judicious choice of terms. (California Bldg. Industry Assn. v. Governing Bd. (1988) 206 Cal.App.3d 212, 236, 237.)

Constitutional/Statutory Basis for the Imposition of Fees or Taxes

Taxes are imposed through exercise of the taxing power. Fees are imposed through exercise of the police power. The California Legislature has inherent police and taxing powers, limited only by the federal and state constitutions. Thus, the state can directly impose through appropriate legislation whatever taxes and/or fees it might wish, subject only to constitutional constraints and federal preemption.

Federal and state constitutions provide for equal protection and due process to protect against arbitrary and unreasonable differential treatment of persons. Likewise, both constitutions protect property rights, prohibit impairment of contracts, secure privacy, and limit searches of persons and property. Assuming the tax or fee is designed and implemented in a manner which complies with these constitutional mandates and limitations, statutory law further governs permissible action.

The California State Constitution grants police powers to all cities and counties. (Article XI, § 7). Consequently, all cities and counties may impose fees, subject to constitutional restrictions and such limitations as the Legislature may impose. (California Bldg. Industry Assn. v. Governing Bd. (1988) 206 Cal.App.3d 212, 234, 237.) Local entities other than cities and counties lack the police power, however, and thus may impose fees only if the Legislature authorizes it.

Local governments' ability to impose taxes depends on the form of government and its organization. Under California law, the state may not directly impose taxes for local purposes, but may either (a) impose local taxes for state purposes or (b) authorize "local governments" to impose taxes for local purposes. (Art. XIII, § 24.) California "charter cities" derive their taxing powers through their charters, subject to constitutional limitations and preemptive state and federal legislation. (Art. XI, § 5.) Non-chartered (general law) cities and counties and other local entities have only such taxing powers as the Legislature vests in them. (Art XIII, §24.) City charters are likely to provide for more unlimited police and tax powers than the Legislature accords to "general law" cities. (See, e.g., Stats 1971, Res.Ch.183, p. 3759 [Vallejo]: "The Council may. . . provide for any tax, license or permit fee, service or charge or other kind of revenue permitted by this Charter or by the Constitution or general laws of the State.")

As with fees, local entities other than cities and counties may impose taxes only if empowered to do so by a specific act of the Legislature.

In general, then, the State may impose either taxes or fees; California cities and counties have broad power to impose fees; cities and counties' ability to impose taxes depends on their form of organization and state authorizations; and other local government entities may impose fees or taxes only if specifically authorized by the state.

Limitations on the Power of State and Other Public Entities to Impose Transportation Fees and Taxes

Both federal and state law restrict the power of the state and other public entities to impose transportation fees and taxes or otherwise limit the use of revenues generated.

Federal Statutory Provisions

-- Federal Highway and Transportation Law

Federal statutory law has long stipulated that no toll of any kind may be imposed on the use of Federal-aid highways, with specified exceptions including bridges, tunnels, and facilities initially built as toll roads (23 USC; Sts. & Hwys. Code § 2201). However, the Intermodal Surface Transportation Efficiency Act of 1991 created certain exceptions to this general rule:

- for the initial construction of federal aid, non-Interstate, toll highways, tunnels and bridges (23 U.S.C.A. § 1012(a))

- for the reconstruction, replacement, resurfacing, restoration, and rehabilitation of existing federal aid toll highways, tunnels and bridges (23 U.S.C.A. § 1012(a))

- for testing the use of congestion pricing on up to five existing federal aid highways, of which two can be interstate highways (23 U.S.C.A. § 1012(b)). At the time this chapter was being written, the Federal Highway Administration had authorized a larger number of planning studies, including several in California. One such planning study is considering congestion pricing on the San Francisco-Oakland Bay Bridge; a second is evaluating a range of pricing strategies for the Los Angeles region, a third is evaluating pricing of HOV lanes in San Diego.

The ban on tolls on most federal-aid highways is a serious limitation on the consideration of congestion pricing or other road pricing strategies. While there has been considerable discussion both in Washington and elsewhere on the desirability of further loosening this restriction, the current Congress has substantially cut congestion pricing demonstration project funding, though work continues using funding authorized previously.

The general federal restriction on tolls does not apply to gas taxes (293 U.S. 533 [79 L.Ed. 641]), registration fees (Carley & Hamilton v. Snook, 281 U.S. 66 [74 L.Ed. 704]), or motor fuel dealer taxes (Anthony v. Kozer, 11 F.2d 641 (D. Or. 1926)).

-- The National Environmental Policy Act of 1969 (42 U.S.C.A. §4321 et seq.)

The National Environmental Policy Act - NEPA - establishes requirements for the evaluation and reporting of environmental effects stemming from a wide range of federal actions. Detailed implementation guidelines have been issued by the federal Council on Environmental Quality and by individual federal agencies, including the U.S. Department of Transportation. Depending on the specifics of the action in question, NEPA requirements could include an assessment of environmental impacts, consideration of alternatives, preparation of detailed statements or reports, and public notice and hearing. Certain transportation pricing projects or proposals could be construed as "federal actions" within the meaning of NEPA and thus would be subject to NEPA provisions.

Major State Constitutional Restrictions

A number of state constitutional and legislative provisions mandate a public vote, limit the use of revenues, or otherwise sharply restrict taxation in California. These provisions must be explicitly dealt with in designing transportation pricing measures. Key provisions are discussed below.

-- Article XIIIA (Proposition 13)

Proposition 13, approved by the voters in 1978, has several important provisions which affect government's ability to levy taxes in California. First, any increase in state "taxes" leading to increased revenues must be approved by two-thirds of the total membership of each house. (Art. XIIIA, § 3.) Second, any new "special tax" imposed by any city, county, or "special district" requires the prior approval of a two-thirds vote of the electorate voting on the proposal. (Art. XIIIA, § 4.) The special tax 2/3 vote requirement does not apply to taxes where the proceeds are deposited in the general fund of cities or counties (City and County of San Francisco v. Farrell (1982) 32 Cal.3d. 47), but does apply to taxes where the proceeds are deposited in the general fund of special districts (Rider v. County of San Diego (1991) 3 Cal. 4th 1).

Districts formed prior to 1978 which lack the power to impose real property taxes are not "special districts" and thus are not subject to the two-thirds vote requirement of Article XIIIA. (Los Angeles County Transportation Commission v. Richmond (1982) 31 Cal.3d 197.) Recently a divided Court of Appeal in essence held that any tax imposed by any independent district, organized after 1978, requires a two-thirds vote. Santa Clara County Local Transportation Authority v. Guaridino (6th Dist. H010835 Nov. 10, 1993). The Supreme Court upheld this decision.

-- Article XIIIB (Gann Initiative)

Article XIIIB establishes an appropriation limit for each governmental entity in California. In any year, governmental entities may not expend more than their appropriations limit for the prior year, adjusted for changes in cost of living and population. As a consequence, an entity which receives revenues in excess of its appropriations limit is required to transfer or refund the excess. For the state itself, fifty percent of any state revenues in excess of the state's appropriations limit must be transferred to the State School Fund, and the balance refunded by revision of the tax rates or fee schedules. Any excess revenues another entity of government receives must be returned through a revision of tax rates or fee schedules.

Proceeds from regulatory licenses, user charges and user fees are considered revenue under Article XIIIB, except "to the extent that those proceeds do not exceed the cost to the entity in providing the regulation, product, or service." (Art. XIIIB, § 8(c).)

Appropriation limits of existing governmental entities may be changed by the electors upon a majority vote, to last for four years. The appropriations limit for new entities is established by the vote of the people.

-- Proposition 62 (Gov. Code Section 53720 et seq.).

Proposition 62 requires that any taxes imposed for a specific purpose ("special taxes") be approved by two-thirds vote of the electorate and requires that any taxes imposed for general purposes ("general taxes") be approved by a majority vote. Government entities other than the State are facially subject to Proposition 62 (Gov. Code § 53720 et seq.). While Proposition 62 purports to apply to chartered cities, it probably does not as a matter of law since a statute (even if enacted by initiative) cannot amend municipal rights derived through the Constitution.

Several cases have held Proposition 62 invalid. (City of Woodlake v. Logan (1991) 230 Cal. App. 3d 1058; City of Westminster v. County of Orange (1988) 204 Cal. App. 3d 623.) Two unreported cases have held that entities without the authority to impose property taxes may enact special taxes without any vote under Proposition 62. (Vernon v. State Board of Equalization (1992) 2nd Dist. B057899; Ward v. State Board of Equalization (1992) 4th Dist. G011284.)

Other State Constitutional Provisions

Several other constitutional provisions could directly affect transportation pricing measures and are briefly mentioned here.

-- Restrictions on Who May Levy Taxes and Assessments

Article XI Section 11 specifies that the Legislature may not delegate to a private person or entity the power to levy taxes or assessments. The Legislature has, however, authorized Caltrans to enter into agreements with private parties to establish toll rates and to impose tolls to repay the cost of developing and operating transportation facilities, together with a reasonable return on investment. (Sts. & Hwys. Code § 143).

Article XI, Section 14 provides that any local government formed after 1976, the boundaries of which include all or part of two or more counties, cannot levy a property tax unless the tax has been approved by a majority vote of the qualified voters within that local government. A tax based on the value of a vehicle, rather than on the privilege of using it, would probably fall under this provision. If the tax were earmarked for a specific purpose by a city or county, or if it were imposed by a special district, it would also require a 2/3 vote under Proposition 13.

-- Restrictions on the Allocation or Use of Funds

Article XIII, Section 1(a) provides that all property, real and personal, is taxable, but must be assessed at the same percentage of fair market value. This would restrict differential taxation of vehicles and might also affect differential taxation of parking spaces, e.g., ones used by single occupant vehicles vs. multiple occupant vehicles. (But differential fees still could be devised.)

Article XIII, Section 14 further provides that all property taxed by local government must be assessed in the county, city, and district in which it is situated. These provisions might, for example, prevent taxation of vehicles not garaged in the locality (further analysis would be needed to evaluate this issue.)

Section 15 of Article XI states that all revenues collected under the Vehicle License Fee law, above the cost of collection, must be allocated to counties and cities according to statute.

Article XVI, Section 6 specifies that neither the State nor other public body may make, or authorize, a gift or a loan of public funds to any other person, association or public or private corporation. Consequently, revenue of one entity cannot be transferred to another entity unless the first entity receives sufficient consideration for the transfer, or unless a "public purpose" for which the transferring entity is authorized is thereby served. The State may distribute revenue to local entities to carry out "State" purposes but a city, for example, could not transfer its revenues to another entity unless a municipal purpose would thereby be accomplished. Partly countering this restriction, Article XVI, Section 24 provides that the Legislature may authorize cities and counties to enter into contracts to apportion between themselves sales or use taxes imposed by them. However, a majority vote of the electorate is required before any such contract becomes operative.

Article XVI, Section 8 was added by Prop. 198 and provides that a fixed percentage of all state revenue must be set aside for the support of public schools. Increased revenue to the

state from transportation pricing measures thus will lead to automatic increased support of the school system. If the increased funds themselves are earmarked for other uses, the state may have to reallocate funds from other programs in order to meet its the fixed-percentage obligation to the schools.[4]

Article XVII, Section 3 specifies that no money may be appropriated by the State for any corporation or institution not under the exclusive management and control of the State. Notwithstanding this provision, private companies may be granted the right to levy tolls to improve preexisting public roads. Blood v. McCarty (1896) 112 Cal.561.

Article XIX, Section 1 provides that State revenue from taxes on motor vehicle fuels, over and above the cost of collection, can be used for specified purposes only. These uses include the operation of public streets and highways, related public facilities for non-motorized traffic, the construction of public mass transit guideways, and mitigation of environmental effects of highways and mass transit. This provision limits the expenditure of the proceeds of any State tax imposed on motor vehicle fuel.

Section 2 of Article XIX further provides that revenues from (a) fees or taxes, (b) imposed by the State (c) upon vehicles or their use and operation, over and above the cost of collection, can be used for restricted purposes only. As in Section 1, these uses include the operation of public streets and highways, related public facilities for non-motorized traffic, the construction of public mass transit guideways, and mitigation of environmental effects of highways and mass transit. In addition, the mitigation of environmental effects of motor vehicle operation due to air emissions is a permitted use of the revenues. This provision would sharply limit the expenditure of the proceeds of any State charge such as tolls, fees for use of HOV lanes, road user charges, vehicle registration fees, or parking charges. However, charges imposed by another entity would not be so affected.

4 In fiscal 1993, the Legislature allocated local property tax revenues to local schools in order to satisfy this duty. See also County of Los Angeles v. Sasaki, 2d Civ. No B077722.

Under Section 3 of Article XIX, revenues subject to Section 1 (motor vehicle fuel taxes) must be allocated by the Legislature in a manner which insures the continuance of existing statutory allocation to cities, counties and areas until a redetermination is made based upon equitable geographical and jurisdictional needs, with equal consideration given to the transportation needs of all areas of the State and all segments of the population. Furthermore, under Section 4, gas tax revenues cannot be used for mass transit until such use is approved by a majority vote of those persons within the area within which the revenues are to be expended.

Under Section 7, Sections 1-4 of Article XIX do not apply to fees or licenses imposed pursuant to the Sales and Use Tax Law or the Vehicle License Fee Law.

State Statutory Provisions Relating to the Adoption of Transportation Fees and Taxes

Finally, statutory provisions affect government's power to adopt transportation fees and taxes and the procedures which must be followed in doing so. Two such provisions deal with referenda and environmental review under the California Environmental Quality Act (CEQA).

-- Referendum Provisions:

If a transportation pricing revenue measure were to be adopted by a city, county, or most districts, it potentially could be subject to a referendum. Referenda are initiated by petitions which must be filed within 30 days after a local ordinance is adopted. The measure is then suspended until it is voted on.

The referendum is not available where the measure is for a tax levy (at least for the usual operating expenses of the entity), or where the Legislature has specifically designated the legislative body of the county, city or district to carry out the program. Some cases have

extended the prohibition to fee ordinances as well as tax measures. (e.g. Dare v. Lakeport City Council (1970) 12 Cal.App.3d 864, 868.)

-- CEQA Requirements:

The California Environmental Quality Act (CEQA), like its federal counterpart NEPA, could apply to a number of transportation pricing proposals. CEQA is of broader scope than NEPA; a wider range of proposals require CEQA review than require NEPA review. (In some cases both NEPA and CEQA reviews are necessary.)

CEQA is particularly likely to apply to transportation pricing measures which use revenues to expand transportation facilities and services. CEQA generally requires a public agency, prior to taking discretionary action on a "project", to consider environmental impacts and to address mitigation measures. CEQA does not apply to the establishment or modification of rates, tolls, fares, and other charges by public agencies, if such charges fund capital projects necessary to maintain service within existing service areas. (Pub. Res. Code § 21080(b)(8).) However, CEQA does apply to rate increases to fund capital projects for the expansion of systems. (14 Cal. Code Reg. § 15273(b).) Moreover, although CEQA does not apply to the development or adoption of a regional or state transportation improvement program, individual projects developed pursuant to these programs are subject to CEQA. (14 Cal. Code Reg. § 15276.)

Actions taken by regulatory agencies, as authorized by State or local ordinance, to assure the maintenance, enhancement or protection of the environment , i.e., regulatory programs which involve procedures for protection of the environment, are exempt from CEQA, except for construction activities and relaxation of environmental standards.

Implications: Advantages and Disadvantages of Classification as Tax or Fee

As the preceding discussion implies, a number of consequences will flow from the classification of a particular transportation pricing measure as a fee or tax. These are briefly outlined below.

Advantages to Classification as a Tax:

- No limit on amount.
- No restriction on use of proceeds, except that proceeds may not be transferred to another entity unless a public purpose for which the first entity has been formed is thereby served.
- No need to establish nexus between the amount of charge and the burden created by or benefit conferred on the person, activity or thing being taxed.

Disadvantages to Classification as a Tax:

- If imposed by the State, it would require a two-thirds vote of each house under Prop. 13.
- The revenues generated would be included in the State's appropriations limit under the Gann Initiative.
- The revenue would factor into subsequent Proposition 198 (State School Fund) computations.
- If imposed at the local level by a city or county, it would require a two-thirds vote of the electorate, unless the proceeds were deposited into the city or county's general fund.
- If imposed by any limited purpose special district formed subsequent to 1978, it would require a two-thirds vote of the electorate.

- If imposed by any local entity, it would be subject to a challenge that a vote is required under Proposition 62.
- If imposed by any local entity other than a chartered city or county, it would have to be authorized by the Legislature.

Advantages to Classification as a Fee:

- If imposed by a city or county, it may not require enabling legislation (i.e., it may lie within the locality's police power.)
- It would not be subject to voter approval under either Proposition 13 or Proposition 62.
- Proceeds do not affect the entity's appropriation limit.

Disadvantages to Classification as a Fee:

- The burden is upon the entity imposing a fee to establish the nexus between the amount of the fee and the burden created or benefit conferred. (See Beaumont Investors v. Beaumont-Cherry Valley Water Dist. (1985) 165 Cal.App.3d 227.)
- Proceeds must be earmarked to compensate for the benefit conferred or burden created.

In general, transportation pricing measures would be easier to adopt if designed as fees rather than taxes, provided that a defensible nexus for the fee can be established and provided further that restrictions on the use of the funds are acceptable. Regardless of which approach is take, note that for many transportation funding sources, provisions of the California Constitution restrict the use of funds to specified transportation purposes.

11.4 Applying These Legal Principles to Specific Pricing Measures

Tolls / Road Pricing in General

The most serious limitation on the use of tolls (road pricing) is the federal statutory restriction on tolls which applies to most federal-aid roads, and hence to most of the roads which would be likely candidates for tolls or congestion prices. While there have been some legal opinions to the effect that road user charges could be structured as "user fees" and thus avoid this restriction, such a claim almost certainly would lead to litigation. The removal of this restriction in favor of state discretion over whether or not to toll, or in the alternative a considerable expansion in the numbers of exceptions allowed and "demonstration projects" made available, would be likely prerequisites to the imposition of tolls on existing federal-aid facilities.

The use of tolls as a means of financing and managing new capacity seems more promising in the short run, along with the restructuring of tolls on existing toll facilities. Under California law, such toll charges could be structured either as taxes or as fees, and in either case would require authorization by the State Legislature. If a tax, Proposition 13 restrictions would apply, as well as other restrictions concerning the adoption of taxes and the use of tax revenues (discussed earlier).

Tolls may raise a variety of other legal questions. For example, the imposition of tolls could have an impermissible impact on contracts if, e.g., the tolls affected the state's ability to pay back bonds issued for road construction. Tolls also might have a questionable effect on contracts in cases where preexisting fixed price contracts involving the provision of transportation services might be affected. (Article I, section 9 [U.S. Constit., Art. I, § 10, subd. 1]: The Legislature may not impair the obligation of contracts.)

Tolling Mixed Lane Highway Capacity

If a toll were designed as a tax, there would be no limitation upon variable tolls conditioned upon level of congestion, time of day or other factors, as long as various categories or vehicles are treated equivalently. If the toll were a fee, a nexus between the amount of the fee and the burden created by, or benefit conferred upon, the driver or vehicle would have to be established. A fee could not arbitrarily distinguish between types of vehicles (e.g., commercial and passenger) without justification, nor could it differentiate by time of travel without an evidentiary basis for doing so. However, a certain amount of latitude would be permitted in establishing presumed impacts of a particular class of vehicles. Russ Bldg. Partnership v. City and County of San Francisco (1987) 199 Cal.App.3d 1496, 1511-1516.

Charges for Use of HOV Lanes by Non-HOVs

A charge for the use of HOV lanes by non-HOVs would in essence create a "toll lane" with the toll being waived for certain vehicles (i.e., HOVs). However, State law provides for the exclusive or preferential use of designated lanes for HOVs (Sts. & Hwys. Code § 142). Any system therefore would have to ensure the "preferential" treatment of HOVs over non-HOVs; i.e., ensure that non-HOVS be allowed only if there is excess capacity in the HOV lanes.

Under federal law, in addition to the general prohibition against tolls on federally funded highways which would require waiver, a charge to use an HOV lane could violate contractual agreements with the federal government regarding funding for HOV lanes. This is because HOV lanes are generally for the exclusive or preferential use of HOVs, though there is no blanket statutory prohibition on the use of such lanes by non-HOVs (23 U.S.C.A. § 142).

Such a toll could probably be justified as either a fee or a tax. It could be a tax for the privilege of using such a lane, or a fee to compensate for the benefit intended to be conferred; i.e., a more rapid commute.

Parking Charges

As current practices indicate, a tax can be imposed on the operators or users of private and/or public parking facilities, and fees can be levied to recover the costs of providing public parking. In addition, a variety of tax policies and statutory requirements can be used to influence the private sector's pricing of parking, although some of the mechanisms range far afield from economic principles.

Public entitities as owners and operators of parking generally have wide discretion in establishing fees for its use. Fees for parking on public property could be more widely implemented to include a fee for all on-street parking, since a private benefit is being obtained at public expense. However, the total amount of the fee could not exceed the value of the benefit conferred/burden created without becoming a tax.

The more difficult and interesting question is whether government can impose a fee on all parking including private parking facilities, structured as an impact fee. For such a fee to withstand legal scrutiny it would have to meet the nexus test and be roughly proportional to the costs imposed on the public.

A government-imposed parking fee levied on private parking facilities would have to be justified on the basis that a burden is created by bringing a vehicle into a given area, or like ground. It would probably not be enough to state that the mere parking of a vehicle creates a public burden, but a justification based on congestion, emissions, or other environmental impacts might be established.

Other requirements that might be structured to meet the nexus test include requiring employers to charge employees for parking and requiring commercial leases to separate out the cost of parking and make such costs optional. However such provisions would raise the issue of whether the fee requirement could be construed as an interference with contracts if, for example, a long-term lease provides for free parking or union agreements stipulate it. Structuring the requirement to avoid this result might entail exempting existing contracts.

Tax policy itself could be used as a mechanism for providing incentives for the private sector to charge for parking. For example, "free" parking could be made taxable to the employee and/or nondeductible to the employer. Tax policy has moved in a somewhat different direction, however; recent changes in federal law have capped the value of free parking that is treated as a "de minimus" employee benefit, and upped the value of permissible non-taxed transit and ridesharing benefits (though the amount is still well below that for parking.) In addition, both California law and a recent federal proposal provide for parking cash-out, a program through which certain employers who provide free parking must also offer their employees the option of taking the cash value instead.[5]

Increased At-the-Pump Charges

At-the-pump charges could be imposed on (a) the quantity of fuel sold, (b) the act of selling fuel, or (c) the act of buying fuel. The charge could be classified as either a fee or tax in the first case. In the latter two cases the charge would be a tax and its amount could be based on the quantity or value of fuel sold, or just a set amount.

At-the-pump charges based on the quantity of fuel sold would qualify as fees only if adequate findings or studies justify the nexus between the amount charged and the benefit conferred or burden created. Benefits and burdens could be justified in a number of ways,

5 At the time of this writing, the California parking cash-out program resulted in differential federal and state tax treatment and in general was not being greeted with much enthusiasm by employers.

with varying difficulty in defending the justification. For example, costs related to the production and transport to point of sale of transportation fuels are at least roughly proportional to amounts sold, as are carbon dioxide emissions.

Charges on fuel purchases are often termed "road user fees" on the grounds that the amount paid by the purchaser reflects how much use his or her vehicle makes of the roads. However, fuel consumption deviates considerably from VMT, and hence is a very imprecise measure of benefit conferred or burden created. Air pollutant emissions are even less directly related to fuel use because of differences in emissions controls among vehicles. Technically, then, charges on fuel sales generally would be more accurately classified as taxes than as fees.

For user fees, advanced technologies can be imagined which could accumulate information on miles driven, emissions produced, facilities used, etc., and then be read by scanners at the pump, but these technologies are a long way from being available. In the meantime, simpler at-the-pump charges proportional to fuel use are the most likely approach, with simple vehicle identification technology (e.g., smart license plates) perhaps becoming available in a few years, allowing vehicle characteristics to enter the calculations. (The legal issues raised by the use of such technologies are outlined later in this chapter.)

In any event, charges on fuel sales probably would be subject to state constitutional provisions restricting the use of revenues (for example, transit operations may not be funded with these revenues.)

Vehicle Registration Fees

Vehicle registration "fees", currently a flat amount plus a market value component, could be modified to include fees for actual or estimated VMT, emissions, or other costs imposed through the use of the vehicle. As in the case of at-the-pump charges, such fees would be greatly facilitated by still-to-be-developed advanced technologies. Simpler methods could be

used, however. A VMT fee, for example, could be justified as a (rough) charge for road use, and levied on the basis of owner/lessee-reported odometer readings at the time of vehicle registration (where the registration record would include previously reported odometer reading and the fee would be based on the difference in readings.) Since under-reporting could be a problem, such an approach would likely require a carefully designed set of enforcement provisions, including sealing the odometer, requiring tamper-resistant odometers, requiring periodic odometer inspection and third-party reporting of readings (e.g., by inspection/maintenance technicians), providing for a penalty or fee for a non-functional odometer, etc.

As a second best strategy an average VMT for vehicles of a particular type and age could be attributed to the vehicle and used as the basis for the fee. However, because of individuals' variable driving habits, such a "fee" might be subject to challenge. Even if the fee were collected in arrears, paid at the time of registration and based on miles driven the previous year, it might be challenged if based on VMT alone, since the burdens created and benefits conferred are commensurably different depending on the facilities used, driving conditions, and so on. For example, persons who drive predominantly on surface streets could challenge portions of a fee allocated to the freeway system, and vice versa; though the agency might be able to successfully defend this approximation as reasonable under the circumstances.

An agency might, however, be successful against such challenges by establishing the reasonableness of its classifications. For example, the use of average VMT estimates for a particular vehicle type and year might be defended on the grounds that the VMT estimates are based on a statistical sample of vehicles in use in the state. A provision allowing for the estimate to be periodically "corrected" based on an actual VMT reading, e.g. at the time of vehicle registration or sale, also would offer evidence of reasonableness.

One issue would be how the VMT fee would be justified - how nexus would be established. If the VMT fee were to be used to pay for road improvements, double-charging might be an issue. The need to show costs imposed or benefits conferred may require a distinct showing

separate from other existing charges. For example, if a road were built and maintained with assessment district funds (where persons within a given area are levied a fee for the road based on benefit conferred), a VMT fee to recompense for use of the road could not be justified, although an additional fee for extraordinary repairs, or for emissions damages, might be. Of course this is a legal issue only if the charge is characterized as a fee, since if treated as a tax double-charging is irrelevant.

An emissions-based registration fee might be levied on each vehicle in an amount necessary to compensate for the damage caused by pollutants created by the vehicle. The vehicle's emissions could be measured at an annual or biennial vehicle inspection testing (with, however, considerable possibility for inaccuracies and/or fraud.) [6] As in-use vehicle monitoring technology improves, emissions might eventually be tested on a continual basis.This might be accomplished through roadside remote sensors or on-board emissions monitors. The critical issue then would be the quantification of the cost of pollution caused by a particular vehicle. That is, what is the monetary cost of damages attributable to a pound of NO_x?

Alternatively, an emissions fee could be based on CARB/EPA estimated average emissions for the type of vehicle and model year. As in the earlier VMT example, a fee based on such averages rather than actual vehicle performance might be challenged on the ground that a particular vehicle was cleaner than others of like year and type and, hence, the fee is a tax. The defense, however, would be that such a classification is reasonable; the courts would be likely to permit a certain latitude in establishing the presumed impacts of a particular class of vehicles. The defensibility of using such average data would be buttressed by frequent surveys of actual emissions levels of a sample of vehicles (a strong evidentiary basis for the emissions level), as well as by the availability of fee adjustments if a car is tested and found to be substantially cleaner than the average.

6 Knowing that their vehicle registration fee would be lower if their car is clean at the time of inspection would give motorists and incentive to have repairs or other adjustments made just before the inspection takes place. The resulting measure would not necessarily be representative of average emissions during the year. (At the opposite extreme, consider the hapless motorist whose vehicle emissions control, unbeknownst to her, breaks down just before the inspection takes place.)

A "tax" based on emissions could be more flexible than a fee in that it could be arbitrary in amount, but differentiation between vehicles of different types and ages would still require a rational basis for distinctions to avoid equal protection concerns. Under California law such a tax would also be subject to Article XIX, section 2, unless it were imposed under the Vehicle License Fee Law, in which case section 2 would not apply. (Art. XIX, § 7.)

With either a fee or a tax, a heavily polluting vehicle might incur a charge that approaches or actually exceeds the value of the vehicle. In these circumstances the question will arise, does this amount to a regulatory taking? The California Constitution Article I, section 7(a) and the 14th Amendment of the U.S. Constitution provide that persons may not be deprived of property without due process. Here, the result will depend on the reasonableness of the charge and the fairness of the process through which it is imposed.

A second issue concerns the potential for such a fee or tax to amount to an impairment of contracts - for example, where an existing fixed price contract does not contemplate a substantial new charge.

It should be noted that the vehicle registration fee would not reach out-of-state vehicles without substantial change in state law and increased enforcement concerning treatment of vehicles temporarily in the state. While provisions for implementing charges could be devised, such provisions may not discriminate against or unfairly assess out-of-state vehicles or interfere with interstate commerce.

The expenditure of proceeds from such vehicle registration fees would probably be subject to California Constitution Article XIX, Section 2. Thus, in order to be classified as "fees", the proceeds from such a program would have to be allocated to remediating the problems caused by such pollutants. However, as is the case for fees or taxes on fuel sales, permitted uses of the revenues could be fairly broadly encompassing and still pass a reasonableness test.

11.5 Other Legal Issues: A Brief Comment

The preceding discussion shows how various transportation pricing strategies might be implemented, with some effort, under existing laws which limit taxes, set strict standards for justifying fees, and restrict use of funds. Other legal issues also will be raised by these strategies, however. Not infrequently, questions about unfair treatment of different user groups, invasions of privacy, and the like have significant legal as well as political components. These issues are discussed here briefly; a more specific discussion would require the development of specific proposals to be evaluated.

-- Do Transportation Pricing Measures Create Unreasonable Distinctions Among Transport Users?

Many transportation pricing measures would distinguish transport users in a variety of ways - whether they are using facilities which are congested or not, whether they travel alone, whether their vehicle gets high or low gas mileage. Questions may arise about the legality of these distinctions, since federal and state constitutional provisions limit unreasonable or arbitrary classifications or differential treatment of persons: Article I, Section 7(a) of the California Constitution and the 14th Amendment to the U.S. Constitution provide that no person may be denied equal protection of the laws. The ban against unreasonable distinctions does not, however, prevent classification by the Legislature or require that statutes operate uniformly with respect to persons or things which are in fact different. Classifications are valid unless unreasonable or arbitrary.

Similarly, California Constitution Article I, section 7(b) and the 14th Amendment stipulate that no citizen or class of citizens may be granted privileges or immunities not granted on the same terms to all citizens. As with the equal protection clause, however, this does not

prevent classification by the Legislature or require that statutes operate uniformly with respect to persons or things which are in fact different.

Finally, California common law provides that the highways within the State are deemed to be public roads held in trust by the State. All members of the public have the right to use highways, subject to reasonable police regulation. (Ex parte Daniels (1920) 183 Cal. 636, 639.) Here again, this does not prevent reasonable classifications for taxation or fee purposes. For example, classifications differentiating trucks and automobiles, single occupancy vehicles and high occupancy vehicles, and so on have been justified in the past.

In general, then, distinctions among users are acceptable as long as the classifications are reasonable.

-- Do Monitoring Aspects of Transportation Pricing Measures Invade Privacy or Constitute Unreasonable Searches?

The development of transportation pricing strategies will depend in many cases on the monitoring of vehicles and their use. Monitoring may rely on very simple methods, such as mandatory reporting of vehicle odometer readings at time of registration, vehicle inspection, and sale, use of parking tickets which record time of entry and exit, and so on, to approaches which apply advanced technologies such as toll tags, video imaging, or smart license plates together with systems of roadway sensors which can identify when a vehicle crosses a certain point or measure in-use emissions. Whether high tech or low, monitoring approaches raise concerns about potential violations of state and federal constitutional bans against unreasonable searches and protections of the right of privacy.

Would monitoring of emissions, VMT, or highway use constitute a search within constitutional meaning of the term? Article I, Section 13 of the California State Constitution and the 4th Amendment of the U.S. Constitution provide that there may not be unreasonable searches of persons or their effects. However, there is no "search" in the

constitutional sense unless there is an invasion into some area reasonably regarded by the victim as private. (Katz v. United States (1967) 389 U.S. 347, 351; see also People v. Hyde (1974) 12 Cal.3d 158, 166 [searches conducted as part of regulatory scheme with administrative purposes rather than as part of criminal investigation to obtain evidence of a crime need not necessarily be supported by probable cause].)

Certain monitoring approaches might also raise concern over invasion of privacy. Under Article I, section 1 of the California State Constitution, privacy is an inalienable right, and this right is broader than the federally recognized right of privacy. (City of Santa Barbara v. Adamson (1980) 27 Cal.3d 123, 130 n.3.) However, in matters relating to governmental intrusions into privacy, the right does not arise where the individual does not have a reasonable expectation of privacy. (Wilkinson v. Times Mirror Corp. (1989) 215 Cal.App.3d 1034, 1046-48.)

The privacy issue with respect to those who voluntarily agree to participate in transportation pricing by having sensor devices placed in their cars will be a matter of contract. The incentive for contracting to have devices placed in their cars is that they need not stop at toll booths but can be charged automatically. The implanting of the sensor devices in their automobiles can contractually be conditioned upon the agreement that the manager of the highway may monitor their vehicles for the purposes of collecting the correct tolls. The uses to which this information can be put should be limited, but probably could include transportation planning and forecasting as well as direct billing of users.

A more difficult issue is when the surveillance devices are used to identify motorists who have not voluntarily agreed to such surveillance. However, while motorists may claim that their privacy is being invaded, it is unlikely that such claims would have merit, so long as the monitoring was for an authorized public purpose.

Overall, invasion of privacy and unlawful search claims are unlikely to have legal merit as long as the transportation pricing measures are well designed and implemented.

-- Would Standardizing Monitoring Equipment Raise Intellectual Property and Anti-Trust Issues?

A technology which will permit several transportation costs all to be billed to a central account will in the end be more economical. For example, if an individual passing through the toll plaza at the San Francisco-Oakland Bay Bridge can receive a bill also containing charges incurred in using the Golden Gate Bridge, operated by a different authority, the cost of the monitoring and billing systems will be reduced and convenience to the motorist will be increased. Parking charges at public and private facilities also might be added to the same bill, further increasing convenience and efficiency. Consequently, rather than setting up competing technologies on different facilities, government may wish to ensure that technologies are compatible.

In order to do this, it will be necessary to establish certain rules about the "architecture" of any systems which will be used and to set forth other criteria in vendors' contracts which will not permit normal intellectual property rules to get in the way of unifying this technology. Any system on which several vendors are agreeing to the standards also raises anti-trust issues. These latter issues can normally be eliminated by government's insistence on certain standards, relieving the private parties from any accusation that they are conspiring to eliminate competitors. However, the seriousness and complexity of the issues mandates that detailed attention should be paid to them once specific proposals are on the table (Nossaman, Guthner, Knox & Elliott, 1993a). Finally, the development of technology carries with it a possible allocation of tort liability to third parties for property damage or personal injury. Sovereign immunity and insurance can be ways of dealing with these concerns (Nossaman, Guthner, Knox & Elliott, December 1993b,c,d,e).

12. Implementation

12.1 Overview

Designing a transportation pricing measure which is estimated to have the desired impacts, is acceptable to the public, and can pass legal muster is a major undertaking. However, a well designed, politically and legally feasible measure is only a starting point. Successful implementation of the measure requires that attention also be given to a number of other issues. This chapter provides an introductory discussion of such issues.

Implementation planning activities typically include resolving who will be responsible for various implementation steps, what specifically they will be expected to do, what funds they will have to pay for their activities, when they will be expected to have carried out each step, where specifically the measure is to be implemented, what objectives it is to be measured against, and how it is to be enforced, monitored, evaluated, and revised as necessary. Specific items that in most cases will need to be dealt with include the following:

- deciding which details of the measure should be specified in its authorizing legislation (if needed) and which ones left to implementing agencies (and/or private entities) to develop or refine

- determining what organizations - public or private - will be responsible for development of the measure and its various implementation elements, including monitoring, enforcement, evaluation, and periodic updating or revision

- providing funding for the initial planning and implementation of the measure, or real-locating existing funds for this purpose (even revenue generating measures generally require up-front planning and implementation expenditures)

- establishing a schedule for detailed planning and initial implementation

- assigning responsibilities for monitoring implementation and possibly, for periodically reporting progress to decision-makers

- defining violations of the measures, classifying the offenses and penalties (e.g., civil or criminal, points against the driver's license, fines, etc.), and providing for enforcement against violators (who is responsible, how enforcement will be paid for, etc.)

- developing performance objectives and criteria for evaluating the success or failure of the measure

- evaluating the measure's effectiveness over time and making or recommending adjustments if necessary or desirable (including periodic price adjustments.)

Each of these tasks involves consideration of existing organizations' current responsibilities, staff skills, and experience; assessment of the compatibility of the new assignment(s) with organization missions or outlooks; evaluation of the costs and benefits of assigning responsibility to an existing unit, potentially changing its mission and scope of control, vs. creating a new organization; and the assessment of the need for and likely costs and benefits of coordinated involvement of multiple organizations or multiple levels of government. Different transportation pricing strategies would impose different demands on implementers and so each implementation plan must be tailored to the specifics of the case.

The chapter does not attempt to recommend a "best" implementation strategy, since that is not only context-specific but depends to a considerable degree on the results of a lot of hard work with elected officials, business and community groups, and other stakeholders. The work program for this study called for the project sponsors and advisory committee members to carry out the implementation planning task as a joint effort with the authors. However, although the subject was discussed at several meetings, the sponsors and advisors chose to leave this task entirely to the authors. Many of the committee members felt that they lacked the authority and organizational and public support to seemingly commit

their organizations to a specific set of preferred actions, and should not in any case do so until their own planning and outreach efforts had been carried out. Without such specifics, of course, cost analysis and other aspects of implementation planning can only be done at a general level or using scenarios and examples. We do that here, leaving the details and the choices for local planning processes to work out.

12.2 Implementation Approaches

The speed at which implementation of a transportation pricing strategy occurs, the magnitude of the change involved, and the scope and scale of the introduction all have important institutional and administrative implications. A program could be implemented all at once or gradually; the price could be gradually increased or simple changed to the desired level; the measure could be introduced on a limited basis or everywhere at once.; Each option and combination of options offers different opportunities and presents different problems.

One possible approach involves the gradual implementation of price increases on an areawide basis. For example, an emission-based vehicle registration fee might initially involve a very small charge, e.g., zero for the cleanest cars, $5 for the average vehicle, and up to $15 for the dirtiest vehicles. The initial fees could be accompanied with a public education effort designed to inform the public of the actual cost of vehicle emissions and ways individuals could reduce the costs they impose. Then, over time, the fee could be increased to levels commensurate with actual costs.

A gradual but areawide approach also could be used for measures designed to replace another program, for example, phasing out fuel taxes or transportation sales taxes and replacing them with VMT fees. Initially the VMT fee could be implemented at a modest level, perhaps a penny per mile; implementation would allow administrators to test out their collection mechanisms, accounting and auditing functions, and the like, and to make

corrections as needed. Once the new systems were running smoothly, the VMT fee could be raised to its intended level and the other funding sources terminated.

Large scale but gradual implementation would require careful building of a coalition supporting the pricing strategy beginning in the planning stages, and nurturing of the relationships and agreements over an extended period. It also would require an active public information and education program so that citizens understand where the program is heading and why. A possible downside is that the modest first increments of the program may not have the same impacts as later phases. For example, a $10 per year vehicle emissions fee is unlikely to generate much of a reaction; the amount is too small to generate concern for cleaning up one's vehicle, nor is it large enough to induce many people to seek ways to avoid compliance. A fee of up to $200-$400 or more would surely produce different responses.

A second implementation approach would rely upon capturing opportunities to introduce pricing in particular market niches, building support for more widespread pricing based on the results of those projects. Participation would be both narrower (because fewer are directly affected) and more focused (because the project is more limited in scope.) The latter approach is certainly more in keeping with the demonstration project tradition, and seems simpler than the extended gradualism of outlined earlier. The problem with this demonstration project approach, however, is that it may have unintended side effects in other parts of the system - diverting traffic to an underpriced parallel arterial and creating serious congestion there, for example - that could create a very bad, and misleading, public impression of pricing and the effects it would have if implemented more broadly.

Regardless of which implementation strategy is selected, there is an expectation that transportation analysts will be able to predict the impacts of transportation prices reasonably accurately. Hence implementation planning must be closely tied to analysis of alternatives, both quantitatively and qualitatively. As earlier chapters explained, some impacts and issues can be dealt with through models and data analysis, while others require legal, political, and administrative know-how.

Models will not always be able to produce the quantitative results sought. Even when the issues are ones susceptible of resolution through technical analysis, in many instances available modeling capabilities are not up to the task. In part these are correctable problems. For example, many traffic assignment models in common use rely on only travel times, omitting travel costs; prices (such as tolls or congestion fees) are not explicitly represented. Many models do include price as a variable in mode choice, but theory says that price also would affect destination choices, trip generation rates, auto ownership levels, and in the longer term, location choices, and few models currently represent these linkages. Price, of course, is relative to income (higher income people being less sensitive to out-of-pocket cost), so income should be explicitly represented in transportation models. Here, too, though, many models fall short. Such models will have to be substantially improved if they are to deal with pricing strategies in a believable way, but we know how to make the improvements.

Other modeling and forecasting limitations are less easily overcome. For example, even advanced modeling systems represent the choice of what time of day to travel only crudely; modeling of land markets is only sketchily done, emissions calculations reflect an average pattern of accelerations and decelerations that may only roughly represent actual travel characteristics on particular facilities. Additional research and model development would be required to overcome these limitations.

Still, the key issues will be how to select reasonable first steps and assure that they are not misleading or even harmful, and how to assure that the equity issues are dealt with. In this regard a fairly simple technical analysis backed up by a carefully reasoned, almost certainly qualitative, analysis of other key issues of concern is probably the best course of action. Carrying out these analyses with participation of interest groups who would be affected by the policy changes would increase the chances of success, by helping the various parties to find points of agreement and to understand the tradeoffs that may need to be made to move ahead.

12.3 Opportunities for Implementing Transportation Pricing Strategies

In part, successful implementation depends on good timing. Sound and sensible proposals can be rejected if they are introduced at the wrong time, and worse yet, such failures may block further attempts at implementation for a considerable period. Selecting a time when implementation can be easily accomplished and/or when it solves a critical public problem can be a key to success.

Along these lines, a number of commentators have argued that the best opportunities for introducing congestion pricing will occur when new toll roads are built and when toll increases are considered for currently tolled facilities (TRB, 1994). In each case, the congestion pricing component of the toll could be an added feature rather than the major focus of the policy. Following similar reasoning, opportunities for introducing a VMT fee may be highest during public debates over how to address a transportation funding shortfall or replace a sales tax that is about to expire. Emissions fees might be introduced to replace an ineffective or unpopular transportation control program or as an element in a vehicle emissions inspection program, included in return for fewer requirements on cars whose emissions controls are still under warranty. A parking tax might be implemented as an element of a local government's specific plan; a parking fee could be part of a traffic impact mitigation program.

As suggested earlier, demonstration projects can be a reasonable way to test out the impacts of certain measures. Carefully designed, they can provide solid data on travel behavior, transportation impacts, and their environmental and energy consequences, and can offer insights into larger social and economic responses (though measurement problems are likely to prevent a fully controlled experiment.) In addition, in practical terms, demonstration projects may be the only way to proceed, because policy-makers and the

public may be willing to try a demonstration project, or a series of them, for proposals about which they have reservations too large to permit unrestricted implementation.

A certain amount of caution is in order about what can be learned from project-level implementation, however. Consider the following hypothetical case of a new toll facility built at the suburban fringe. Residents and property owners in the suburban area are in broad support of highway improvements and agree to building the new facility as a toll road, believing that it is the only way to quickly obtain the funding for a significant capacity expansion. As part of the project design, revenues are committed not only to pay for the facility but also to offset any negative impacts it creates; for example, relocation assistance, sound walls, buffer parks, landscaping, commute alternatives programs, ridesharing services, and shuttle buses are to be funded with part of the revenues. A peak/off-peak price differential is introduced as a way to assure sufficient revenues and avoid congestion on the new facility and is accepted as an element of the project's design without generating significant public reaction.

The resulting project pays for itself and successfully increases public benefits both for those who choose to use the new tolled facility and for those who remain on previously available routes. (The latter are better off because congestion declines over the entire area network with the provision of the new toll road capacity.) Overall, the assessment of the project is highly positive, and indicates that similar projects are also likely to be successful.

However, if ultimately congestion pricing is of greatest interest on existing facilities in built-up areas where capacity expansion would be difficult or impossible, the lessons learned from our example may be only partially relevant and in some cases could be misleading. In the built-up area, pricing an existing facility could divert traffic to already congested routes, and without additional capacity in the system traffic conditions could get worse for some. Impacts could be far more extensive in a built up area, and means of compensating those harmed could be harder to devise and more complex to evaluate. In short, the different situation would produce different issues and impacts and make the analogy to the demonstration project a tenuous one.

This example illustrates the need to select demonstration projects that will serve as representative examples, and to have a sufficient number and range of demonstrations to cover the range of implementation contexts of concern to the program.

12.4 Specific Implementation Issues Raised for Each Transportation Pricing Measure

In addition to the general considerations outlined above, which are broadly applicable, each transportation pricing measure raises its own set of implementation issues. Here we briefly touch on a few of them, as a guide for future planning efforts.

Congestion Pricing

-- Key Implementation Issues

Probably the biggest issues with congestion pricing are how high to set the fees and how often to vary them. A link-by-link variable pricing scheme would probably be the most efficient, but it would also might be extremely difficult to explain to the public, administer, or enforce. Deciding what to do with the revenues of congestion pricing would be another major issue, if the focus group and interview findings indicating conflict over appropriate expenditures hold up.

-- Implementation Steps and Time Frame

The federal limitations on tolls substantially restrict congestion pricing to existing toll facilities (in California, bridges), to new toll roads currently under development, to any demonstration projects that might be approved and implemented, and possibly to certain

non-federal-aid facilities. Unless the facilities in question fall under one of these exceptions implementation of congestion pricing would appear to be stymied.

Demonstration projects now underway should offer some insights into the likely implementation steps and time frame for various congestion pricing schemes, although for the reasons stated earlier in this chapter extrapolation from the cases must be done only to comparable situations.

-- Possible Assignment of Lead Responsibility for Implementation

Existing agencies such as Caltrans or the MPOs could administer a road pricing scheme, but would need to add personnel. MPOs have limited experience with toll administration (though some have roles in toll analysis, toll setting, and revenue allocation) and until recently Caltrans' experience was limited to conventional tolling approaches and demonstrations of new technology. (Caltrans is now a partner in the S.R. 91 demonstration project.)

The use of prices to manage congestion would be a departure from previous approaches used by public agencies, and conflicts with existing agency missions could arise, which might lead to pressure for creation of new agencies specifically dedicated to this policy. An alternative approach would be to contract for private operators to run the pricing program, as is being done for S.R. 91 and for several facilities in other states.

-- Technology Required for Implementation

Congestion pricing could be implemented with conventional toll booths, although delays at the booths would be an issue at locations where there is not enough room to implement a sufficient number of channels to avoid congestion.

Automatic vehicle identification/electronic toll collection (AVI/ETC) technologies are not strictly necessary but have proven highly beneficial in overcoming the toll booth delay issue. Either debit cards or vehicle identifiers (or both) are already available and have been implemented on toll roads in a number of states including Texas, Kansas, and New Jersey.

AVI/ETC technologies would be the only practical way to price all the facilities in a corridor, freeways and arterials. Such multi-route pricing might be necessary to avoid undesirable levels of traffic diversion.

Parking Pricing

-- Key Implementation Issues

As earlier chapters have illustrated, a variety of measures fall under the general rubric of parking pricing. Specific measures could range from a surcharge on all parking arrivals and departures during the peak periods, designed to recoup the cost of congestion and environmental damage, to changes in the tax treatment of parking benefits, designed to alter supplier as well as consumer behavior. Implementation issues will depend heavily on which of the many possibilities is selected.

A major issue is how to design a parking pricing strategy that actually would affect travel behavior. For example, a surcharge on employee parking would change travel choices if the employee pays the surcharge, but not if the employer covers the cost. Similarly, elimination of employer tax deductions for parking provided to employees would alter travel choices only to the extent that employers take steps resulting in employees paying for parking.

Probably the biggest issue facing parking pricing implementation, however, is that in most metropolitan areas, responsibility for parking currently is dispersed among scores of government agencies and hundreds of private owners and operators. Devising a policy that will work given such an institutional context could be a very big challenge.

-- Implementation Steps and Time Frame

Specific steps and the time frame for implementation are highly dependent on the specific strategy or strategies selected. Many parking pricing strategies would require policy formulation, detailed analyses, drafting of ordinances, preparation of staff reports, environmental review and possible preparation of a detailed environmental impact report, and public hearings and other outreach efforts; implementation of such strategies could take a year or more, and follow-up outreach efforts, inspections, enforcement actions, and evaluations would be needed. Many other changes in parking ordinances and regulations could be developed and implemented administratively, perhaps requiring six months on average. If local actions are to be coordinated on an areawide basis a long lead time would almost certainly be required (and success can by no means be assured.)

Some strategies most likely would be phased in over a period of several years, e.g., provisions that leases must separately identify parking costs, and possibly provisions removing parking subsidies' tax deductibility.

-- Possible Assignments of Lead Responsibility for Implementation

Most parking is privately owned and operated, although government also is a provider of both on- and off-street parking. Changes in parking pricing policy could arise as a matter of private sector / government owner-operator decisions (perhaps in response to tax policies or other incentives and disincentives) or could be induced or imposed by changes in government rules and regulations. Parking regulations are generally considered to be a local government responsibility, although state legislation establishes much of the basic framework (including tax provisions and other basic policy.) However, some forms of parking pricing, such as a surcharge or impact fee on employee parking, could be implemented by a regional agency such as an air district or an MPO if that agency had the legal authority and political will to do so.

Requirements for employer-based trip reduction and parking cash-out provisions appear to have generated a certain amount of interest in parking pricing among employers, although government retreat on these policies has removed some of the earlier incentive and many employers remain reluctant to terminate existing free parking benefits in any case. Employers might be more interested in implementing parking pricing if there were tax or other incentives for them to do so. For example, employers that charge market rates (or some minimum rate) for employee parking might be exempted from other traffic mitigation requirements, or might be allowed a lower traffic impact fee, on the grounds that parking pricing would be the most effective strategy available to most employers.

-- Technology Required for Implementation

Modern computer-based parking control equipment can simplify the implementation of parking pricing strategies, particularly ones with complex fee structures based on time of

day, vehicle occupancy, validation, etc. However, pricing strategies are routinely and successfully implemented without such technologies.

Enforcement is somewhat more complicated where record-keeping is not computerized. However, hand-held-computers for vehicle identification and ticketing are already in widespread use in parking operations and have greatly speeded enforcement, improved the accuracy of the data base, increased yields from tickets, and reduced opportunities for evasion (previously time limits were commonly evaded by moving the vehicle a few spaces or removing tire markings). AVI and/or ETC equipment would speed the effort even further.

Fuel Tax Increases

-- Key Implementation Issues

From a technical perspective, fuel tax increases are in some ways the simplest of the transportation pricing measures to implement, because they are well tested and well understood. However, if the tax increases are to be based on cost internalization (e.g., adding the cost of pollutant emissions, etc. to the tax bill), a detailed and complex cost accounting and cost allocation effort may be needed.

-- Implementation Steps and Time Frame

Building support for fuel tax increases, especially ones characterized as at-the-pump fees, could be a major uncertainty in implementation planning. Typically it has taken several years for tax increase proposals to proceed to a vote.

-- Possible Assignments of Lead Responsibility for Implementation

The fuel taxes would probably be collected as at present. Assignments of responsibility over disbursements of the tax would likely be the major issue here.

-- Technology Required for Implementation

No new technologies are required for a standard fuel tax, although taxes with a variable component based on vehicle emissions or safety characteristics would necessitate additional vehicle identification and monitoring technologies. If gas station owners demand prepayment due to higher amounts involved, technologies that allow credit card or cash payment at the pump may become more popular.

VMT Fees

-- Key Implementation Issues

VMT fees could be based on estimated averages for each vehicle type and age, or could be determined from odometer readings, roadside sensors, or on-board monitors. The specific design would depend on the objectives to be served, which could range from adding a charge to cover the costs of auto-highway externalities, to establishing a fee that would replace current transportation taxes. A broad characterization of the purposes of this strategy might generate more support than a simple "tax on mobility" could garner. Depending on the specific approach chosen, however, federal limitations on the imposition of tolls, discussed earlier, could apply.

-- Implementation Steps and Time Frame

VMT fees could be phased in or implemented all at once, on a facility basis, a regional basis, or a statewide basis. Over time, if alternative fuel vehicles begin to increase as a percentage of the vehicle fleet, the reasons for this means of pricing may be more obvious than they are now, and VMT fees might be more readily accepted as a supplement to or replacement for existing sources of revenue such as the fuel tax.

-- Possible Assignments of Lead Responsibility for Implementation

If a simple fee structure based on typical mileage ranges for a vehicle make and model were implemented, the VMT fee could be a straightforward add-on to motor vehicle registration and licensing, handled by the Department of Motor Vehicles or a private contractor. A more complex VMT fee requiring odometer readings, etc. might be implemented through the vehicle inspection and maintenance program. New technologies might allow direct billings to the vehicle owner or at-the-pump charges based on readings of on-board monitors, with either a public agency (probably the regional MPO or Caltrans) or a private firm (owner/operator of a private toll road using VMT fee pricing, or a contractor to a public agency) handling the program administration.

-- Technology Required for Implementation

Either a low-tech or a high-tech approach could be used to implement a VMT fee. For example, in a low-tech approach, VMT fees could be based on a simple schedule (in turn based on periodic surveys of motorists) listing average VMT per year by age of vehicle. A high tech approach might depend on on-board electronics to keep track of VMT and to signal a reader in each filling station, thereby allowing an at-the-pump charge to be added with each refueling.

Emissions Fees

-- Key Implementation Issues

Calculating the marginal cost of emissions of various sorts and translating these costs into per-mile equivalents is a complex task but one that is important to the credibility of this pricing measure. Designing the program to minimize the potential for fraud also could be very important.

-- Implementation Steps and Time Frame

Any near-term implementation probably would begin with a simple fee based on model year average emissions and odometer readings, perhaps supplemented by on-road monitoring studies. Over time, a more sophisticated treatment of emissions could be introduced as technologies for on-board emissions monitoring are proven and become widely available. However, given the slow turnover of the fleet, substantial market penetration by new technologies could take a decade or more following their introduction.

-- Possible Assignments of Lead Responsibility for Implementation

Programs could be designed and implemented by state agencies or could be handled by regional agencies such as air districts or possibly MPOs. Administration also could be handled under contract with a private firm or firms, who (for example) could provide r equipment for monitoring, carry out monitoring studies, handle billings, and so on.

-- Technology Required for Implementation

Both low-tech and high-tech implementation mechanisms could be designed. Implementation based on actual emissions (rather than a schedule of average emissions) would lead to a significantly more effective (but also more complex) fee implementation.

Tamper-proof odometers also would be highly beneficial to this program, as would remote sensors.

12.5 Costs of Implementing Transportation Pricing Measures

Like other elements of implementation, the costs of implementing transportation pricing measures largely depend on the specifics of design and the timing of implementation. However, in practically every case it should be possible to hold costs to a small percentage of overall revenues, generally no more than 5-10 percent.

Keeping costs of implementation low is largely a matter of using common sense in the design of the implementation plan. For example, a cost-effective implementation plan generally would use proven methods and technology rather than rely on previously untested approaches and new technology; innovations could certainly be tested as part of an implementation effort, but through a low-risk approach (for example, first trying the innovation out in a small-scale demonstration project.) Also, cost-effectiveness requires that program designers select approaches that minimize administrative overhead, apply the measure only where it is effective and practical, use enforcement only to the extent that the added revenues produced exceed enforcement costs, and incorporate procedures for periodic update of prices, so that the effectiveness of the pricing measure is not lost to inflation.

As the preceding discussion indicates, timing will significantly affect what is feasible and practical over the next twenty years. Technological advances are likely to vastly increase the range of methods that can be cost-effective in implementing pricing strategies. For example, automatic vehicle identification, advanced traffic detection and management systems, video image processing, smart card billing systems, and on-board and roadside emissions monitoring devices are some of the technologies currently being implemented across the US and abroad that could have transportation pricing applications. As these technologies are refined and experience with them mounts, implementation strategies relying on advanced technologies are likely to be favored not only as more accurate but also as lower-cost than low tech alternatives. AVI and smart card technologies, for example, are already proving to be cost-savers for toll collection and could easily handle variable congestion pricing, parking charges, and VMT fees. Emissions monitoring devices are still in the early stages but are steadily advancing in accuracy and sophistication. Available technology includes the on-board devices that warn the driver of excessive emissions rates, currently being introduced to the vehicle fleet, as well as the remote sensing devices currently being used for monitoring and enforcement programs. Technologies are being developed that could record cumulative emissions, running time, etc., and could be available in the next 10-15 years. (Sawyer, 1995 and 1996, personal communication.)

In the short term, however, simple methods which do not rely on advanced technologies are more likely to be implemented. As noted earlier, a fuel tax increase or a change in the tax treatment of parking could simply build upon existing programs. An emissions fee or a VMT fee could be based on average levels for each vehicle type and age, and collected through the vehicle registration process (which could be annual, or could be changed to a quarterly or even monthly billing.) Congestion pricing could be implemented on existing toll facilities by instituting a peak period toll surcharge at toll booths or on specially designated lanes open only to cars that agree to the tolls and to equip their vehicles with toll tags. Employee parking charges could be handled through payroll deductions.

Whether implementation occurs in the short term or in the longer run, then, it should be possible to design a fairly straightforward implementation strategy whose costs are modest.

To illustrate this point, we consider in more detail the costs of specific ways in which each of our five pricing measures could be implemented.

Congestion Pricing

In a study of road pricing for all limited access facilities in the Seattle region, researchers estimated that costs of collecting the tolls (including equipment, installation, maintenance, operation, and administrative costs) would average, at current rates, about one cent per vehicle mile traveled (VMT) over all VMT, or two to three cents per peak period vehicle mile traveled (Pozdena, 1994). The researchers expect that costs would substantially decline as equipment costs drop, as would be expected if road pricing comes into widespread use or if the equipment is used for other purposes such as traffic management.

The cost of installing toll collection equipment on single facilities varies considerably. Reported equipment costs per lane currently range from $15,000 to $100,000; the lower costs are for automatic vehicle identification (AVI) / electronic toll collection (ETC) only, while the higher costs include a manual toll collection component. AVI/ETC costs, including the costs of a "control center" for processing the AVI readings, are already dropping and are expected to further decline as the use of this equipment becomes more common, as expected.

Costs of toll facility operations and maintenance are similarly varied, ranging from less than $5000 per lane for AVI lanes to as much as $200,000 per lane for manual toll booths. Clearly the AVI option, or a combination of AVI and automatic cash collection equipment, is the more practical approach for widespread congestion pricing. (See Pietrzyk, 1994.).

Suppose we have a five mile, four lane limited access facility on which we install a combination of AVI equipment and staffed toll booths, for a total capital cost of $50,000 and an annual operating cost of $100,000. If 4,000 vehicles per lane per day are subject to tolls (producing a total of twenty million tolled vehicle-miles per year on the facility), the facility

will generate $200,000 a year per penny of toll per vehicle mile. With a one cent toll, $50,000 in equipment costs could be paid off in the first year of operation while covering all operating costs and generating revenues of $50,000. Subsequent years would generate $100,000 in revenues. A congestion price averaging five cents per mile would, in the first year, produce gross revenues of about $1 million and net revenues of some $850,000. A single five mile dedicated lane with AVI access only would incur much lower expenses - first year equipment, operations, and maintenance of perhaps $20,000 - and so would produce considerably more net revenue.

Of course, there is no specific reason why a one year payback would be necessary; the appropriate period for payback would depend on the useful life of the equipment and the cost of money, among other things. Since the useful life of tolling and monitoring equipment should be considerably longer than one year, calculations based on a one year payback are highly conservative. In addition, public ownership, operation, and management are not the only, and not necessarily the best, ways to proceed. Private provision of facilities and services, public-private partnerships, arrangements for leasing equipment from a vendor, and contracting for both equipment and program management are all options that deserve consideration.

Since equipment costs are fixed, the cost-effectiveness of congestion pricing would be greater if implemented on a facility for which pricing is justified for a number of hours each day, such as is the case with many toll bridges and major commuting corridors. If tolls were to become an accepted way of collecting general transportation revenues, perhaps replacing part or all of other taxes (sales, property, fuel) now used to fund transportation, cost-effectiveness would further increase.

Use of tolls as a general transportation funding mechanism also would be important to the cost-effectiveness of pricing on arterials. Pricing major arterials frequently will be necessary to avoid negative traffic spillover impacts from pricing limited-access facilities. However, urban arterials carry substantially lower volumes of traffic than limited-access facilities (a four lane facility carrying 25-45 thousand vehicles per day with 10,000-18,000 vehicles

during congested periods is typical), so costs of equipment would be spread over fewer vehicles than is the case on most limited-access facilities. At the same time, arterials present greater opportunities for toll avoidance if collection devices are sparsely distributed, so more equipment may be needed than in the limited access case.

Consider a four lane divided arterial with major intersections at quarter-mile spacing, carrying 32,000 vehicles/day (12,000 vehicles during peak hours). Conventional toll booths or automatic collection devices are impractical in this setting, so AVI equipment will be used. If it proves necessary to install AVI readers at every intersection, one per approach lane, four per intersection, to capture a sufficient percentage of trips, the cost per intersection of AVI equipment (at $15,000 per reader) would be about $60,000 (i.e., $240,000 in capital costs per mile.) Operating and maintenance costs would add some $20,000 per intersection - $80,000 in operating costs per mile per year.

Borne by the peak period users only, and assuming some 10,000 - 11,000 vehicles per day remain peak users, a charge of about nine cents a mile would be needed to recapture capital costs in one year. (Again, however, note that there is no magic in a one-year payback, or indeed in a system in which equipment is purchased rather than leased. Paid back over a ten year period at ten percent interest, a $240,000/mi. capital cost could be paid for with charges of about 1 1/2 cents per mile.) Operating costs would be about 2 1/2 cents per mile per year.

Clearly, the cost of pricing arterials is fairly high, at least compared to the cost of pricing limited access facilities. However, such costs are not so high as to render arterial pricing infeasible. Rather, they point to the need for careful consideration of the amount of equipment actually needed, recognizing the tradeoff between measurement of all vehicle movements vs. costs, and suggest that some arterials would not be priced unless the costs of equipment dropped substantially. Also, because the cost per vehicle mile of AVI equipment would be much lower if the cost applied to all vehicle miles, not just peak period miles, congestion pricing might be a special feature of general road pricing.

Note that the estimate of $60,000 per intersection used for estimation purposes here is far in excess of the costs of automated traffic surveillance and control systems (ATSAC). For example the ATSAC system being implemented in Los Angeles has been estimated to cost about $9,000 per intersection ($7,000 in 1988 dollars); these costs include a proportionate share of control center costs. The equipment is estimated to have a fifteen year life and is being implemented at about 250 intersections per year. (Los Angeles Dept. of Transportation, June 1987.) Technological advances such as spread spectrum radio communications rather than hardwire connections are likely to further reduce these costs (Skabardonis, 1995.) If the costs of equipment for arterial pricing were more like those for traffic control systems - i.e., lower by nearly a factor of seven - such pricing obviously could be used more readily.

Other costs associated with implementation of congestion pricing would include smart cards for each user vehicle; equipment to add money to the cards in a deduction system or, in the case of a billing system, to handle the billing; enforcement costs; and general program administrative costs. Smart cards or other vehicle identification devices currently cost from $2 to $60, depending on the type; read-and-write cards cost more than debit or read-only cards. In some toll road applications the user purchases or "leases" this equipment with a deposit, although elsewhere the card/transponder is provided free of charge with prepayment of a minimum balance. Toll road experience suggests that many agencies prefer a debit card (prepayment) approach rather than a read-only card with billing for charges; prepayment appears to avoid the burden of bill processing and bill collection. Debit cards nevertheless require some mechanism for replenishment of the card, either at fixed or mobile stations or through the mail. A variety of mechanisms for handling either billing or account replenishment could be utilized; in particular, this function could be a road authority function or could be handled by a private vendor, much as transit passes are now handled by transit agencies, banks, transportation commute stores, large employers, etc. A multi-purpose card, which would allow payment for tolls, parking, or a variety of other transportation services, is also an option.

Enforcement costs would need to be considered. High-speed video camera evidence is accepted in several states and abroad and is a relatively inexpensive way to enforce ETC violations. Alternatively, police enforcement can be used. Some attention may have to be given to guarding against illegally obtained or counterfeit toll tags, much as we currently have to guard against illegally obtained parking permits and transit passes and counterfeit credit cards. Levels of enforcement and fines for most violations could be set to be self-financing; the more serious offenses might be treated as thefts or as fraud.

Parking Pricing

Proposed measures which would reduce or eliminate tax deductions for employer-provided parking, make employer-provided parking a benefit taxable to the employee, etc. would increase state and federal tax receipts. Responses of employers and employees would be likely to vary with location, business type, employee income, and so on; the employer who stops leasing parking for employees because of the change in tax treatment would experience a reduction in paperwork, whereas the employer who continues to provide free parking but now must account for it in tax reporting would face increased costs. Such costs might amount to a few dollars per employee per year.

Shoup (1994) calculates the likely federal income tax revenues from a parking cash-out variant of this proposal at nearly $1.2 billion a year; if implementation costs from all sources (employer record-keeping and reporting, government accounting, audit and enforcement, etc.) were to amount to $6/employee a year - more than most experts believe these items would cost - and the program applied to 100 million workers, revenues would exceed costs by a factor of two.

Consider next a parking surcharge levied by an air district (or a transportation authority) on all daytime employee parking, defined as parking spaces utilized by employees between the hours of 6 am and 6 pm weekdays. A surcharge set at 25 cents to one dollar per space per

day might be thought of as a rough approximation of an emissions charge; a surcharge of $1-$5 might be thought of as a rough approximation of a congestion fee.

The costs of implementing such a surcharge would vary substantially with the implementation design. A simple approach, and one that would cost relatively little to implement, would be to require employers to report the number of parking spaces they provide to employees each month and simply transmit the amounts due on an annual, quarterly, or monthly basis. Further, the surcharge could be collected on behalf of the responsible agency by an existing tax collection agency, avoiding the need for a special bureaucracy to handle payments, audits, enforcement actions, etc. As an add-on to existing reporting and collection activities, the marginal costs of the program would be quite low, probably in the range of five percent of revenues. (As with other fees collected via taxes, special provision would have to be made for those who are exempt from filing; the same would be the case if the fee were attached to a business license, etc.)

Such an approach would result in substantial revenues, and could be an important source of funding for transportation improvements to alleviate air pollution and/or congestion; but (as has been discussed elsewhere) its direct impact on travel behavior is less clear. Some employers might decide to pass the surcharge along to their employees, and some of the employees would likely reduce their parking use; but many other employers might decide to simply pay the surcharge as a cost of doing business, with no change in parking policy for employees.

If the intent is to require the employee-parking consumer to pay a government-mandated parking fee, a simple implementation strategy would be to require the employee to pay the fee directly. Because there is no existing mechanism for charging for parking in most locations, implementation of a fee might most easily be done in through a payroll deduction, to be transmitted with other income or payroll taxes and thence distributed to the responsible agency. There would be some added costs to the employer for accounting (somewhat higher than in the variant presented earlier) and some added costs to the tax collection agency, but again, these costs should be no more than a few dollars per affected

employee per reporting period. Cost-effectiveness would depend entirely on how large a parking charge was imposed, but if the administrative costs amounted to $5 per month per employee and the parking fee was set at $3/day ($60-$66/mo.) costs would be 7-8 percent of revenues.

Fuel Tax Increases

A fuel tax increase is the easiest of the five transportation pricing measures to implement; all the mechanisms for collecting and disbursing fuel taxes are in place and changing the tax rate would be a very simple procedure. The costs of implementation would be accordingly low, a negligible percentage of revenues. A possible exception is that with a substantial tax increase, e.g., 50 cents or more a gallon, there would be the possibility of increased levels of tax evasion, smuggling of untaxed fuel, or other illegal activity. The costs of enforcement associated with such criminal activities are highly uncertain.

VMT Fees

Consider a VMT fee based on average annual mileage for the vehicle type and model year. Such a fee could be automatically included in the amount billed to each owner as part of the regular vehicle registration fee. A continuous vehicle mileage sampling program (or a continuous panel of vehicles) could be implemented to provide the basis for average annual mileage, and could be designed to produce statistically valid data on a statewide or regional level. Such a program might cost $200,000 annually, including data sampling and analysis. (These data would have value in a variety of programs, including traffic management, energy conservation planning, and air quality planning.) If the VMT fee were applied to 20 million vehicles, the annual per vehicle cost of the VMT sampling program would be trivial, only a penny per vehicle. Similarly, costs of developing, testing, and implementing software and forms to calculate the fees and add them to a each registration fee billing would be negligible on a per-vehicle basis.

A public information campaign involving mailings to each vehicle owner could be considerably more expensive. For example, a brochure providing an explanation of what the VMT fee is, how it works, and why it is being established might be mailed to each vehicle owner during the first year of the program at a one-time cost of, say, $2.00 - $5.00 per vehicle. This could be backed up with an information sheet inserted each year in the registration billing, at a cost of less than $1.00 per vehicle including preparation and handling costs. With a modest one cent per mile VMT fee the typical vehicle would be assessed $50 -$150, so these costs are a small fraction of revenues - not more than 10 percent in the first year and less, perhaps one percent, thereafter.

Additional collection and enforcement costs could be covered by late fees and perhaps fines for seriously late payments and other minor violations, although some types of illegal activity would probably be treated as criminal offenses.

A VMT fee also could be implemented as a toll, either for specific facilities or on a broader basis. (See the discussion of implementation costs under congestion pricing for cost implications.)

Emissions Fees

An emissions fee calculated based on average data (emissions per mile for the vehicle type and model year times average VMT for the vehicle type and model year) could be implemented much like the VMT fee just described, again with costs amounting to a small fraction of revenues. An emissions fee based on the emissions measurement taken at the time of the vehicle's inspection and maintenance test also could be done fairly simply - for example the fee could be billed upon receipt of the vehicle's mailed-back emissions test certification, or by electronically transmitting the emissions test as it is performed to a file which then would be linked to the registration data for the vehicle.

Suppose the design of such a program, including revision of billing processes and so on, costs one million dollars. Applied to a fleet in of more than 20 million vehicles, this cost would amount to less than a nickel a vehicle. It should be possible to hold the annual cost per vehicle of public information, billing, collection, and enforcement to a few dollars per vehicle. Costs totaling $5-10 per vehicle would require less than 5-10 percent of likely revenues for emissions fees set at a one cent per mile rate.

Emissions fees also could be based on in-use emissions, much like congestion pricing or VMT fees, by adding information on the vehicle make and model to determine the price per mile. A billing system could be used, or a debit card system might be devised in which the card was attached to a particular vehicle. The development of on-board vehicle emission monitoring equipment capable of accounting for cumulative cold starts, tailpipe emissions, etc., would allow for much more sophisticated emissions fees. As noted earlier, such equipment is currently being developed or is in the planning stages; costs are not yet known.

Implications for Cost-Effectiveness

For each transportation pricing measure discussed here, we have shown that it would be possible to design an implementation strategy which would be cost-effective. It should in general be possible to hold costs to no more than 5-10 percent of revenues even in the first year; in many cases much lower implementation costs should be achievable. Clearly, however, cost-effectiveness depends on the details of the proposed action. Specific, reliable cost-effectiveness calculations thus must await the development of a detailed program design.

To illustrate, however roughly, the magnitude of transportation pricing measures' effectiveness over costs, we have prepared a series of tables which describe implementation scenarios and associated implementation costs for the five pricing strategies. The scenarios and cost estimates are for the Los Angeles region in the year 2010. Table 12-1 sets forth assumed collection methods for the various measures, and describes the basis for the associated cost estimates, assuming that the capital costs of AVI/ETC equipment are be fully allocated to each measure using them. (The capital costs are assumed to be amortized at 10 percent per year over a ten year period.) Table 12-2 then presents a series of cost-effectiveness and revenue generation metrics for the five measures using these assumptions. In Tables 12-3 and 12-4, an alternative assumption is made, namely that AVI/ETC capital costs have already been covered (for example, traffic monitoring and other advanced traffic operations programs might implement AVI technologies, which then could be used for ETC purposes.) Hence in these tables, only annual operations and maintenance costs are included.

Note that all of the scenarios created here assume low implementation costs. For example, the percent of gross revenues estimated to be needed for administration ranges from 1.2 percent for fuel tax increases to 15 percent for VMT fees (using Table 12.1 assumptions; administrative costs drop to 5.9 percent of VMT fee revenues using Table 12.3

assumptions, and would drop to under 3 percent if the fee went up to, say, five cents from the 2 cents shown here.) In an actual implementation, of course, any of these numbers could go up, or down, depending on the choices made by program developers.
These tables illustrate how much cost-effectiveness measures depend on the specifics of program design, since the numbers for the two high tech options change considerably depending on how equipment costs are allocated.

The calculations also illustrate the difficulties in interpreting cost-effectiveness data. For example, a simplistic reading of Table 12.2 would suggest that fuel taxes are more cost-effective than VMT fees. However, that is because the table assumes that the administrative apparatus for the gas tax is already in place, and only small additional costs must be expended in implementation of the higher tax amount; VMT fees, in contrast, are assumed to be a new program requiring significant expenditures for implementation. In Table 12.4, where both fuel tax increases and VMT fees are assumed to utilize facilities and procedures already in place, differences are much smaller.

Cost-effectiveness numbers also are dependent on the uses to which net revenues are put. Treatment of the revenues are omitted here, which amounts to an assumption that the revenues will be spent such that the resulting benefits are at least as great as the costs to users (amounts paid.) In such circumstances the revenues (amounts collected from consumers) are a transfer, not a real cost.

12.6 Conclusion

Implementation planning for transportation pricing strategies needs to be carried out in an intensively participatory and well integrated planning process. While implementation considerations should inform the earliest steps of planning and analysis, specific proposals must be on the table and stakeholders must be involved if a full analysis of implementation options is to be carried through to the selection of a feasible, equitable, desirable course of action. In the absence of such specifics and without the committed participation of

stakeholders, we can only touch upon implementation considerations and offer scenarios. More specific analysis must await more specific proposals. Nevertheless, the chapter illustrates that means for implementing pricing strategies in a cost-effective way should be within reach.

Designing a sound implementation plan is not an easy matter; it requires attention to institutions and organizations, budgets and accounting, and it often involves tradeoffs between accountability and flexibility, technical precision and ease of implementation. Attention to these implementation issues should pay off, however, in a smoother, more credible, and more effective program.

Table 12.1: Implementation Scenarios and Cost Estimates - South Coast, 2010
Example 1: Full Cost Responsibility for High-Tech Approaches

Policy	Collection Method	Basis for Administrative Cost Estimate
Congestion Pricing	AVI/ETC equipment Installed on a majority of the freeway and arterial systems; cards on all vehicles.	About 18,000 arterial and freeway locations would have to be instrumented. Amortized annual capital costs for each location could be about $2,000, with an additional $5,000 for maintenance. Annual cost per vehicle (for ID cards and billing) could be about $20.00. The annual administrative cost of congestion pricing thus might be $346 million for the region's estimated 11 million vehicles.
Parking Pricing	Surcharge collected by the employer and transmitted as per payroll taxes.	$5.00 per worker per month, for about 10,000,000 workers ($50 million total).
Fuel Taxes	Collected through existing mechanisms.	5 percent of revenue, for enforcement and information dissemination ($186 million total).
VMT Fees	AVI/ETC equipment installed throughout the freeway and arterial systems, and on a portion of the collector system.	Cost of a congestion pricing system, plus an additional 18,000 instrumented locations ($472 million total).
Emissions Fee	Collected by the DMV with the registration fee.	5 percent of revenue, for enforcement and information dissemination ($55 million total).

Table 12.2: Selected Cost-Effectiveness Estimates, South Coast - 2010
Example 1: Full Cost Responsibility for High-Tech Approaches

Administrative Cost ($)

Policy	Total Administrative Cost	Administrative Cost Per..... Vehicle Mile Reduced	Delay Hour Reduced	Ton of ROG Reduced	Gallon of Fuel Reduced
Congestion Pricing ($.15/mile, peak only)	$ 346,000,000	0.1162	1.5318	135607	1.1064
Parking Pricing ($3/day)	$ 50,000,000	0.0222	0.8464	61050	0.5685
Fuel Tax ($.50/gallon)	$ 186,000,000	0.0336	2.4441	98643	0.4205
VMT Fee ($.02/mile)	$ 472,000,000	0.0833	5.1685	244360	1.9085
Emissions Fee (avg. $.01/mile)	$ 55,000,000	0.0167	1.8068	21744	0.2965

Total Revenue ($)

Policy	Gross Revenue	Revenue Per..... Vehicle Mile Reduced	Delay Hour Reduced	Ton of ROG Reduced	Gallon of Fuel Reduced
Congestion Pricing ($.15/mile, peak only)	$7,343,000,000	2.4662	32.5091	2877915	23.4811
Parking Pricing ($3/day)	$4,151,000,000	1.8403	70.2666	5068376	47.1959
Fuel Tax ($.50/gallon)	$3,724,000,000	0.6731	48.9340	1974979	8.4196
VMT Fee ($.02/mile)	$3,144,000,000	0.5551	34.4273	1627683	12.7128
Emissions Fee (avg. $.01/mile)	$1,106,000,000	0.3358	36.3326	437249	5.9628

Table 12.3: Implementation Scenarios and Cost Estimates - South Coast, 2010
Example 2: Partial Cost Allocation for High-Tech Approaches

Policy	Collection Method	Basis for Administrative Cost Estimate
Congestion Pricing	AVI/ETC equipment Installed on a majority of the freeway and arterial systems; cards on all vehicles.	Assumes that instrumentation for vehicle detection would be in place for other purposes (no additional equipment needed) but that enforcement and information dissemination costs would be similar to those required for fuel taxes ($186 million total)
Parking Pricing	Collected by the employer.	$5.00 per worker per month, for about 10,000,000 workers ($50 million total).
Fuel Taxes	Collected through existing mechanisms.	5 percent of revenue, for enforcement and information dissemination ($186 million total).
VMT Fees	AVI/ETC equipment installed throughout the freeway and arterial systems, and on a portion of the collector system.	Assumes that instrumentation for vehicle detection would be in place but that enforcement and information dissemination costs would be similar to those required for fuel taxes ($186 million total)
Emissions Fee	Collected by the DMV with the registration fee.	5 percent of revenue, for enforcement and information dissemination ($55 million total).

Table 12.4: Selected Cost-Effectiveness Estimates, South Coast - 2010
Example 2: Limited Cost Responsibility for High-Tech Approaches

Administrative Cost ($)

Policy	Total Administrative Cost	Administrative Cost Per..... Vehicle Mile Reduced	Delay Hour Reduced	Ton of ROG Reduced	Gallon of Fuel Reduced
Congestion Pricing ($.15/mile, peak only)	$ 186,000,000	0.0625	0.8235	72898	0.5948
Parking Pricing ($3/day)	$ 50,000,000	0.0222	0.8464	61050	0.5685
Fuel Tax ($.50/gallon)	$ 186,000,000	0.0336	2.4441	98643	0.4205
VMT Fee ($.02/mile)	$ 186,000,000	0.0328	2.0367	96294	0.7521
Emissions Fee (avg. $.01/mile)	$ 55,000,000	0.0167	1.8068	21744	0.2965

Total Revenue ($)

Policy	Gross Revenue	Revenue Per..... Vehicle Mile Reduced	Delay Hour Reduced	Ton of ROG Reduced	Gallon of Fuel Reduced
Congestion Pricing ($.15/mile, peak only)	$7,343,000,000	2.4662	32.5091	2877915	23.4811
Parking Pricing ($3/day)	$4,151,000,000	1.8403	70.2666	5068376	47.1959
Fuel Tax ($.50/gallon)	$3,724,000,000	0.6731	48.9340	1974979	8.4196
VMT Fee ($.02/mile)	$3,144,000,000	0.5551	34.4273	1627683	12.7128
Emissions Fee (avg. $.01/mile)	$1,106,000,000	0.3358	36.3326	437249	5.9628

13. Assessment

13.1 Transportation Impacts and Policy Effectiveness

How do transportation pricing measures affect travel behavior and transportation system performance? How effective are they in reducing congestion and emissions and in conserving fuel? Overall, the study found that these measures could have significant, positive impacts in each of the four major metropolitan areas of California.

Congestion Prices: Congestion prices sufficient to keep both freeways and arterials operating close to capacity (level of service D/E) were evaluated. During the peak periods of demand, such prices would average about 4 cents a mile in Sacramento, about 6 cents a mile in San Diego, about 9 cents a mile in the Bay Area, and about 10 cents a mile in the South Coast region. Actual costs would vary considerably from these averages, from zero (where there is little or no congestion) to as high as 75 cents to a dollar on the handful of highway links with the very worst congestion. Such charges would reduce overall VMT and PM_{10} by only one or two percent, in most cases, because those who can do so would shift to their routes or times of day; however, emissions and fuel consumption reductions in general would be higher than proportional because less travel would be in stop and go conditions. Both prices and benefits would be higher in Los Angeles and the Bay Area than in San Diego and Sacramento, which are less congested.

Parking Fees: A region-wide employee parking fee of a minimum of $3.00 per day - approximately the minimum cost of providing an employee parking space in most metropolitan areas - was examined. (In areas where current parking charges are higher than the $3.00 amount, the current rates were assumed to remain in place.) Such a fee for parking would result in a reduction of VMT and trips in the 2-3 percent range and a similar reduction in fuel use and emissions. Notably, the effect would be smallest in the Bay Area, because a higher proportion of that region's employees already pay for parking.

Gas Tax Increases: Two levels of gas tax increase were examined. A 50 cent increase would reduce VMT and trips by amounts ranging from 3.9 - 4.3 percent. A $2.00 gas tax - an amount that would bring fuel prices to mid-range European levels - would reduce VMT and trips by 12-14 percent. Pollutant emissions reductions are approximately proportional to the reductions in travel. However, fuel consumption and greenhouse gas (CO2) reductions would be significantly larger, ranging from 8.8 - 9.3 percent for the 50 cent tax increase to 31 -33 percent for the $2.00 tax increase. The difference between changes in VMT and changes of fuel use is because many consumers would purchase more fuel efficient vehicles (and would use their more fuel efficient vehicles more often than their less efficient ones.) The more fuel efficient vehicles would help bring the cost of travel back down, hence overall travel (trips, VMT) and pollution (largely proportional to trips and VMT) would drop less than fuel use and greenhouse gas emissions.

Vehicle-Miles Traveled (VMT) Fees: Flat VMT fees were analyzed in a range from 1 cent to 10 cents per mile. Detailed results for 2 cents per mile indicated that VMT, fuel use, and all emissions would drop by about 4-5 percent. At 5 cents per mile, these performance measures drop by about 10 percent, and at 10 cents per mile they drop by nearly 20 percent.

Vehicle Emissions Fees: Two fee alternatives based on emissions were evaluated. In the first alternative, the fee would be based on the statewide averages of emissions per mile for a vehicle of the age and type being driven, multiplied by the vehicle's mileage accumulated since its last recorded odometer reading. This approach would charge older cars higher fees on a per mile basis, offset in part by the somewhat lower average mileage per year for these older cars. In the second alternative, the fee would be based on measured emissions and mileage based on the vehicle's odometer reading. This second alternative would result in much higher fees per mile driven for high emitters of any age, and only modest fees per mile driven for clean vehicles. Similarly, it would result in modest fees for a car that is driven a modest amount, and much higher fees for a car that is heavily used. For a fee set to average about 1 cent per mile, costs per vehicle would range initially from $40 to about

$400 per year under the first alternative and would range initially from $10 to about $1000 under the second alternative. With either alternative, the main impact would be on emissions, as many consumers would retire or repair heavy emitters to reduce their fees, and would continue (or resume) their previous driving patterns. VMT and PM_{10} reductions of about 2 percent would result, but emissions reductions of as much as 6-8 percent for the first approach, and 16-21 percent for the second approach, could be obtained.

Joint Effects: Combinations of the measures also were considered. A package combining congestion pricing, employee parking charges of $1.00 per day, a 50 cent gas tax increase, a 2 cent VMT fee, and emissions fees based on statewide averages for each vehicle type (the first emissions fee approach described above) and model year would reduce VMT, trips, and PM_{10} by about 8-9 percent, and would reduce fuel use, pollutant emissions, and greenhouse gas emissions by some 10-17 percent. A package with congestion pricing, employee parking charges of $3.00 per day, a $2.00 gas tax, a 2 cent VMT fee, and vehicle-specific registration fees would reduce VMT, trips, and PM_{10} by about 19-22 percent and would reduce emissions and fuel use by 30- 50 percent.

Land Use Impacts: Changes in transportation pricing policies of the type and magnitude considered here are unlikely to significantly alter the rate of growth of the region, but they could alter patterns of development, principally by encouraging more compact growth around centers and more efficient travel choices. Location-specific impacts are likely only for those measures that result in differential price changes within the region, as congestion pricing and parking pricing might do. These location-specific impacts may be seen as positive or negative, depending on the viewpoint of those affected. Businesses, households, and local governments all can take steps to reduce the impact of land use changes and some of their responses may in fact alter the cost impact of the measures.

13.2 Equity Issues

Transportation price increases are especially a concern for low income people who have a limited ability to "choose" to pay the higher costs and hence would be priced out of routine use of certain high-cost travel options. Higher transportation prices also are a worry for moderate income people, especially those who have little flexibility about when or where they travel and hence might have to devote a larger share of their income to transportation.

A major finding of the study is that most households in the lowest income group - the one-fifth of the California households that make less than $18,676 per year - would not be affected by charges for parking at the workplace or by congestion pricing. This is because few of these households contain a worker, and of those who do, a very high percentage use transit or walk to work.

Overall, the households in the lowest income quintile (lowest fifth) produce only about 7 percent of the VMT. However, they would be the most likely to change their travel behavior if transportation pricing strategies were implemented. The next-to-lowest income group, the quintile with household incomes between $18,676 - $34,518, would feel a moderate impact, but a substantial number of this group also commutes by transit or carpool or works off-peak hours.

The biggest impact of these policies would fall on middle income households, who currently tend to drive to work and have free parking. The highest income group also would pay more, although in all four urban areas it is this upper income group that is most likely to already pay for parking.

Gas tax increases also would fall most heavily on middle and upper income groups. Only about six percent of current fuel taxes are paid by members of the lowest income group;

while this group owns cars, they drive them only modest amounts. The twenty percent of the state's households in the second-to-lowest income group pay about 10 percent of fuel taxes currently, also reflecting their moderate use of their cars. Both groups would reduce fuel use, at least in the short run, if prices increase. Again, it is the middle and upper income groups that would pay most of the tax increases.

Because of data limitations, it is harder to say how vehicle registration fees would affect different income groups, particularly for the more complex policy options such as emission-based fees. (Data sets report auto age and the owner's household income, or auto emissions rates, VMT, and area of residence, but no available data set directly links emissions levels and the incomes of vehicle owners.) Nevertheless, the available data do provide some insights into equity impacts. Using data collected by Caltrans as part of a statewide travel survey, we find that about 55% of the vehicles over eight years old are owned by the upper middle and affluent households, mostly as second, third, or even fourth or fifth cars. The remaining 45% of the older cars are owned by the two fifths of the households with low or moderate incomes. To the extent that vehicle registration fees fall most heavily on these older vehicles, they also would fall somewhat more heavily than proportional on low and moderate income households.

Equity can also be examined by looking at the distribution of impacts by location in the region (e.g.,, central city vs. suburbs), by gender of the traveler, by race and ethnicity, and so on. For the policies considered, impacts do not appear to be strongly place-specific Furthermore, exploratory analyses done for this study show that the distribution of impact is more strongly dependent on income than on demographic factors, i.e., differences between the sexes and among racial and ethnic groups basically track income differences.

13.3 Using the Revenues from Transportation Pricing Strategies

One way to overcome concerns about adverse effects of transportation price increases is to use the funds raised from the pricing strategy to improve the transportation system. For example, congestion pricing revenues could be used to remove bottlenecks, fund traffic operations improvements such as coordinated traffic signal timing and faster accident clearance, or otherwise increase transportation capacity and eliminate design problems which lead to congestion. Such revenues also could be used to support transit improvements or carpool and vanpool programs; better alternatives to driving would make increased costs for the auto more palatable.

Revenues also could be targeted to particular problems or needs. For example, some or all of the net revenues generated by emission fees could be earmarked to help low-income households clean up their dirty vehicles or replace them with cleaner used cars. In the latter case a cash payment could be provided, or a voucher might be offered, permitting the recipient to buy transit passes or to obtain another car at a subsidy which would vary with income (following the model used in housing programs.) The vehicle repair element of this program would have the added benefit of stimulating employment. The vehicle buy-back or voucher program would require detailed planning to avoid excessive costs (for example, it might be necessary to limit buy-back eligibility to individuals, limit applications to one per individual, and require that the vehicles must have been registered in California for at least 120 days at the time of program adoption.) Everyone could benefit from a well-designed program of this sort: the low income household would have a cleaner, better running car, and the general public would have cleaner air.

A limited number of analyses were carried out as part of this study to examine the effects of "mitigation measures", i.e., implementation of strategies thought to be able to offset certain adverse impacts of price increases. The mitigation measures were proposed by the advisory committee to the study and were based on the long-range transportation plans of

each region. The mitigation measures, analyzed in conjunction with parking charges, gas tax increases, and congestion pricing, focused on transit improvements which would reduce wait times (by increasing the frequency of service) and increase accessibility (by extending services to more users). These mitigation measures would enhance the effectiveness of pricing measures by a moderate amount (e.g., by adding the Los Angeles transit improvements proposed for the year 2010 to the package of pricing measures, ROG reduction would increase from -39% to -41%, a 5% improvement in effectiveness.) Such investments could offset many of the difficulties posed by higher prices and could substantially increase user benefits if carefully deployed. However, the mitigation measures considered did not necessarily represent the optimal use of funds from a cost-benefit perspective nor the most effective strategies from an equity viewpoint. Since it is possible to overspend on mitigation, or to otherwise select projects which result in net welfare losses, it will be important to evaluate both costs and benefits of mitigation measures and to focus investments on cost-effective mitigation strategies in follow-up studies.

Another possibility would be to use the revenues from transportation pricing strategies to reduce, or eliminate, a tax currently paid by consumers. For example, policy-makers could eliminate the sales tax currently used in many counties to fund transportation, and replace it with fuel taxes or VMT fees. While this approach provides no money for transit improvements and other program enhancements (since no net revenues are produced), it would replace a relatively regressive tax with a fairer set of charges based on transportation use and social welfare in that fashion.

13.4 Public Acceptability

What would it take to win public acceptance of transportation pricing measures? The results of focus groups with members of the general public and interviews and discussions with policy-makers and interest group representatives indicate that some pricing strategies would be more acceptable than others, that matching the strategy to local conditions would be

important, and that clear commitments about uses of pricing revenues would be a necessary prerequisite to public support.

Focus group members understandably were not enthusiastic about transportation price increases, but they did agree that good transportation and a better environment are worth paying for. Most were willing to consider higher transportation prices if 1) they could be sure that the funds generated would be devoted to transportation improvements, and not diverted to other uses; and 2) they could feel confident that those in charge of the funds would be held accountable for providing real benefits to the public, and could have the funding taken away from them if they failed to do so.

A vocal minority was opposed to any increase in transportation prices. These individuals believe that government is wasteful and indifferent to the needs of the working person, and that transportation pricing strategies would only exacerbate both problems. At the opposite end of the spectrum were individuals who felt that problems created by the automobile justified significant price increases as well as vigorous regulatory restrictions on auto use. By far the most common reaction was a mild, somewhat grudging acceptance of the idea that price increases could help reduce congestion, air pollution, and fuel use, and would raise revenues for improving the overall transportation system. In addition, most thought that the funds could be used to provide important improvements if they were earmarked for such uses and expenditures had to be reported in detail.

Gas tax increases were the most widely accepted of the strategies, although the reviews were mixed. Most of the participants accepted the point that the gas tax had declined, in real terms, over the past several decades, and most felt that an increase would be acceptable, especially if implemented gradually. Some, however, characterized the gas tax as "just another way to gouge the middle class."

Some of the participants thought that an increase in at-the-pump charges would be an effective way to alter how much driving people do, in the short run, and what kind of cars they drive, in the longer run. However, most felt that a tax increase of less than 50 cents

would have almost no effect on their own travel behavior. Many thought that at-the-pump charges would be too blunt an instrument to be used for congestion relief or air pollution reduction. Almost all felt that any gas tax increase should be earmarked for transportation; the most frequently supported use for the revenues was to greatly improve transit and/or speed planned transit improvements. Some did not want to see more money spent on highways; a smaller number felt that this would be an important use of the moneys.

Vehicle emissions fees were hard for most of the focus group participants to understand, though once explained, the concept seemed reasonable to most. Many felt that passing the smog check should suffice as a control on emissions. Participants who owned old cars worried that they could face sharply increased fees, and owners of cars that had barely passed their last smog check were alarmed by this option. Several participants expressed concern over how such a fee would affect low income owners of old vehicles, but there was mixed reaction to a possible subsidy to offset this impact. Vehicle buy-back programs were viewed positively by some, but others expressed strong reservations because the buy-back prices were rarely high enough to pay for a "good" used car as a replacement.

There was solid agreement that an emissions fee should be based on actual vehicle performance, not a "typical" rate for a vehicle of a particular age (etc.); but there also was a great deal of skepticism about the amount of bureaucracy this might require, as well as the potential for fraud. A number of participants felt strongly that the current policy of allowing certain cars that are heavy polluters to continue to operate should be greatly curtailed or eliminated.

VMT fees were also difficult for many to understand, and many argued that the issues a VMT fee would address were already covered by fuel taxes (or could be so addressed if the fuel tax were raised.) One strong point in favor of VMT fees is the prospect of a vehicle fleet fueled in part by electricity. Under those circumstances many would favor replacing fuel taxes with a VMT fee as the means of paying for road use.

Reactions to congestion pricing varied with urban area; the strategy was seen as potentially effective in the Bay Area and Los Angeles, but of limited relevance in Sacramento and San Diego. In all four metropolitan areas some of the participants said that, at least some of the time, they would pay a fee to avoid congestion during peak periods; but almost no one said they would willingly pay it on a regular basis. A number of participants also felt that congestion pricing was basically unfair because the well-off who could afford to pay the fee already have many privileges (e.g., set their own work hours, work at home, etc.) while others, perhaps more time-constrained but less affluent, would either be forced to use far inferior options or to pay a fee they could ill afford. Several participants blamed unnecessarily inflexible employer work scheduling policies for much of the congestion, and felt that government should address this first rather than hit workers with higher fees.

Congestion pricing was hard for most discussion group participants to understand, except for applications on bridges, toll roads, and special lanes. This is in part because few are familiar with toll tags or other automatic vehicle identification technologies (AVI), and imagined that toll booths would have to be added to collect the fees. Once AVI was explained to the group, most saw it as by far the best way to implement congestion pricing. A small number worried about the government knowing who traveled where, but this was not a concern for most participants.

Parking pricing policies were the least supported by discussion group members. Most felt that parking was already priced where it was most costly to provide, and that where it is free and plentiful, the alternatives to driving and parking are too poor to be competitive, so that pricing would make little difference in travel behavior. On the other hand, the participants who currently pay for parking thought that parking pricing should be employed more often. Several participants expressed concern about another government regulation on business; several others doubted that such policy would be implemented or enforced. Few could imagine a government-imposed tax or fee on parking that would be substantial enough to alter behavior or fund significant improvements to commute alternatives; nor did they believe that employers or other private sector parking owners would make parking charges available to improve commute alternatives. Finally, if a parking charge were imposed at their

workplace, most thought they'd park elsewhere - on a nearby street or in a nearby shopping center, for example.

Although most participants believed that pricing strategies would generate significant amounts of revenue, there was no clear consensus on how such revenue might be used. The use of transportation pricing revenues to improve commute alternatives was seen as quite ineffective in Los Angeles and, to a lesser extent, in Sacramento: participants opposed highway expansion, but also felt transit could never be competitive except, perhaps, to downtown. Many felt that the money would be wasted by incompetent bureaucracies or arrogant politicians. In contrast, in both the Bay Area and San Diego, many felt that useful transit improvements could be made and that other desirable projects could be implemented.

Interviews with local officials and interest groups have uncovered very similar reactions. Most believe that pricing strategies could be effective in reducing congestion, emissions, and fuel use, if carefully implemented. However, many also were skeptical that effective implementation would proceed. The barriers, in this view, are an apparent lack of broad-based support for action, the strength of the anti-tax movement, the high visibility of government action on most of the strategies, and the lack of clear precedent demonstrating overall benefits and an ability to offset inequities. Suggestions for overcoming the barriers included the following:

1) If implementation is to proceed, business, environmental, and social justice communities must be willing to publicly advocate transportation pricing measures and to take on the effort needed to educate the public.

2) Specific proposals must address the equity issues directly, and must offer concrete commitments for offsetting harm in an environmentally and socially acceptable way.

3) Approaches that give local governments or regions authority to implement pricing programs matching their circumstances make more sense than uniform statewide ap-

proaches, with measures designed primarily for revenue generation (e.g., a VMT fee designed to supplement or replace current funding sources) the primary exception. Authorization for local action permits those communities that can build support for a measure to proceed without forcing the issue on those who are not prepared to act. In many cases a city- or county-level authority would be sufficient to avoid spillover problems.

4) Several transportation pricing measures may become more acceptable as new technologies such as AVI, tamper-resistant odometers, and remote sensing are implemented. These new technologies would greatly aid in the implementation of congestion pricing, VMT fees, parking pricing, and perhaps vehicle registration fee policies; as consumers become more accustomed to new technologies they may also become more accepting of pricing strategies which utilize these devices. Furthermore, if low emission and zero emission vehicles become a realistic option for more people, public willingness to accept road pricing, higher fees for petroleum fuels, and emissions fees also should increase.

13.5 Implementation Planning Issues

Finding effective, politically plausible transportation pricing measures is a major accomplishment, but additional steps must be taken if implementation is to proceed and be effective. A number of legal and institutional issues must be addressed, ranging from the characterization of the measure as a tax or a fee to the selection (or creation) of public or private organizations to carry out each step of the implementation process. Among the items that always need to be considered in implementation planning are specific assignments of responsibility, schedule, and funding for carrying out the detailed program design, actual implementation, public outreach and liaison, implementation monitoring and enforcement, evaluation and reporting, and periodic updating or revisions to the measures. Specific measures raise numerous other implementation issues that would have to be addressed, and of course political feasibility would have to be continually evaluated as the details of the design are worked out.

Implementation could proceed in a variety of ways for most transportation pricing measures. For some measures, the most plausible designs would build upon existing programs and assignments of responsibility. For others, new technologies and new institutional arrangements seem to be the preferable way to go. Implementation strategies also depend, however, on the timing, scope and scale of implementation. Designs which provide for learning from initial implementation stages, whether in market niches or at "introductory prices", have great potential both as a test bed for new ideas and as a device for introducing new approaches to the public.

Cost-effectiveness is an important element in implementation planning, as are solid estimates of implementation costs and net revenues (along with a revenue expenditure plan.) Rough estimates suggest that the costs of implementing transportation pricing strategies can be kept to 5-10 percent of gross revenues; the resulting revenue projections and cost-effectiveness metrics would be highly favorable. However, cost, revenue, and cost-effectiveness estimates are highly dependent on the details of the implementation design, so are rightfully done only after a specific proposal has been set forth.

13.6 Conclusion and Recommendations

Transportation pricing measures offer substantial potential for reducing congestion, improving air quality, reducing energy consumption, and increasing the overall efficiency and effectiveness of California's transportation systems. Assuming that prices are set at levels justified by long-run marginal social costs and revenues are spent in efficient ways, our analyses show that such measures would be:

- effective at achieving environmental, social, economic, and operational objectives, at prices that are justifiable on economic grounds;

- unlikely to alter land use patterns substantially, at least at the pricing levels considered, but mildly supportive of higher densities and more efficient location choices;

- capable of generating large net revenues, assuming a moderate level of cost control in the design;

- mostly incident on middle and upper income travelers, though lower income travelers would feel the effects most sharply;

- enhanced by mitigation measures, including measures that offset income effects for the lower income groups;

- implementable in a variety of ways, involving the private sector as well as public entities, and utilizing either existing technologies or new ones as they become available.

In short, transportation pricing strategies could be cost-effective alternatives for improving the overall function of the transportation system.

A major issue, however, is whether transportation pricing measures can garner sufficient political support to be implemented. Most transportation pricing measures require, or would be greatly enhanced by, new legislative mandates or delegations of authority, but political leaders are skeptical. They look at the long-established record of resistance to tolls and fees, note current attitudes opposing taxation, and doubt that public opinion would support transportation pricing any time in the near future. While polls and focus groups indicate that public opinion is not so negative as this view would suggest, the lack of substantial, visible support for pricing (despite stalwart efforts on its behalf from a few) suggest to political leaders that the effort required for implementation is great and the likely rewards few.

At the same time, there is deep sentiment in elements of the planning, engineering, academic, environmental, and business communities that the failure of current prices to convey accurate signals to travelers is a root cause of many of the problems our transportation systems now face. Partly because of this sentiment, some of the institutional and technological impediments to transportation pricing recently have eased. Nevertheless, it is far from clear that this support is strong enough and focused enough to keep pricing options on the agenda and increase their feasibility.

Many transportation pricing proposals when introduced to the average citizen sound like ordinary taxes clothed in extraordinary rhetoric. Work with focus groups shows that this cynicism about government revenue collection is a deep-seated impediment to transportation pricing, but it is not insurmountable. In particular, attitudes about pricing appear to respond strongly to information about its rationale, its workings, and its potential benefits, as well as to specific commitments about how revenues would be used. In terms of public education, there is the possibility that a few well-crafted, representative pricing demonstrations which succeed in a very public way could produce a rapid shift in public attitudes. This is why new toll road and HOV buy-in projects such as S.R. 91 and the ISTEA congestion pricing demonstration projects around the country have assumed such importance.

Another common objection to transportation pricing concerns the effect on the poor. For example, congestion pricing as we have presented it here is a policy designed explicitly to help the transportation system and the economy function more efficiently by persuading those with the lowest values of time not to use the system during peak periods. Income certainly is a factor (though not the only factor) in determining values of time. Our work shows that the poor do not travel as much as is commonly assumed, especially by highway, although those who do travel would be disproportionately affected by higher prices. The Bay Bridge work, for example, shows that only about 3 percent of morning commuters on the Bridge fall into the lowest income quintile. This means both that the potential for devastating impacts on the poor is not large and that such impacts could be mitigated with a relatively modest commitment of resources. Focus group discussions revealed mitigation to be a touchy issue, however. People generally felt that improved transit in appropriate corridors

would be good, but that any program of direct compensation (such as a "lifeline" subsidy for toll tags) would have to be very tightly controlled.

A more serious political issue for transportation pricing may well be the effect on the middle class, especially on the second and third income quintiles. Households in this income range would not be considered poor, but generally do operate under tight budget constraints. Much of the effectiveness of pricing derives from changing the behavior of this group who often must travel but cannot afford a significant additional outlay. Subsidies to transportation and to mortgage lending since World War II have promoted a level of daily travel among this group that could not be sustained if prices were more closely aligned with the marginal social costs.

For pricing to occur in more than a token way, the electorate - including, presumably, the bulk of the middle class - must understand and agree that the benefits of marginal social cost pricing outweigh the costs. Two paths to this awareness have been suggested. The first path rests on an argument that the rapid growth of congestion over the past two decades and the deterioration of conventional funding mechanisms such as fuel taxes are clear evidence that our historical subsidies to the transportation system have become increasingly dysfunctional. As this argument goes, subsidies simply will have to decline in order to keep the transportation system functioning, a move which the electorate will come to support as it learns the dimensions of the problem. The real policy question then revolves around how to smooth the transition of the lower middle classes to a regime of significantly higher mobility costs. The essence of this argument is that realignment of transportation pricing is inevitable, and the role of the professional community should be to point toward the most ethical and efficient strategies.

The second path rests on a more aggressive set of assertions about the benefits of pricing. Pricing, in this line of argument, is seen as a way of making transportation funding more progressive by inducing higher income travelers to pick up more of the costs. At the same time, it is argued that some pricing measures could have the effect of improving transit and HOV alternatives to such a degree that everyone is better off despite higher prices for

driving alone. For example, this kind of win-win outcome is a real possibility with congestion pricing, which would allow buses and perhaps carpools to reap the travel time advantages without incurring additional costs (though environmental impacts could be a concern if highway expansion were an element of the strategy). This approach has the advantage of being much more positive than simply relying on a perception of crisis, though without real-world examples it relies heavily on modeling and analysis for its credibility. Again, we reach the view that highly visible, representative demonstrations of successful pricing are essential to moving public opinion.

In conclusion, there is little doubt that transportation pricing can be economically efficient and effective at reducing mobile source emissions. However, pricing at the levels required for significant effect would represent a major institutional change in the transportation system. While many will fear such a change even if technical assessments suggest a benign outcome, our work hints that a majority would be open to persuasive arguments about the rationale for pricing. Thus, the real unanswered questions revolve around implementation: are the arguments really persuasive enough? is it possible to reach a broad enough sector of the electorate with these arguments? Are the potential benefits of pricing to key stakeholders large enough to induce the kind of sustained effort that will be necessary to achieve such a substantial institutional change? We do not know the answers to these questions, but experience with tentative efforts at pricing now underway could teach us a great deal. Beyond that, further research on implementation issues, and especially the political and insitutional aspects of implementation, is highly recommended.

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List of Inventions Reported and Published

None

Appendix A: Glossary

AASHTO - American Association of State Highway and Transit Officials
ABAG - Association of Bay Area Governments (sister agency to MTC)
ATSAC - automatic traffic surveillance and control
AVI - automatic vehicle identification
BART - Bay Area Rapid Transit
BPR - Bureau of Public Roads
BAAQMD - Bay Area Air Quality Management District
CarTalk - Policy Dialog Advisory Committee to Assist in the Development of Measures to Significantly Reduce Greenhouse Gas Emissions from Personal Motor Vehicles
Caltrans - California Department of Transportation
CARB - California Air Resources Board
CBD - central business district
CEC - California Energy Commission
CPI - Consumer Price Index
CO - carbon monoxide
CO2 - carbon dioxide (a greenhouse gas)
CEQA - California Environmental Quality Act
CS - Cambridge Systematics
EDF - Environmental Defense Fund
EMFAC7F - California Air Resources Board's emissions model
EPA - Environmental Protection Agency
ETC - electronic toll collection
DOE - Department of Energy
DRAM/EMPAL - Direct Residential Allocation Model / Employment Allocation: components of a land use model used in several metropolitan areas
FHWA - Federal Highway Administration
FTA - Federal Transit Administration (formerly UMTA)
HCM - Highway Capacity Manual
HOV - high occupancy vehicle
ISTEA - Intermodal Surface Transportation Efficiency Act of 1991
LOS - level of service
MEPLAN - a land use model used primarily outside the U.S.
MPO - metropolitan transportation organization
MTC - Metropolitan Transportation Commission (for the San Francisco Bay Area)
MTCFCAST - MTC's travel modeling package
NEPA - National Environmental Policy Act
NOx - oxides of nitrogen
OECD - Organization for Economic Cooperation and Development
PM_{10} - Particulate matter with a diameter of 10 microns or smaller
POLIS - land use model used in the San Francisco Bay Area
PPM - parts per million
PUMS - public use microdata sample of the U.S. Census

PUMA - public use microdata area defined by the U.S. Census
ROG - reactive organic gases
SACOG - Sacramento Area Council of Governments
SANDAG - San Diego Association of Governments
SCAG - Southern California Association of Governments
SCAQMD - South Coast Air Quality Management District
SIC - Standard Industrial Classification
SOV - single occupancy vehicle
SR - state route
STEP - a computer package for microsimulation of travel demand
SRGP - Short-Range Generalized Policy Analysis Program
SYNSAM - a computer package for the generation of synthetic samples
TCM - transportation control measure
TRANUS - a land use model used primarily outside the U.S.
TRB - Transportation Research Board
TRIP - version of STEP used for EDF work in Los Angeles
UCB - University of California at Berkeley
UTPS - Urban Transportation Planning System (regional transportation modeling package)
UMTA - Urban Mass Transportation Administration (now FTA)
VOC - volatile organic compound
VKT - vehicle kilometers of travel
VMT - vehicle miles of travel

Appendix B: Description of the STEP Analysis Package

B.1 Overview

This appendix discusses STEP, a travel demand modeling package designed for planning applications and policy analysis. STEP is composed of an integrated set of travel demand and activity analysis models, supplemented by a variety of impact analysis capabilities and a simple model of transportation supply. STEP is based on microsimulation - a modeling technique which uses the individual or household as the basic unit of analysis rather than dealing with population averages. (cf. Orcutt, 1976). STEP results are aggregated only after the individual or household analyses are completed, allowing the user great flexibility in specifying output categories.

STEP's models use actual or forecast data on household socioeconomic characteristics, the spatial distribution of population and employment ("land use"), and transportation system characteristics for the selected analysis year(s). The socioeconomic characteristics of a sample of households and its members are usually taken from a regional travel survey or from the U.S. Census Public Use Microdata Sample (PUMS). Population, number of households, and employment by category (type) are taken from the regional "land use" data base. Transportation level-of-service data (times and costs) are derived from the region's travel model system. The land use data are provided to STEP for subareas (which could be zones, districts, or corridors) and for the region as a whole; the level-of-service data are provided in the form of large matrices of interzonal times and costs. STEP then reads through the household sample, attaching level-of-service and land use data to each household record as necessary. For each household, STEP uses its models to predict a daily travel and activity pattern for each individual in the household. Finally, household travel is summed up and household totals are expanded to represent the population as a whole.

STEP can analyze any change in the population or in the transportation system that 1) can be represented in terms of the variables in its models and 2) can be associated with a specific geographic area or grouping of households. Testing the effect of a change in conditions or policies is a simple matter of re-analyzing the household sample using the new data values, and comparing the results with previous outputs. For example, a new highway or new transit service can be represented by changed travel times and costs for the areas served; a parking price increase can be represented by an increase in out-of-pocket costs;

an increase in income in a particular area or for a particular population subgroup can be represented by editing the household file to incorporate the revised incomes. Along similar lines, future years can be represented through proportional factoring and reweighting of survey observations to reflect expected regional trends, or can be based upon a more sophisticated microsimulation of household changes based on cohort survival and other methods of demographic forecasting.

The sampling framework preserves the richness of the underlying distribution of population characteristics and permits tabulation by any subgroup with sufficient observations to be statistically significant. For example, the results can be disaggregated by income level and age, which would allow an assessment of effects for, say, various income quintiles among the retired population. This is a significant advantage over an aggregate model, which uses zonal averages for most socio-economic data.

STEP maintains its quick response capability while achieving great detail in representing behavior in part by reducing its detail in representing transportation networks. STEP does not have an internal transportation network representation and traffic assignment model, so changes in level of service resulting from changes in demand must be calculated in another way.

To approximate the effects of changes in demand on network performance and vice versa, a simple routine for estimating level-of-service was incorporated into STEP in the early 1980s (Harvey, 1983). The simplified level of service model uses peak and off-peak travel times and base case demand estimates to calibrate a supply function for appropriate spatial groupings of trips (i.e., trips in broadly-defined "corridors"). For each change in demand, the calibrated function can be used to compute a new "equilibrium" in the corridor. While this simplified level of service model is useful for many analyses, it is intended only as an approximation of changes in network performance and is likely to be inadequate in cases where large network perturbations could occur or where specific route choice changes are at issue. When network questions are critical, STEP must be used in conjunction with a more detailed network model. Procedures for "interfacing" STEP with conventional network models have been developed for this purpose.

Several features of STEP make it useful as modeling tool for policy analyses. STEP's regional, subarea, and corridor-level analysis capabilities fit well with the scope and scale of

many policies proposed for urban areas. Its model formulations display linkages consistent with travel behavior theory and represent key time and cost variables as well as demographic variables. Its use of microsimulation makes it possible to address many of the questions about equity and the distribution of impacts that frequently arise in policy pricing. Finally, it is far faster and less expensive to run STEP than to apply a conventional regional model system.

STEP's data analysis capability is another important asset. STEP's microsimulation formulation permits the package to be used as a survey tabulation technique employing sophisticated data transforms and linkages. For example, many travel surveys contain detailed information about the vehicles each household owns and indicate which vehicle was used for each trip made on the survey day(s). Using STEP, these vehicle data can be tabulated so that exact usage patterns by model year or vehicle type can be determined. They also can be related to personal and household characteristics to yield useful information about, e.g., low-income households' dependence on old vehicles and their contributions to vehicular emissions.

STEP itself was originally developed for sketch planning analyses in the San Francisco Bay Area and in its initial versions used the Bay Area's travel models developed in the 1970s (Harvey, 1978). Since that time, all of the models in STEP have been completely reestimated and additional models addressing location choice, time-of-day of travel choice, and congestion effects have been added. The most recent formulations are nested logit. A number of versions of STEP are currently available, including options that permit the analysis of activity data as well as travel data, and versions that use either MOBILE or California EMFAC emissions data.

STEP has been utilized in a number of Bay Area studies over the years, and has been adapted for use in studies in Los Angeles, Sacramento, Chicago, and the Puget Sound region (Seattle). Applications can proceed with model reestimation specifically for the region - essentially, by creating a completely set of new models for STEP - but to date applications outside the Bay Area have relied on extensive recalibration of the default (Bay Area) models plus a limited amount of re-estimation as needed to match local conditions.

The basic structure of the STEP model system is shown in Figure B-1. The basic data requirements of the STEP model are summarized in Figure B-2, and a typical sequence of activities for a STEP application is shown in Figure B-3.

In the remainder of this document, the analysis concepts used in STEP and the basic features of the STEP models are presented. Because STEP was developed over a long period and several versions are in current use, the document provides a brief history of the modeling package and describes key applications.

B.2 The STEP Analysis Concept: Microsimulation

STEP is based on the concept of microsimulation, which was pioneered by the economist Guy Orcutt in the late 1950s. Orcutt created a method for analyzing prospective social welfare policies by applying an ensemble of models depicting relevant individual and household behavior to a set of households drawn from survey data. Simply put, Orcutt's method was to process one household at a time, using the models to estimate how the behavior of the household and its members would change given some adjustment in social policy. Overall estimates were developed by summing up the results for individuals and households, using appropriate population weights.

This method, sometimes called sample enumeration, has at least two powerful advantages. First, it allows all of the information known about households and individuals to be used in the behavioral models. In contrast, a conventional modeling approach typically relies on what can be summarized at an aggregate level, say for census tracts or traffic analysis zones. Much of the information content of a survey database can be lost in this way.

Second, the microsimulation approach supports broad flexibility in output tabulations, because of the detail that is known about each household and individual. In particular, behavioral changes can be compared among subgroups of the population - such as by income, age, household structure, and race - that are more difficult to isolate in an aggregate modeling framework.

With microsimulation, in order to report statistically valid results for a geographic subarea, there have to be enough households or individuals in the sample to represent that subarea.

If one is interested in flows between subareas - as in a typical transportation analysis - the typical travel survey's sample size can be a constraint. However, recent computer and software advances, along with now proven methods of generating good synthetic household samples based on the US Census Public Use Microdata Sample (PUMS), have made it possible to attain any desired level of spatial detail by performing microsimulation with up to a full population of the region.

The Orcutt microsimulation approach had been around for some time when disaggregate models of household and individual travel choice (especially for mode of travel) were first developed in the early 1970s. Microsimulation was widely used by researchers to test their specifications and to exercise their models "in-house", but none of the field applications of these models involved microsimulation, partly because of its heavy computational demands and partly because practitioners preferred incremental improvements to their aggregate models over the wholesale model system reconfiguration microsimulation would have entailed.

B.3 Microsimulation as an Application of the MTC Model System: SRGP and STEP

The first practical planning application of microsimulation in travel demand analysis was developed as a quick-response method of applying an innovative set of models developed for the San Francisco Bay Area in the mid-1970s. By that time, disaggregate travel demand modeling had advanced enough to suggest that a full demand model system covering all elements of traveler behavior could be developed with disaggregate techniques. A consortium of consultants and academics from Cambridge Systematics (CS) and the University of California at Berkeley (UCB) was asked to develop such a model system for the Bay Area under contract to the Metropolitan Transportation Commission (MTC).

The models were specified with one eye toward conventional infrastructure planning and another toward emerging proposals for travel demand management. Both travel time (in its various forms) and travel cost appeared as variables throughout the new models, whereas cost had not been acknowledged previously as a potentially important policy lever. The resulting models were innovative yet constrained by conventional approaches to the

representation of travel behavior. The model system in effect generates a weekday travel pattern for a specific household, as a function of the level-of-service characteristics of available modes (both peak and off-peak), the location of the household's residence, and key socio-economic characteristics of the household (such as income and number of workers). Standard trip purpose categories were used (home-based work, home-based social-recreational, home-based other, and non-home-based). But within each trip purpose there was a tight hierarchical relationship among 1) the quality of modal alternatives connecting trip origins and destinations; 2) the choice among potential trip destinations, and 3) household and individual decisions about how much to travel. Both choice of destination and number of daily trips (by motorized means) were found to be highly dependent on measures of accessibility. Household auto ownership also was found to vary directly with highway accessibility and inversely with transit accessibility.

MTC wanted the full model system to function in a conventional network- and zone-based framework, because infrastructure planning remained their most important model application. The CS/UCB team accomplished this by stratifying households in each traffic analysis zone by the most important household characteristic - income - then using census data to calculate average values of other household characteristics for each zone and income stratum and applying the household models to each zone and income stratum as if they were conventional aggregate formulations. The resulting large-scale model system was cumbersome, but innovative in its treatment of accessibility.

Recognizing the difficulty of using such a model system for screening myriad demand management (or infrastructure) proposals, the CS/UCB team also produced a microsimulation package for MTC based on the original disaggregate formulation of the models. Because the Bay Area's most recent travel survey dated from 1965, they also developed a method for synthesizing a household sample from census data (Coslett, 1977).

The microsimulation program, developed by G. Harvey (then at UCB) and J. MacMann and R. Nestle (then at CS), was initially named SRGP- **S**hort-**R**ange **G**eneralized **P**olicy Analysis Program (Cambridge Systematics, 1976). It drew on five streams of data to carry out a microsimulation using the new MTC model structure:

1. A file of household survey records, synthetically-generated for the Bay Area prototype, but potentially from an actual household travel survey.

2. A file of zone-to-zone travel times and costs, representing AM peak and off-peak conditions and highway and transit options.

3. A file of zonal characteristics, including population, households by dwelling unit type, labor force, employment by job category, land area by use category, and average all-day and hourly (mid-day) parking costs. The zonal file also allowed two aggregations of zones for use in the remaining inputs and outputs: 1) a zone-to-county definition, for reporting by easily-recognizable jurisdictional boundaries; and 2) a zone-to-district definition, where districts were intended to be the smallest possible sub-county areas for which statistically-valid samples were present.

4. A file of model coefficients, with an allowance for additional adjustments to constant terms on a county-to-county or district-to-district basis.

5. A file based on a simple script language to allow quick transforms of variables on a district-to-district or global basis. For example, the script language could be used to add $3.00 to the all-day parking charge for a specific district or group of districts.

Once the ensemble of data was set up and the model calibrations were refined (to produce acceptably accurate flows, shares, etc. on a district-to-district basis), SRGP could be used to scan quickly among a variety of demand management strategies. Other, more complex, land use and infrastructure changes also could be tested by modifying the input files directly, but relatively little emphasis was placed on such applications initially.

The first major change to the microsimulation software was the addition of auto emissions models, carried out by Harvey and Atherton in 1978 (Cambridge Systematics, 1978). The revised software was used to investigate how regional emissions burdens might be affected by transportation policy levers. The microsimulation models were used to provide a first-order estimate of the number, time of day (through crude trip purpose correlations), length, and average speed of trips by each household under different policy scenarios. Emissions data taken from EMFAC in California and MOBILE outside California were used to estimate trip emissions as a function of average trip speed and vehicle condition (cold or hot) at start-up. By summing the transportation emissions estimates over a sample of households, total transportation emissions and changes from the "base case" were estimated.

CS also added a fuel consumption calculation and applied the SRGP microsimulation software in several studies for the Department of Energy (DOE) (Cambridge Systematics, 1978) and others. However, applications of SRGP ended in the early 1980s, in part because of a general decline in funding for transportation planning studies in that period and in part because the SRGP software, optimized for the computer capabilities of the mid-1970s, became increasingly in need of an overhaul.

During this same period, MTC took over its own version of the microsimulation software. Working directly for MTC, Harvey expanded the outputs, added calculations of "expected utility" (a direct and rigorous benefit measure), and produced a manual (Harvey, 1979). The MTC software was renamed STEP at the request of CS, to avoid confusion about divergence from SRGP.

After a flurry of exploratory activity with STEP, MTC lost interest in it; in the early 1980s MTC's modeling efforts focused on making use of its new, high quality household travel survey (Crain & Associates, 1981), and data preparation and reestimation of the main, large-scale model system were given priority over the microsimulation software. However, Harvey continued to refine the STEP microsimulation software for use as a teaching tool in classes on transportation policy and travel demand. Between 1982 and 1989, he made a number of significant changes, including a total re-write of the software for the microcomputer, based on a structured approach designed to ensure ease of maintenance as well as to optimize speed. He also added a number of models and analysis modules, discussed in the following sections.

B.4 STEP Enhancements, 1982-1989

The key enhancements added to STEP in the 1980s included a simple supply model; a fuel consumption model; survey analysis capabilities; stated preference / expert system analysis capabilities; a residential location choice and land supply model; a work location choice model; a time of travel model; and an estimation data set generator routine. Each of these enhancements is discussed below.

-- Supply Model:

With support from the California Energy Commission, a simple supply equilibration routine was added to give a first-order indication of how a large change in demand might be diminished by compensatory changes in travel time (Harvey, 1983). An equation generalized from the well-known Bureau of Public Roads (BPR) formula was adapted for this purpose:

$$t = t_0*(1+(v/c)^b)$$

where:

t is the travel time per mile at volume v
t_0 is the "free-flow" travel time per mile
v is the peak VMT
c is - conceptually - the peak capacity in VMT
b is a parameter of the function

Two options for applying the formula are provided. The first involves equilibrating for each individual peak period trip without regard for what is happening to other travelers. An initial demand model calculation is made for the base conditions represented by peak and off-peak highway travel times in the STEP inputs. The resulting "personal peak VMT" becomes v in the above equation. The variables t and t_0 are just the original peak and off-peak travel times per mile, derived from the STEP inputs. Given a value for b, a "pseudo" capacity (c) can be computed. Values of b of about 2 seem to give the best indication of real network performance. The resulting equation then can be used to estimate how the peak travel time for this traveler might change when the demand (again measured in "personal peak VMT") changes as the result of some policy. For example, suppose that daily parking costs are raised by $3.00. The "personal peak VMT" for a given traveler will drop by some amount. But a lower v will yield a lower t in the above equation, which translates into a lower peak travel time. In turn, the new time - when used in the demand models - produces a somewhat higher estimate of "personal peak VMT". So it goes back and forth until the change in peak travel time and the revised "personal peak VMT" stabilize. Careful programming minimizes the number of steps in this "equilibration". Generally, the change in regional aggregate peak VMT due to the policy in question is about 20 percent smaller after accounting for the highway supply effect than from a pure demand response.

A second, superficially more plausible method of equilibration applies the same formula in basically the same way to logical groupings of travelers. The districts defined in the STEP zonal data file are used to approximate major corridors in the region. Each inter-district movement is assigned to such a "pseudo corridor". Then the base case values of v, t, t0, and c are calculated for each pseudo corridor by enumerating the full sample once without applying any policy changes. Values of b around 2.1 seem to work best in this case (probably reflecting the presence of more extreme values of v/c in the "personal peak VMT" approach). Using the supply equation for each "pseudo corridor", the demand effects of proposed policies then are "equilibrated" through repeated enumeration of the sample, with an appropriate adjustment to the average corridor peak rate of travel (t) at each step. Again, careful programming minimizes the number of steps in this "equilibration", and the process is aided by the fact that the functions involved are quite well behaved in this context.

The "pseudo corridor" approach yields about the same attenuation of policy effects on regional VMT as the "personal peak VMT" approach (i.e., about 20 percent in the congested networks of the Bay Area and Los Angeles). The results appear to be consistent enough for a given network that it may not be necessary to equilibrate the results for every STEP run - a consistent x percent reduction (once x has been determined) can be applied to the pure demand outputs. However, the appropriate x value in this shortcut must be determined for each set of base network conditions (not only from region-to-region, but for different time periods within each region).

--Fuel Consumption Model:

Again with support from the California Energy Commission, a trip-based fuel consumption model was synthesized from the literature and implemented in STEP (Harvey, 1983). The model consists of two equations. The first gives the average gallons per mile for a reference speed as a function of vehicle weight and vehicle idling fuel consumption:

$$f(v_0) = a_1 * W + a_2 * I$$

while the second yields a multiplicative adjustment for speeds above the reference speed:

$$f = f(v_0) * (b_0 + b_1 * v + b_2 * v^2 + b_3 * v^3)$$

where:

$f(v_0)$ is the fuel consumption in gallons per mile at speed v0
v_0 is the base vehicle speed
W is the vehicle weight (lbs)
I is the vehicle fuel flow rate at idle, in gallons per minute
f is the fuel consumption in gallons per mile at speed v
a_1, a_2, b_0, b_1, b_2, and b_3 are coefficients

Some of the household samples used with STEP have included information about the make, model, and year of each household vehicle (and occasionally an average mpg for each vehicle as estimated by the respondent). More generally (as when the STEP auto ownership model is used), specific data are not available that would enable an independent estimate of fuel economy for each vehicle. In these cases, the first equation above is replaced with an estimate of average fuel economy for the fleet, and the second equation is re-normalized to provide an appropriate adjustment above and below the reference speed.

-- Survey Analysis Capabilities:

An option was added to STEP for obtaining base case information by interpreting and tabulating a household survey rather than applying travel demand models (Harvey, 1987). In effect, the models are replaced with actual daily travel patterns, which still can be correlated with the zonal- and network-based data present in STEP's database. The software uses trip or activity diary records to build daily activity sequences for each individual and daily trip chains for each vehicle. If there is specific information about the make, model, and year of the vehicles, then the program can produce a highly accurate accounting of the emissions and fuel consumption characteristics of each trip.

"Handles" also were provided in the software for special tabulations beyond the normal STEP outputs. Typically, these must be programmed specially for each survey.

--Stated Preference and Expert System Analysis Capabilities:

In conjunction with the survey tabulation feature of STEP, software handles were provided for a rules-based (or more formal) method of representing policy effects directly through changes in activity/travel patterns. For example, stated preference surveys might be used to explore how respondents to a trip diary think they would alter their travel patterns in response to some policy change. Then, either the specific changes described by the respondents, a set of expert system-type rules generalized from the responses, or a mathematical model estimated from the responses can be programmed into the STEP code.

STEP has been used in this way only to carry out some "what if" analyses of proposed transportation measures. In the Bay Bridge congestion pricing study, for example, we tested different levels of time-of-day shift and mode shift in response to higher peak tolls, in order to assess the implications of errors in the models. (A more formal activity change module is planned for STEP based on the outcome of the Bay Area stated preference survey planned for 1996.)

-- Residential Location Choice and Land Supply Model:

A residential location choice model (Harvey, 1989), enhanced by a simple land supply procedure, was added to STEP to capture the changes in location that might occur in response to changes in transportation investments and policies. The model uses districts based on the Census Public Use Microdata Areas (PUMAs) rather than on the more detailed traffic analysis zones. Each PUMA is considered a potential residential location. A different choice model was developed for each of several household types, defined by:

- type of dwelling unit (single family vs. multi unit)
- type of financial arrangement (own vs. rent)
- number of employed adults (1, 2, or 3)
- presence of minor children (yes or no)
- ethnicity (Hispanic, black, Asian, other)

A specific location choice model has the following form:

Pi = exp[Ui]/(exp[U1]+...+exp[Un])

Ui = b1*(price{i}/f(inc)) + b2*eth{i} + b3*crime{i} + b4*tax{i} + b5*sch{i}
+ b6*sum(ln[mode choice denominator{ij}])

where:

i indicates a potential PUMA of residence
j indicates the zone of work
n is the number of PUMAs in the system
Pi is the probability this household will choose to live in i
U is the perceived utility of a PUMA as a residence
price{i} is the mean monthly price at i of the household's current type (rent, own, single, multi)
f(inc) is a non-linear transform of the household's income
eth{i} is the percent at i with this household's ethnicity
crime{i} is the rate per 100,000 of serious and violent crime at location i
tax{i} is the property tax on a home of average value at i (homeowners only)
sch{i} is the average per pupil expenditure in location i (households with children only)
sum(ln[mode choice denominator{ij}]) is the sum of the log of the denominator of the mode choice model for each worker in the household
exp[] indicates "e" to the power denoted in brackets
ln indicates the natural log
b1,...,b6 are parameters fit by estimation

The parameters are different for each household type and region. For example, single worker, single person households do not place much importance on work trip accessibility (measured by the mode choice denominator), while the location behavior of two worker, two person households is well explained by work trip accessibility alone. In general, price, crime,

and work trip accessibility are the most important variables, and the models can be run plausibly with those alone.

In a typical analysis, the residential location choice model is run first on the base case data, in order to develop a set of location- and household-type-specific dummy variables to replicate the base distribution of households. Future zone characteristics (other than accessibility) can be taken from available sources or explored through scenario testing.

The exogenous specification of prices in the location choice model would be problematic if things change enough, because large shifts in location preferences would surely alter these prices. To approximate this effect, a simple land supply response procedure was added. The supply response depends on information about the remaining land area available for development at each location, and about the amount of land consumed on average by a unit of each housing type. Basically, the location choice models are not allowed to violate the cap on developable land in a location or drop below the number of occupied units present in the most recent (actual) base year (other rules of this sort would be possible). Rather than simply imposing boundary constraints on the allocations, however, price adjustments are used to shift allocations through the residential location models. At the upper end (over-allocation), prices of all housing types in the location are shifted up by a single factor. At the lower end (under-allocation), the price of each housing type is reduced in proportion to the degree of under-allocation (but by no more than 50 percent, so that instances of under-allocation in some extreme cases cannot be avoided). A reasonably efficient search routine is used to "equilibrate" the prices and location choices.

Information on the remaining development potential of each location was readily available in the Bay Area, where these models were initially developed. Some metropolitan areas do not produce such data routinely. In these cases, it is necessary to either 1) estimate the developable land area from, say, gross land area and approximate density assumptions or 2) simply assume a cap on the percentage change (up and down) that can occur in each location, and test the sensitivity of results to the caps. In the extreme case, one can assume that the housing stock will stay the same at each location, and allow prices to adjust accordingly. Though such a tightly-constrained analysis may be valid in some circumstances, the results would imply a very high impact on low income households.

Modeling results for residential location would improve if a more detailed picture of the housing stock by subarea were available. But the approach described here is sufficient to provide a first-order understanding of the circumstances under which location might be sensitive to transportation conditions.

-- Work Location Choice Model:

A work location choice model was added to STEP.[1] This work location choice model is simply the work trip distribution model from the full MTC model system:

$$P_j = \exp[U_j]/(\exp[U_1]+\ldots+\exp[U_n])$$

$$U_j = \ln[A_j] + b*\ln[\text{mode choice denominator}\{ij\}]$$

where:

i indicates the zone of residence
j indicates the zone of work
n is the number of zones in the system
Pj is the probability that a worker living in i works in j
U is the perceived utility for a zone as a workplace
Aj is the attractiveness of zone j as a workplace
exp[] indicates "e" to the power denoted in brackets
ln indicates the natural log
b is a parameter fit by estimation

The mode choice denominator contains all of the information from the work mode choice model for a trip between zones i and j. While the model could be construed as a conventional gravity type, it was in fact estimated from disaggregate data using multi-modal accessibility factors drawn from the work mode choice model.

[1] The original version of STEP did not address workplace location; the number of workers in a household and the location of each primary workplace was assumed to be known from the household file.

Because this model presents a fairly crude picture of work location choice (e.g., it is not internally constrained to match workplaces with available jobs), we have tended to use it mainly for longer-term studies, and to interpret the results primarily as an indication of where labor market pressure might arise for a different spatial arrangement of commercial and manufacturing activities than indicated by the official zonal forecasts. For studies of near-term policy effects, we have tended to keep the status quo arrangement of workplaces as embodied in the survey.

STEP can be run to force the work trip attractions to match the employment in each zone. This is achieved by creating "pseudo" attraction factors that are allowed to rise or fall until the "true" attractions are matched.

For compatibility when both the residential and workplace location models are in use, an alternate version of the residential location model was estimated using the workplace location denominator for each worker rather than the mode choice denominator.

--Time of Travel Model:

A simple time-of-travel for AM Peak work trips was added to STEP.[2] The model focuses on work starting time for auto drivers, as indicated by work trips reported in the survey data. We assumed that the morning departure time from home (which arguably is of greatest interest to transportation planners because of its tendency to be sharply peaked) stems from two partially-related behaviors: a determination of the desired work start time and a decision about when to begin traveling in order to satisfy the desired start time. Put differently, given the work start time, departure time is determined largely by the performance of available travel modes. (Of course there will be exceptions to this, as when a parent must time the work trip to match the start of daycare or school.)

The model asks first whether the worker is likely to have a "regular" schedule, defined as a work start time between 5:30 am and 10:30 am. This is treated as a binary probability of following a regular schedule, as a function of household income, household size, and the

[2] As of this writing, time of travel for other trip purposes is based on distributions drawn from travel survey data.

ratio between am peak and off-peak highway travel time. Then, the model computes the probability of starting in each of the five peak hours, as a function of household size and, again, the ratio of am peak to off-peak travel (coefficients are allowed to vary by time period). The result is a simple placement of each worker in an hour of the peak period or off-peak.

Response to the am peak/off peak ratio is not linear. In fact, the ratio does not make much difference until it reaches about 1.8, but by about 2.0 it has become a very strong explanatory factor. This indicates that congestion may not have much influence on activity scheduling until it becomes quite severe. To put this finding into perspective, as of 1990 only about 5 percent of the work trips in Los Angeles and the Bay Area are exposed to routine peak travel time ratios of 2.0 or higher, less than 1 percent of San Diego work trips are exposed to this level of congestion, and no Sacramento work trips are.

Occupation and industry variables have been omitted from the standard model formulation because these variables are not always available from household travel surveys. However, exploratory tests in the Bay Area indicate that even a crude indicator of industry, such as the first digit of the SIC (Standard Industrial Classification) code, greatly improves the predictive ability of the time of day models. Whereas the average work start time for all "regular" workers in a place like the Bay Area is almost exactly 8 am, with a skewed distribution toward later start times, start times for individual industries peak anywhere from 7:00 am (financial sector) to 9:30 am (retail sector). Travel time ratios and household characteristics remain important in the presence of these industry/occupation variables, but overall model performance is greatly improved. The more advanced versions of the time of travel models currently can be added to STEP with some programming.

-- Sampling of Alternatives Capabilities:

The models dealing with spatial allocation (trip distribution, workplace location, residential location) were altered to allow sampling of alternatives from the full universe of spatial choices, with weighting of results according to the sampling rate. These sampling options offer a clear tradeoff between speed and accuracy (although it should be noted that when large numbers of alternatives are available, sampling is nearly as accurate as full enumeration of the alternatives.)

-- Estimation Data Set Routines:

The survey analysis routines in STEP were augmented to produce estimation data sets for each type of model included in the overall package. These routines have become an integral part of STEP, so that when a new survey is configured for use in STEP (with appropriate zonal and level-of-service data), it is a relatively simple matter to estimate new models. (STEP applications drawing on synthesized household data clearly cannot yield estimation data sets.)

--Summary:

By the end of 1989, STEP was available in four principal formats:

1. A travel demand microsimulation module, based on the original MTC disaggregate model system.

2. A travel demand microsimulation module with the original MTC disaggregate model system at its core, augmented by a supply response routine, a work trip time-of-day model, a work location choice model, and a residential location choice model.

3. A household travel survey analysis module, for linking survey data with spatial (zone) and network data, for estimating the emissions and fuel consumption implications of survey trips, for producing survey tabulations, and for generating new estimation data sets for travel and location models.

4. A travel demand microsimulation module, based on the original pattern of trips documented in each household survey response, allowing the use of rules, a formal model, or stated preference survey results in depicting policy-driven changes to each household's travel pattern.

This ensemble was supported by a library of ancillary software for estimating models, converting to and from binary file formats, pre-processing surveys to correct or remove

obvious errors, and creating synthetic household data from Census and other survey sources.

B.5 Recent Applications and Modifications of STEP

Beginning in 1989, STEP was applied in a number of policy studies and forecasting efforts, several of which led to significant enhancements of the STEP package. These are discussed in this section.

-- Bay Area Air Quality Conformity Analyses:

When the San Francisco Bay Area failed to attain the federal air quality standards by 1987, MTC was required to implement a previously-devised contingency plan. Part of the contingency plan called for a review of the air quality impacts of each new highway investment in the region, and for the delay until attainment of any highway found to increase emissions. MTC was sued for not carrying out this portion of the contingency plan, and, after an unsuccessful effort to apply a qualitative rating scheme to each proposed highway, agreed to perform a model-based emissions assessment of the highway program as a whole (by comparing with emissions under a no-build scenario). A consensus typology of potential travel and land use differences between the build and no-build alternatives was developed by both sides of the case (ranging from different route choices all the way through changes in trip generation, auto ownership, and location). MTC found that its model system was capable of capturing most of the hypothesized effects, but feedback through the model hierarchy above trip distribution was not usually carried out because of high resource requirements (both computer time and personnel).

Noting that STEP had preserved the original model hierarchy and feedbacks and was cheaper and faster to use than the full model system, MTC proposed to carry out the analysis of feedback effects by passing to STEP inter-zonal travel time matrices representing the highway alternatives and receiving from STEP inter-district trip tables depicting differences in origin-destination trip patterns. If the differences exceeded certain threshold values, the district-level trip tables then were to be used to factor MTC's inter-zonal trip tables for reassignment to the networks and reassessment of emissions

differences (emissions outputs from STEP were not used for this purpose, though they could have been).

Procedures were developed for passing trip tables from STEP to a large-scale network model, by distributing the trip total from each specific STEP district-to-district cell among all of the affected zone-to-zone combinations, proportional to the pattern present in a prototypical zone-to-zone trip table. STEP itself takes the zone-to-zone trip table - which ideally should represent a "closely comparable" run of the large-scale network model - and carries out the translation from district to zonal flows. This capability makes it now routinely possible to use STEP in conjunction with a network analysis package. Note that by expanding the size of the STEP sample - synthesizing additional observations, if necessary - it is possible to increase the number of inter-district cells that STEP can support statistically - to the point that synthetic replication of the total population would support a full zone-to-zone trip table (actually, about 20 percent of the population would be enough for most zonal systems).

STEP has now been used in five cycles of highway program analysis. It has never has indicated shifts in trip patterns sufficient to warrant a change in the large-scale model results.

-- Bay Area TCM Studies:

The State of California passed a new Clean Air Act in 1988 with a one-hour ozone standard (allowing zero exceedences) of .09 ppm (parts per million), far more stringent than the applicable federal standard. A companion piece of legislation instructed the San Francisco Bay Area to take the lead in exploring whether transportation control measures (TCMs) could be used to attain this standard. The region was asked to carry out an analysis without considering changes to automotive technology beyond what the California Air Resources Board (ARB) had mandated already. One purpose of the exercise was to instruct the legislature on what the policy alternatives to further regulation of automotive technology might be.

A quick analysis of ambient air quality measurements and previous dispersion model runs indicated that a reduction of about 30 percent below expected levels of ozone precursors

would be necessary. MTC and the Bay Area Air Quality Management District (BAAQMD; "Air District") convened a broadly representative task force and set about scanning, categorizing, analyzing, and prioritizing a comprehensive set of measures brought to the table by all involved parties. The result was a three-tier strategy:

1. Measures that entail little additional public cost and are unlikely to generate intense political opposition (i.e., "traditional" transportation control measures such as ridesharing promotion, voluntary employer-based trip reduction, and increased telecommuting). These measures together were found to yield a 3-5 percent reduction in reactive organics (ROG).

2. Measures that entail substantial additional public cost but whose political opposition would be likely to focus only on the need for additional revenue (i.e., transit infrastructure and service expansions, and perhaps high-occupancy vehicle [HOV] lanes). Investments that could be funded with a 10 cent additional fuel tax were considered, because that level of additional taxation was deemed ultimately acceptable to the public for environmental and congestion reduction purposes. These measures together were found to yield a 4-7 percent reduction in reactive organics (ROG).

3. Measures whose actual implementation would be likely to generate political opposition. These included an array of pricing options (VMT fees, large increments to fuel taxes, parking fees, congestion pricing, and emissions-based registration fees - the latter obviously treading on the Legislature's prohibition) and land use measures (higher densities around transit stations, incentives for mixed-use development, transit and pedestrian friendly designs, etc.). Several groupings of these measures that could yield 15-25 percent reductions in reactive organics (ROG) were developed.

STEP played a role in analyzing measures for each tier. The simple measures at level 1 mostly were not amenable to travel behavior modeling, so STEP was used to test the implications of various levels of effectiveness found in the literature by imposing appropriate changes on the survey trip pattern and computing emissions reductions. The infrastructure measures at level 2 were analyzed with STEP by running interzonal level of service tables for each alternative, derived from the large-scale network model, through the STEP

enhanced demand module. The pricing measures at level 3 were analyzed directly by imposing various configurations of new prices on the STEP database.

Most of this work could be carried out with only minor improvements to the STEP ensemble of programs. But the pricing measures entailed a more significant change. A subtle advantage of the original MTC model system was the presence of travel price in all of the individual model specifications - accessibility derived from the mode choice models appears in each of the trip distribution, trip generation, and auto ownership models. The location models added to the basic MTC package also incorporated price in this manner, but the worker time-of-day model did not. This made it impossible to test congestion pricing and other time-dependent pricing policy options. Without any precedent for time-variant prices, either in the Bay Area or in a closely-comparable city, it also was not possible to estimate a new time-of-day model incorporating price.

In this situation, we revised the STEP time of day model to reflect price effects using the data on hand, by assuming that price could be converted to an equivalent amount of time using the value of time from each worker's mode choice utility. The effect of different peak and off-peak prices on time of travel then could be tested by: 1) expressing each price (peak and off-peak) in minutes, using the mode choice value of time as a conversion factor; 2) adding the peak time equivalent to the numerator and the off-peak time equivalent to the denominator of the ratio used in the time-of-day model; and 3) applying the time-of-day model in the normal way. (Any prior differences that may have existed between peak and off-peak prices are ignored.) Note that this method does not assume a single value of time for all workers, because STEP's microsimulation entails a separate calculation for each worker, based on a value of time that depends on the worker's household income.

It is clear that a more empirically-based treatment of price-dependent time-of-day choice would make STEP a stronger model for pricing studies. Data from CA State Route 91 surveys or from stated preference surveys collected in Portland, San Francisco, and Dallas/Fort Worth may provide a basis for further model development in the near future.

-- Los Angeles Pricing Studies:

Soon after completion of the Bay Area TCM work, the Environmental Defense Fund (EDF) raised the possibility of carrying out a similar study for the Los Angeles region, with a focus on pricing measures. The ideal approach would have been to adapt a suitable set of LA models to the STEP microsimulation framework. However, the existing models for the region did not incorporate the necessary feedbacks of price and time through the behavioral hierarchy. Furthermore, model estimation was made difficult by the vintage of the region's survey data. At the time (1990-91) the most recent estimation-quality data set was from 1967. Probably no metropolitan area in the US had experienced greater social, economic, or spatial change over that period, making it difficult to argue convincingly for the representativeness of the older data. In addition, models of transit choice - central to the STEP ensemble and critical to a appraisal of future LA transportation policy - were impossible to estimate because of the small number of transit trips present in the 1967 survey data and the generally low quality of transit service available at the time. (Our experience has been that reliable mode choice coefficients for a full set of time and price variables - in-vehicle time, walk time, initial wait time, transfer wait time, and fare - are possible only when the estimation data reflect considerable transit service that is competitive with highway travel, through some combination of transit quality and highway congestion. Thus, data from Boston, Chicago, New York, and San Francisco tend to yield strong mode choice specifications, while data from cities such as Los Angeles and Sacramento often have difficulty resolving any effect of time or price on mode choice.)

The two critical problems in applying STEP to LA thus concerned vintage and local content. Vintage was an issue in any event because most of the STEP models had been developed on 1965 Bay Area data. So, for the EDF Los Angeles application, we first updated some of the coefficients based on the Bay Area's high quality 1981 household travel survey (primarily constant terms, scaling factors, and affects of aggregate zonal characteristics). We did not develop entirely new specifications at this time due to resource limitations (mode choice specifications were tested and found to replicate 1965 values reasonably well).

Local content was a more difficult issue. We took a relatively small household survey that had been conducted in 1976 (about 7000 observations; the completeness of its trip diaries had always been questioned, so we could not consider the survey for model estimation),

and "grew" it to 1990 using district-level demographic and income data (the 1990 PUMS for LA was not available at the time). Then, we added 1990 network and zonal databases provided by the Southern California Association of Governments (SCAG) and ran the models with their Bay Area coefficient values. For comparison, we judged that the best source of data on local travel patterns was the current "base case" from the regional model system, as embodied in the home-based work, home-based other, and non-home-based trip tables (and the rearrangement of those tables into peak and off-peak flows). While these tables were produced by the region's large-scale model system, as a calibrated base case they also contained substantial information from exogenous sources such as the US Census journey-to-work tables, transit counts, and measured highway link flows (which, of course, is the reason why it is possible to use interzonal travel times from the large scale model to run a STEP base case).

STEP outputs and SCAG trip tables were each configured to be comparable at the district-to-district level. Then, STEP constant terms and factors were adjusted to achieve basic agreement with the SCAG outputs at the district/mode/time trip table level. A prototypical adjustment sequence involved:

- Adjusting mode choice constants, first at the county-to-county level, then for a small number of district-to-district interchanges, to achieve comparable mode shares for each district pair ("comparable" is a term of art in this usage).

- Adjusting the time-of-day constants to achieve about the same prediction of peak hour flows. In most cases, because peaking in large-scale models does not vary significantly among district-to-district pairs. only a handful of time-of-day adjustments are necessary.

- Adjusting trip distribution constants, first at the county level, then for a small number of district-to-district interchanges, to achieve about the right shares to each destination from each origin. Where more than one STEP model contributes to a trip type, both models are adjusted in tandem.

- Adjusting auto ownership constants, so that available district (or county) data for households by auto ownership level are matched.

- Adjusting trip generation constants, so that about the "right" number of trips per household is produced in each district.

- Adjusting residential location constants so that about the right number of households is placed in each district.

When the adjustments are made by moving up the hierarchy in this way, only one pass through the modeling sequence is required (though repeated runs are necessary to develop the adjustments at each level)

The Los Angeles models were applied in two studies published by EDF (Cameron, 1991, and Cameron, 1994.) The first study examined a series of pricing strategies, and the second focused on the equity issues raised by such measures.

-- Examination of Modeling Uncertainties:

As part of the first EDF Los Angeles study, there was a great deal of interest in characterizing the "confidence interval" around each policy forecast, given the statistical variability of the STEP models. Two sources of uncertainty were investigated:

- The uncertainty associated with coefficient estimates. STEP was modified to allow coefficients to vary according to a normal distribution whose mean is the value of the coefficient and whose variance is derived from the coefficient's t-statistic. With this option selected, STEP begins a run by selecting new coefficient values randomly from the normal distributions, then it carries out one microsimulation pass to create a "base case" with the new coefficients and a second pass to test a policy with the same coefficients. If this process is repeated a large number of times (using a different random number seed each time), the result is a simulated distribution of the change in each STEP output measure predicted to result from the policy.

- The uncertainty implied by the probabilistic nature of the STEP models. Up to this point in its development, STEP used choice probabilities exactly as they are applied in the large-scale travel models. For example, if the mode choice calculation for a

particular worker yields .2 for the transit probability and .8 for the auto probability, and if this worker in the STEP sample represents 100 workers in the population, then the worker's morning trip is counted as twenty transit trips and eighty auto trips. In reality, the worker is making a single trip that has a 20 percent chance of being by transit and an 80 percent chance of being by auto. An alternate way to interpret the probabilistic outcome is to pick randomly from the model-generated distribution and assign all 100 people for whom the worker is a proxy to that option. Over many repetitions of the process, the 100 people would be assigned to transit about 20 percent of the time and to auto about 80 percent of the time.

STEP was modified to allow this discrete interpretation of travel and location probabilities as an option. For each household in the microsimulation, the full hierarchy of probabilities is computed - residential location, auto ownership, destination (for multiple trip types), mode, and time-of-day (continuous functions such as trip generation are left as deterministic values). Then, moving from the top (residential location) down, a specific option is chosen randomly at each level according to the calculated probability distribution. These selections move down the hierarchy, creating a path through the tree of alternatives. Finally, all of the sample weight for the household is assigned to the identified sequence of outcomes rather than being split among all possible outcomes according to the calculated probabilities.

Uncertainties stemming from both the imprecision of coefficient estimates and the use of discrete sampling were explored systematically for the EDF Los Angeles work. (A third potential source of statistically measurable error - sample size - was ignored, because with the 5000+ households that STEP routinely uses sample size is not important to the accuracy of regional-level forecasts.) After 100 runs, we found that about 80 percent of the outcomes were clustered within 10 percent of the original forecasts of change in VMT, vehicle trips, etc. Moreover the variation due to the two sources of error taken together never exceeded 30 percent on either side of the original forecasts. About 5/6 of this variation was attributable to coefficient imprecision.

The effect of coefficient imprecision in this analysis is highly dependent on the t values for variables most strongly influenced by the proposed policies (i.e., cost, and secondarily time). In general, the cost and time coefficients in the STEP models have asymptotic t

values ranging from |2.5| to |6.0|, which might be classified as "moderate" statistical significance. These t values could be raised easily by increasing the size of the estimation data sets - an easy matter, since the original ones were held to about 1000 observations to reduce the time required for each run of the estimation software. A doubling of the sample size probably would decrease the width of the interval by about 30 percent (i.e., from +/- 25 percent to about +/- 18 percent).

The small additional contribution of discrete sampling to uncertainty is explained by the number of households in STEP's LA database (about 5000). With such a large number of observations contributing to the regional total for each output measure, it really doesn't make much difference whether households are apportioned across all choice outcomes or assigned to a specific set of outcomes. This source of uncertainty would be of greater concern in assessing the small sample properties of a microsimulation such as STEP.

Despite the effort involved, the outcome of this exploration of uncertainty was not entirely satisfactory, because it did not address what most people would recognize as the largest potential sources of uncertainty: future values of factors such as fuel price, household income, and population and job growth. All of these are critical factors in travel and location behavior. To cite one example that lies outside our immediate focus but nevertheless is quite instructive, aggregate non-business air travel (passengers enplaned per annum) appears to be proportional to real income raised to the power of 4. Thus, predicting a 5 percent increase in real income when it instead drops by 5 percent could result in nearly a 50 percent over-prediction of air traffic (i.e., .1.05^4/.95^4=1.49).

For the most part, urban travel behavior models are not quite that sensitive to income, but a number of parallels can be drawn. For example, when significant congestion (and associated delay) begins to appear in a metropolitan highway system, the non-linearities of traffic flow make the delay increase roughly geometrically with population. Thus, in a region such as Los Angeles, already experiencing much highway congestion, a mistake in the assumed growth rate can have huge implications for the long-run impact of a policy such as congestion pricing. An analysis of LA congestion pricing in 2010 with a 2.5 percent growth rate versus a 1.5 percent growth rate (current "official" forecasts foresee a 2 percent growth rate) indicated that congestion pricing would be more than two times as effective at the higher rate (in hours of delay reduced), given the same infrastructure assumptions for both cases.

Congestion pricing is something of an extreme example, because highway delay is so much a phenomenon of marginal traffic growth. To be more systematic about major sources of uncertainty, we picked plausible ranges for three key variables and ran STEP for different regionwide transportation policies to gauge the effects on analysis results for LA in 2010. The variables and their
ranges were:

Fuel Price (1991 dollars per gallon)	1.00-2.00
Real Household Income (Percent of 1991 Mean)	95-120
Population Growth (Annual % Change From 1991)	1-2.5

STEP was run for combinations of the extreme values of these variables. The results of the analysis can be summarized through the example of one output measure - regional total VMT.- and one policy - a VMT fee, tested for values from 1 to 10 cents per mile. The estimated percent change in total VMT ranged from 25 percent below to 15 percent above the original predictions using default 2010 assumptions. In other words, if the original STEP run for 2010 conditions indicated a 5 percent decrease in VMT, then errors in the key input variables might raise that estimate to 5.75 percent or lower it to 3.75 percent.

The story seemed to be the same when we predicted total VMT in 2010, but the implications were quite different. The extremes in the above example yielded future VMT projections that were 30 percent above and below VMT at the "official" forecast values (i.e., from about 300 million to about 550 million daily VMT in the LA region). In other words, uncertainty in the future baseline was at least as large as the change in VMT predicted for the largest VMT fee.

Another source of uncertainty concerns the specifications and structure of the travel demand models. What if important variables with a bearing on travel responses are omitted? What if the basic behavioral structure embodied in the models turn out to be wrong? What if the impact models (such as for emissions) are inaccurate? It was not possible to explore these issues in any detail as part of the EDF work, but the questions certainly should be kept in mind. For example:

- The major system variables used to model travel behavior are time (several categories) and cost, yet safety, reliability, and comfort are known to be important considerations as well. Are we confident that the effects of these non-standard variables will be neutral in the face of price changes, or would population subgroups respond differently to price changes depending on their sensitivity to the changes (e.g., women more likely to pay higher prices when alternate modes are perceived as unsafe; airport access travelers more likely to pay higher prices when alternate modes are perceived as unreliable)?

- The validity of conventional models has been questioned by many researchers, both for the decision calculus attributed to tripmakers and for the high level of abstraction with which the components of the daily trip pattern are treated. For example, the continuous, compensatory relationships of time and cost in linear utility equations, widely used in economics, are viewed with skepticism by psychologists, whose empirical work points to hierarchical treatment of attributes and other less-analytically-convenient patterns of cognition. As another example, travel demand modeling as now practiced has been challenged by those who favor a method that explicitly treats travel as a by-product of the total household activity pattern viewed holistically.

- The validity of current emissions factor models is under intense challenge, both for understating the level of emissions by as much as a factor of two and for treating the process by which vehicular travel produces emissions in an overly simplified way. For example, while published factors do not provide clear evidence about what happens to emissions on freeway segments under forced flow, these conditions are precisely what a well-designed congestion pricing scheme would ameliorate.

A prudent course of action in the face of such uncertainty is to adopt the most robust analysis style possible and to be honest about the conclusions. This means being explicit about imprecision in the data, the model coefficients, and the forecasts. It also may mean exploring alternate ways of eliciting information about behavior and even examining other plausible behavioral paradigms. Exploration of alternate data collection methods is the rationale for the stated preference surveys recently conducted or now underway in Portland (OR), Washington (DC), San Francisco, and Dallas/Fort Worth. Examining the implications of different behavioral paradigms was the motivation for the model development described

in the next section (and also is the rationale for the Los Alamos model development effort funded by the Federal Highway Administration).

-- Applications of STEP in Other Regions:

STEP has been used in a number of other studies in the last five years, including a project to analyze packages of pricing measures for California's four largest metropolitan areas (Los Angeles, the Bay Area, San Diego, and Sacramento) and smaller efforts to investigate pricing policies for the Puget Sound Region and Chicago. As part of these studies, STEP was not only transferred to new regions, but was re-estimated for Los Angeles and the Bay Area using new travel surveys and new network data.

It turns out to be most practical to undertake a partial, rather than full, reestimation of the STEP models in the typical case, because of the problem with transit quality cited earlier. The rich detail of travel time coefficient estimates that is possible in a region like San Francisco, where for some trips transit actually competes with auto in door-to-door time, cannot be inferred from data in a less transit-oriented city. There, transit dependency, based on low auto availability, is the dominant mode choice phenomenon. Good mode choice models require both of these behavioral processes to be present in the estimation data. When there is only transit dependency, time plays almost no role in mode choice (i.e., drive alone vs. HOV time differences usually are small and not well measured). Where time is not a factor in choice, the argument for using the mode choice denominator as an accessibility measure disappears, and the logic of the hierarchical, accessibility-driven model structure falls apart. This problem is so serious and so prevalent that it has become common to carry out transit investment studies with transferred coefficients for key mode choice variables.

A partial model transfer for STEP is carried out by preserving a core of time and cost of coefficients from the original specification and re-estimating the remainder of the models using appropriate statistical software. It is necessary to exercise extreme caution to make certain that level-of-service variable definitions are reasonably consistent between the donor region (say, San Francisco) and the recipient region (say, Sacramento). In several applications we have found it prudent to re-estimate the "original" models using adjusted variable definitions, in order to match data available from the recipient region.

-- STEP Model Re-Estimations:

While the original MTC specifications performed (and continue to perform) plausibly in policy studies, the desirability of making a number of improvements was increasingly apparent as STEP was applied in new regions and to new policy issues. The following changes were identified as the most needed:

- Re-estimation of the models on new survey data
- Re-estimation of the models using rigorous nested logit procedures and linkages among levels of the model hierarchy
- Re-estimation of the models to cover non-motorized modes of travel, and to recognize trip interdependencies and trip chaining
- Re-estimation of the models to address activities instead of trips per se.

Elements of each of these changes has been carried out. First, the STEP models were reestimated using 1981 Bay Area data, with changes to introduce a modern treatment of the nested logit relationships. Second, an entirely new set of travel models based on a reclassification of daily activities was developed, initially using the 1981 Bay Area travel survey. The goal of this exploratory effort was to incorporate more information about trip chaining and time of travel in STEP, by organizing the prediction of the daily trip pattern around schedule-constrained activities such as work and school, and directly integrating decisions about the less time-specific activities which tend to be associated with these.

The new models address five types of urban travelers:

- Full-Time Workers
- Part-Time Workers
- Students
- Non-Employed Working-Age Adults
- Non-Employed Retired Adults

As different as these new models may seem from older formulations, they still produce the same basic types of outputs for policy assessment and for input to a large-scale network analysis. In comparison with the more conventional MTC specifications (as augmented for STEP), activity-oriented models tend to show somewhat greater effects from policies that focus on work travel, because of the association of so many non-work activities with the work trip chain. Other differences appear as well, but in general it is more remarkable how closely policy assessments from the new activity models parallel ones from the older STEP formulations. In retrospect it seems that the initial concept and subsequent modifications of the MTC models must have captured many of the implications of activity-travel interrelationships without attempting to do so explicitly.

Both the revised version of the STEP travel models and the new activity-oriented models for STEP were developed within the STEP ensemble of software, so that reestimation of either structure for a new database is automatically possible once the data have been set up to run with STEP. Using this capability, either partial or complete reestimation was carried out for each of the regions modeled with STEP in the past five years - Chicago, Los Angeles, Sacramento, San Diego, Seattle, and the San Francisco Bay Area.

-- Bay Bridge Congestion Pricing Demonstration Project Application:

The most recent extension of STEP occurred for the San Francisco Bay Bridge Congestion Pricing Demonstration Project, funded by FHWA under the Intermodal Surface Transportation Efficiency Act of 1991. The focus of the Bay Bridge analysis was on time-of-day tolls in a specific corridor. STEP's revised travel and activity-oriented models were viewed as capturing enough of the relevant behavior to be usable without significant modification. However, two issues arose during the application of STEP in this very different spatial context: 1) the available household travel survey sample (about 8000 clean observations for the Bay Area) was too sparse to support detailed inferences about the Bay Bridge corridor, at least without abandoning fixed workplaces from the sample in favor of the workplace location model; and 2) a much more detailed treatment of traffic operations on the Bridge was desirable, in order to address the concerns of policy-makers.

The problem of sample size was addressed by adapting the entire Bay Area PUMS file (about 110,000 households) for use in STEP. This file contains all of the household data needed to run STEP's modeling options, with the exception of home and workplace traffic analysis zones. PUMS includes some location information, in the form of Public Use Microdata Area (PUMA) designations for each household's home and primary workplaces, but more specificity is required for travel behavior modeling (PUMA populations average about 125,000 in the Bay Area, compared with about 9000 per traffic zone). Home census tracts for the PUMS households were inferred based on the PUMA of residence (by correlating with available tract-level crosstabs for household size by income); work zones were added based on the PUMA of employment (using MTC's most recent work trip table as the basis for a probabilistic assignment). The resulting sample was run through STEP to make the required coefficient adjustments (i.e., to match base case regional travel patterns).

Details of highway operations at the Bay Bridge were addressed by adding a feature that allows the highway level-of-service for a specified set of district interchanges to be determined partly by a simple stochastic queuing model. The concept is tailored for a setting like the Bay Bridge, where a single facility can be isolated and treated separately. The facility is imagined as a downstream link fed by two upstream links. The first upstream link (an HOV bypass lane, in the Bay Bridge case) operates with sufficient capacity that a bottleneck will not form in the range of expected volumes; the second upstream link operates at an average service rate determined by the capacity of the downstream link minus the flow on the first upstream link. In other words, all the vehicles arriving on the first link (the HOV bypass) are served but only those vehicles on the second link (mixed-flow lanes) for which there is residual space downstream (on the Bridge) are served. The second link is treated as a simple Poisson queue whose average service rate equals the residual capacity in each time period (there is no provision for spillback to links further upstream).

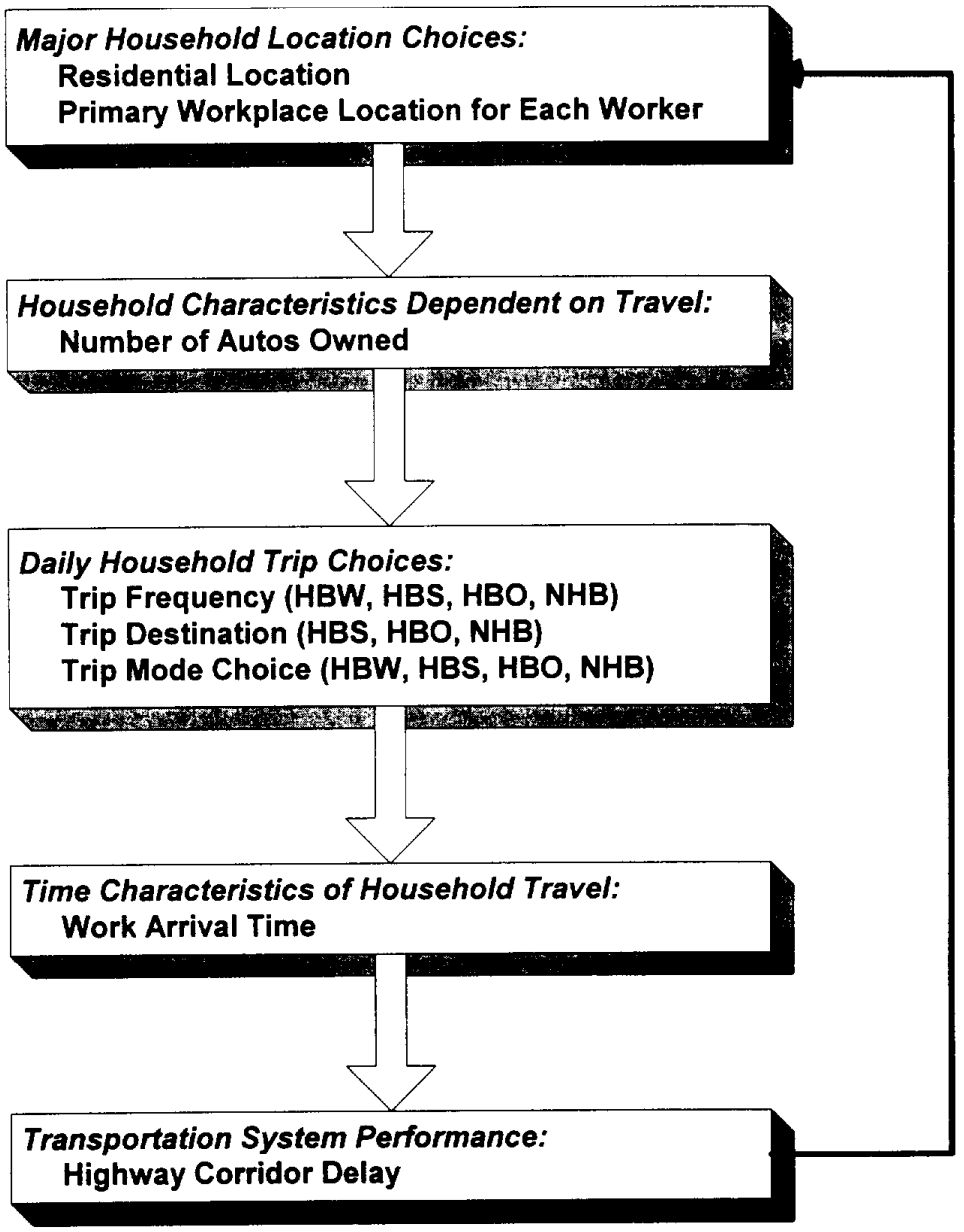
The links are tied into the broader highway system at nearby nodes in the regional highway network, and STEP is provided with access to tables containing network-based travel times and distances (in the usual STEP format) for trip segments leading to and following from the facility. STEP assembles the travel times as they are needed during sample enumeration. As required for the simpler supply models discussed earlier, STEP must go through several iterations of supply and demand calculations to reach a stable equilibrium. The first iteration works with facility queuing times approximated from the regional network times (peak and

off-peak) for the special facility links, using a linear approximation for the buildup and erosion of the peak. In each subsequent iteration, STEP provides a flow profile by hour (using the demand functions, based on travel times from the previous iteration) which are input to the internal supply functions (including the queuing model) to calculate hour-by-hour travel times. For the queuing model only, the STEP hour-by-hour demand predictions are smoothed to produce a continuously varying arrival rate (with care to conserve the total peak period demand).

The ability to focus supply calculations on a specific facility was formalized in a new version of STEP. This version allows up to five facilities in the highway system to be treated in detail, with each facility represented as a miniature network, and the performance of each link represented through a simple stochastic queuing process. Route choice outside each facility model still is not represented, so the detailed treatment may be applied only when route switching is made difficult or impossible by the topology of the network.

A feature allowing more detailed treatment of rapid transit also was added to this version of STEP, in order to provide a better treatment of rail transit access and egress and to make it easier for STEP to examine transit policies. Instead of drawing on the usual regional network tables for transit level-of-service, STEP can reference station-to-station tables of rail transit times and costs. Access is handled through mode choice sub-models that draw from tables of access times and costs covering each zone-to-station combination.

Figure B.1:
STEP Model Structure with Enhanced MTC Models



Note:
HBW - Home-Based Work Trips
HBS - Home-Based Shopping Trips
HBO - Home-Based Other Trips
NHB - Non-Home-Based Trips

Figure B.2:
Primary STEP Data Requirements

Basic Data:
- Regional Household Travel Survey
- 1990 US Census Public Use Microdata Sample

For the Survey Year:
- Geography
  - land area, population, housing stock
  - for tracts, zones, and/or districts
- Network Level-of-Service
  - highway, transit
  - am peak, pm-peak, off-peak
  - times, costs

For Each Forecast Scenario:
- Geography
  - land area, population, housing stock
  - for tracts, zones, and/or districts
- Network Level-of-Service
  - highway, transit
  - am peak, pm-peak, off-peak
  - times, costs
- Economics
  - expected real income growth
  - expected real fuel price growth

Figure B.3:
Sequence of Activities for a STEP Application

Prepare Survey Data for Initial Analysis:
- Screen Survey for Unusable Observations
- Reweight Survey to Match Key Census Demographic Characteristics
- Reformat Network and Geographic Data to Match Database Requirements
- Assemble and Test Database

Calibrate the STEP Models:
- Run STEP for Base Conditions
- Compare STEP Calculations with Actual Household Travel Patterns
- Adjust Constants, Beginning with Upper-Level Models, and Rerun STEP
- Iterate the Adjustment Process Until the Overall Fit is Acceptable

Prepare STEP for the Forecast Scenario:
- Adjust Household Data to Reflect Changed Conditions
  - income
  - subarea population
  - household type cohorts
- Reformat Network and Geographic Data to Match Database Requirements
- Assemble and Test Database
- Run STEP to Create a Base Case

Test the Policy Alternative(s) with STEP:
- Alter the Database as Necessary to Represent the Policy Option
- Run STEP to Estimate the Effects of the Policy Option
- Post-Process the STEP Outputs
- Repeat the Analysis Sequence for Variants of the Policy Option

Appendix C: Basic STEP Equations in Detail[1]

The following subsections provide a summary of the principal travel demand models used in the MTC version STEP. Detailed specifications are included for:

- Home-Based Work Mode Choice
- Shared-Ride Occupancy
- Home-Based Shop Trip Destination and Mode Choice
- Home-Based Shop Trip Frequency Model
- Home-Based Social/Recreational Trip Destination and Mode Choice
- Home-Based Social/Recreational Trip Frequency Model
- Worker-Household Vehicle Ownership
- Non-Worker Household Vehicle Ownership
- Home-Base Work Trip Distribution

These nine models were developed for the Metropolitan Transportation Commission (MTC) using data from the San Francisco Bay Area, and were part of the version of MTC's regional travel model known as MTCFCAST. Three additional models from MTCFCAST, covering non-home-based trips, are also included in the STEP software.[2]

C.1 Home-Based Work Mode Choice Model

The basic model form is multinomial logit:

$$P_m = \frac{\exp(U_m)}{\sum_{i=a,s,t} \exp(U_i)}$$

where: P_m is the probability of choosing mode m;
U_m is the traveler's utility for mode m;
i represents the set of available modes:
i = a > drive alone
s > shared ride
t > transit.

1 The models presented here are from the MTC version of STEP. STEP's models are updated periodically and new versions of the travel model ensemble are added (see Appendix B).

2 For documentation of the non-home-based models in STEP, see Harvey, 1978.

The utility equations are defined on the next page. It can be seen that, e.g., the utility for drive alone is:

$$U_a = -2.512 - .00000714 x dinc - 1.067 x cbd - .0244 x\, ivtt_a - .077 x\, walk_a - 21.43 x (cost_a \div inc) + 1.958 x autos + .677 x head$$

	Coefficient Value	Variables in the Utility			Explanation
		a	s	t	
1	-.00000714	dinc	dinc		Household disposable income
2	-1.067	cbd			Constant for central business district
3	-.347		cbd		Constant for central business district
4	.327		nwork		Number of workers in household
5	-.0244	ivtt(a)	ivtt(s)	ivtt(t)	In-vehicle travel time (minutes)
6	-.077	walk(a)	walk(s)	walk(t)	Walk time (minutes)
7	-.045			wait1	Transit initial wait (minutes)
8	-.0428			xferwait	Transit transfer wait (minutes)
9	-21.43	cost(a))inc	cost(s))inc	cost(t))inc	Cost (cents) / household income ($)
10	1.958	autos			Number of autos in household
11	1.763		autos		Number of autos in household
12	1.389			autos|aac	Number of autos for auto access
13	-1.237			aac	Constant for auto access to transit
14	.677	head			Constant for head of household
15	-2.512	const			Drive alone constant
16	-3.473		const		Shared ride constant

Home-Based Work Mode Choice Model

C.2 Shared Ride Work Trip Auto Occupancy Model

The model is a simple linear regression, constrained to have a value greater than 2:

$$srocc = \max(2, [2.542 - .00004717 x dinc + .01116 x\ ivtt_s])$$

where: srocc is the shared ride occupancy;
dinc is the household disposable income;
ivtt(s) is the shared-ride in-vehicle time.

C.3 Home-Based Shop Trip Destination and Mode Choice Model

The shopping destination/mode choice model is a logit probability equation with a set of choice alternatives encompassing the auto and transit modes and the full set of zones accessible to a household for the shopping trip purpose. Each specific mode and destination combination is a separate alternative. Thus, if ten destinations are available, each with two modes, there are twenty choice alternatives recognized by this model.

The basic model form is:

$$P_{dm} = \frac{\exp(U_{dm})}{\sum_{j=1}^{nzones} \sum_{i=a,t} \exp(U_{ji})}$$

where: P_{dm} is the probability of taking a shop trip to destination d by mode m;
U_{dm} is the traveler's utility for the destination d mode m combination;
i represents the set of available destinations (defined as zones or districts);
j represents the set of available modes (a or t).

The utility definitions for a given destination are given on the next page. E.g., the utility of the auto mode to a specific destination d is:

$$U_{da} = -.8631 + .2563x\, cbd_d + 5.053x(autos / hhsize) - .000202x(time_{da}\, xinc)$$
$$-.02447x\, cost_{da} + .0005995x\, rden_d + \ln(rjobs_d)$$

	Coefficient Value	Variables in the Utility		Explanation
		Auto	Transit	
1	-.8631	const		Auto constant
2	.2563	cbd		Constant for central business district
3	.8912		cbd	Constant for central business district
4	5.053	autos/hhsize		Autos per person in household
5	-.000202	time(a)*inc	time(t)*inc	Door-to-door travel time (minutes) weighted by income
6	-.02447	cost(a)		Cost (cents)
7	-.02299		fare*hhsize	Transit fare (cents) weighted by household size
8	.0005995	rden	rden	Retail density (employees per population serving acre)
9	1.0	ln(rjobs)	ln(rjobs)	Natural log of retail workers in zone

Home-Based Shop Trip Destination and Mode Choice Model

C.4 Home-Based Shop Trip Frequency Model

The shop trip frequency model is a non-linear regression yielding an inverse function of household characteristics, home zone characteristics, and aggregate destination attractiveness (as embodied in the expected utility for shopping destination/mode choice). The exact model specification is:

$$hbshop = \frac{.8194}{.07766 + \exp(-.34174 x hhsize - .051512 x (inc \div 100) - .052681 x E[U_{dm}] + .1146 x \ln(eden + 1))}$$

where:

hbshop is the number of daily home-based shopping trips per household;
hhsize is the number of persons in the household;
inc is the household income ($);
$E[U_{dm}]$ is the expected utility from the shopping destination/mode choice model, defined as the natural log of the denominator of that model's logit equation;
eden is the service and retail employment density, in workers per gross acre.

C.5 Home-Based Social/Recreational Trip Destination and Mode Choice Model

The social/recreational destination/mode choice model is a logit probability equation with a set of choice alternatives encompassing the auto and transit modes and the full set of zones accessible to a household for the social/recreational trip purpose. Each specific mode and destination combination is a separate alternative. Thus, if ten destinations are available, each with two modes, there are twenty choice alternatives recognized by this model.

The basic model form is:

$$P_{dm} = \frac{\exp(U_{dm})}{\sum_{j=1}^{nzones} \sum_{i=a,t} \exp(U_{ji})}$$

where: P_{dm} is the probability of taking a social/recreational trip to destination d by mode m;
U_{dm} is the traveler's utility for the destination d mode m combination;
j represents the set of available destinations (defined as zones or districts);
i represents the set of available modes (a or t).

The utility definitions for a given destination are shown on the next page. Based on this table, the utility of the auto mode to a specific destination d is:

$$U_{da} = 1.844 - .215x\, cbd_d + 2.167x(autos \div hhsize) + .3368x rautos - .0001097x(time_{da}\, x inc)$$
$$-.0256x\, cost_{da} + .0609x\, rden_d + .0244x\, popden_d + .6998x \ln(pop_d \div rjobs_d) + \ln(rjobs_d)$$

	Coefficient Value	Variables in the Utility		Explanation
		Auto	Transit	
1	1.844	const		Auto constant
2	-.215	cbd		Constant for central business district (destination)
3	1.19		cbd	Constant for central business district (destination)
4	2.167	autos/hhsize		Autos per person in household
5	.3368	rautos		Autos not used for work trips
6	-.0001097	time(a)*inc	time(t)*inc	Door-to-door travel time (minutes) weighted by income
7	-.0256	cost(a)		Cost (cents)
8	-.0108		fare*hhsize	Transit fare (cents) weighted by household size
9	.0609	rden	rden	Retail density at destination (employees per acre)
10	.0244	popden	popden	Population density at destination (persons per acre)
11	.6998	ln(pop/rjobs)	ln(pop/rjobs)	Natural log of population) retail jobs at the destination
12	1.0	ln(rjobs)	ln(rjobs)	Natural log of retail employment in the destination zone

Home-Based Social/Recreational Trip Destination and Mode Choice Model

C.6 Home-Based Social/Recreational Trip Frequency Model

The S/R trip frequency model also is a function of household characteristics, home zone characteristics, and destination characteristics (as embodied in the expected utility for social/recreational destination/mode choice). The exact model specification is:

$$hbsr = .1398 x \exp(.4671 x \ln(hhsize) + .005055 x (hhsize - nwork) + .3963 x \ln(inc \div 100) + .06785 x E[U_{dm}] - .3213 x \ln(seden + 1))$$

where:

hbsr is the number of daily home-based social/recreational trips per household;
hhsize is the number of persons in the household;
nwork is the number of workers in the household;
inc is the household income ($);
$E[U_{dm}]$ is the expected utility from the social/recreational destination/mode choice model, defined as the natural log of the denominator of that model's logit equation;
seden is the service employment density, in workers per gross acre.

C.7 Worker-Household Vehicle Ownership Model

The worker-household vehicle ownership model is of the logit form with three ownership alternatives -- zero, one, and two or more vehicles.

The basic equation is:

$$P_v = \frac{\exp(U_v)}{\sum_{k=1}^{2+} \exp(U_k)}$$

where:

P_v is the probability of choosing vehicle ownership level v;
U_v is the household's utility for vehicle ownership level v;
k represents the set of vehicle ownership levels:
k = 0 > zero autos in household;
1 > one auto in household;
2+ > two or more autos in household.

The utility definitions are shown on the next page. E.g., the utility of owning one auto is:

$$U_1 = 4.989 + .3935 x sinfam - .05419 x eden - \frac{2.689}{hhsize} + .06814 x\, twork_1 + .7919 x \ln(rinc_1)$$

	Coefficient Value	Variables in the Utility			Explanation
		0 Vehicles	1 Vehicle	2 or More	
1	4.989		const		One vehicle ownership constant
2	5.689			const	2+ vehicle ownership constant
3	.3935		sinfam		Constant for single family detached unit
4	1.342			sinfam	Constant for single family detached unit
5	-.05419		eden	eden	Workers per acre in the home zone
6	-2.689		autos)hhsize	autos)hhsize	Autos per person in household. The variable "autos" has the value 1 for v=1 and 2.25 for v=2+.
7	.5608	tshop			A measure of the quality of transit service from the home zone for non-work trips, defined as the sum of transit utilities divided by the sum of auto utilities for the shopping destination/mode choice model.
8	.06814	$twork_0$	$twork_1$	$twork_{2+}$	A measure of the quality of transit service from the home zone for work trips, defined as the household head's work trip transit utility divided by the sum of work trip drive and work trip shared ride utilities.
9	.7919	$\ln(rinc_0)$	$\ln(rinc_1)$	$\ln(rinc_{2+})$	Natural log of the remaining income after housing, auto ownership, and commuting expenses are taken into account.

Worker-Household Vehicle Ownership Model

C.8 Non-Worker-Household Vehicle Ownership Model

The non-worker household vehicle ownership model has the same form as the worker model. The utility specifications and coefficients are shown below.

	Coefficient Value	Variables in the Utility			Explanation
		0 Vehicle	1 Vehicle	2 or More	
1	-.8695		const		One vehicle ownership constant
2	-8.357			const	2+ vehicle ownership constant
3	-.0682			popden	Population density in home zone (persons per acre)
4	.3188		$\ln(\frac{dinc}{hhsize})$		Natural log of the household disposable income per person
5	1.227			$\ln(\frac{dinc}{hhsize})$	Natural log of the household disposable income per person
7	.5608	tshop			A measure of the quality of transit service from the home zone for non-work trips, defined as the sum of transit utilities divided by the sum of auto utilities for the shopping destination/mode choice model.

e.g., the utility of owning one auto is:

$$U_1 = -.8695 + .3188 x \ln(\frac{dinc}{hhsize})$$

C.9 Home-Based Work Trip Distribution

Effects of changes in accessibility on non-work trips are reflected in the shopping and social/recreational models described earlier. Work trip distribution also might be expected to change, though not in the same ways as non-work trips. The original work trip distribution model from MTCFCAST is a work "destination choice" model similar to (but simpler than) the shopping and social/recreational versions. The basic model form is:

$$P_d = \frac{\exp ¿\ln(workers_d) + 1.811x \sum_{v=1}^{2+}(P_v xE[U_{m|v,d}])¿}{\sum_{i=1}^{nzones} \exp ¿\ln(workers_i) + 1.811x \sum_{v=1}^{2+}(P_v xE[U_{m|v,i}])¿}$$

where: P_d is the probability of choosing destination d as the workplace;

$workers_i$ is the total number of workers in zone i;

$E[U_{m|v,i}]$ is the expected utility of work mode choice to destination i, given auto ownership level v;

P_v is the probability of choosing household auto ownership level v;

nzones is the number of zones in the region.

Appendix D: Baseline Transportation and Emissions Data

As the text of the report explains in some detail, we have presented most of our analysis results in terms of percent changes from a base case rather than in terms of absolute totals of VMT, trips, time, emissions, fuel consumption, and so on. One reason is that the kinds of models used for this study are more likely to yield robust estimates of changes in transportation system measures than of regional totals. A second, closely related, reason is that there can be a remarkable degree of disagreement among credible estimates of transportation system performance - especially for long-range forecasts, but even for current conditions.

Nevertheless, because many readers will be more accustomed to thinking in terms of absolute changes, we have assembled a set of estimates covering California's four large metropolitan areas for the two analysis years featured in the report - 1991 and 2010. These are shown in Table D.1 for eight key measures of system performance:

- Vehicle-miles traveled
- Vehicle trips
- Vehicle hours
- Reactive Organic Emissions
- Carbon Monoxide Emissions
- Oxides of Nitrogen Emissions
- Particulate Emissions
- Fuel Consumption

The estimates cover personal travel, defined approximately (in CARB terms) as the sum of light-duty auto, motorcycle, and a majority of light-duty truck travel. They are derived from STEP outputs, but correspond closely to MPO and CARB estimates current in January 1994 (when the majority of our analyses were initiated). The emissions estimates reflect the EMFAC7F emissions model then current.

While some use of these data is made in the body of the report, notably to illustrate the application of percent changes produced by STEP (Chapter 7) and to investigate cost

effectiveness, we recommend that readers substitute up-to-date estimates from the local MPO, CARB, or other credible sources when pursuing their own calculations.

Table D.1: Example Baseline Data for California Metropolitan Areas

			Daily Totals - Personal Vehicles Only							
Year	Region	Area Type	Vehicle Miles (000)	Vehicle Trips (000)	Vehicle Hours (000)	Reactive Organics (tons)	Carbon Monoxide (tons)	Nitrogen Oxides (tons)	Particulates (tons)	Gallons of Fuel (000)
1991	Bay Area	Air Basin	99100	14000	3600	251	1600	159	24	4670
	Sacramento	County	19800	3600	600	58	360	37	5	940
	San Diego	County	54400	7600	1800	151	1060	97	13	2580
	South Coast	Air Basin	251500	30800	9100	559	3680	378	61	11810
2010	Bay Area	Air Basin	141400	18800	5400	53	480	60	33	5100
	Sacramento	County	31100	4100	1100	11	105	13	7	1120
	San Diego	County	73900	9800	2600	40	330	39	17	2660
	South Coast	Air Basin	360900	40700	13900	126	1130	158	84	13030

Sources: STEP outputs; EMFAC7F (1/94)

Appendix E: Focus Group Information

E.1 Schedule

2 hours total per group

moderator with 10-12 participants

5 min.	opening statement and ground rules
20 min.	overview of the proposals
15 min.	overview discussion (Question 1)
40-60 min.	discussion of key strategy (Questions 2-5)
15-35 min.	comparison with other options (Question 6)
5 min.	open-ended question (Question 7), closing statement and wrap-up

E.2 Locations and Key Topics

Bay Area (San Jose)	Vehicle Registration Fees and Parking Charges
Bay Area (Berkeley)	Congestion Pricing - Bay Bridge
Sacramento	Vehicle Registration Fees and Parking Charges
Los Angeles (Encino)	Congestion Pricing and Parking Charges
San Diego	Congestion Pricing and Fuel Fees

E.3 Script

INTRODUCTIONS AND GROUND RULES (5 minutes)

Good evening. My name is _____ and I will be your moderator for this evening's session.

We thank you for joining us this evening, for a group discussion on transportation strategies to reduce congestion, air pollution, and fuel consumption. We will be spending the next two hours together in what we hope will be a lively discussion. We will begin by hearing about four strategies that are being considered by public policy-makers as possible ways to influence transportation choices, and then we will discuss one of the strategies in detail. Toward the end of the session we will come back to the other strategies and discuss how you would rank them in comparison to the others. I will present the strategies to you, pose

questions, help keep the discussion on track, and encourage everyone to participate, but I will not be a participant myself.

There are some simple ground rules for this session. First, we want to assure you that we will treat any personal information you provide us as confidential. While your comments, views and suggestions are being recorded and you are being observed by members of our group from behind the one-way mirror over here, none of you will be identified individually in the reports. Your names and other information about you personally will not be reported.

Second, we want you to speak your minds about the strategies that you will hear about at this session. It is likely that there will be differences of opinion. Sometimes you may be in agreement, and other times you may not agree with one another. That's fine; we are anxious to hear the full range of viewpoints. You should feel free to say what you think. Also, let's make sure we hear from each of you.

Finally, we want to emphasize that the strategies that we are going to consider tonight are in the preliminary discussion stages. Because of this, not all of the details have been worked out on some of the proposals, and there may be several different ways to go. Your views will be important in helping policy-makers decide which ideas are worth pursuing and which are not, and will shape their thinking about how to proceed. Also, we may not have answers to some of the questions you raise. Don't let that stop you from asking the questions! Your questions will be used to guide the next steps in the studies and discussions.

So, with that said, let's begin.

OVERVIEW OF THE PROPOSALS (20 minutes)

Californians face a number of problems that are directly related to how much we travel and the transportation choices we make:

Show story boards

Traffic congestion is an irritating, stressful, and costly problem for many commuters, according to polls conducted in the state's major metropolitan areas. Congestion also increases the costs of doing business in the state and discourages some companies from making investments here.

Air pollution is a major environmental problem and a direct threat to the public's health. California has the dirtiest air in the United States, and every large city in the state violates federal and state health standards. Federal and state laws mandate improvements and the state could lose federal funds if we can't clean up the air. Businesses also could face constraints on growth.

Transportation's **dependence on petroleum** makes it the least flexible sector of the California economy from an energy perspective. Transportation's heavy dependence on oil not only puts the state at risk in the event of a disruption in overseas supplies, but makes transportation a major source of the emissions that are contributing to global warming.

Major efforts have been undertaken to reduce these problems, and some progress has been made. But for a variety of reasons the problems persist. For example, a new cars emits only a fraction as much pollution as did the new car of 20 years ago. The vehicle fleet also is much more energy efficient than it used to be. But the growing number of cars on the road and increases in the amounts that people are driving offset some of the gains. Growth in traffic also has outstripped highway expansions, contributing to increased congestion in many areas. Stop-and-go driving in turn leads to increased fuel use and higher emissions.

State and local agencies have tried to entice travelers to reduce their driving by offering alternatives, such as transit services, preferential high-occupancy vehicle (HOV) lanes for carpools and vanpools, and bike and pedestrian facilities. While some travelers do make use of these options, voluntary programs and incentives to increase this use have been only partly successful. In most areas, seventy percent or more of the commute trips are made by driving alone - a percentage that actually is higher than it was ten years ago.

Today, federal and state requirements for air pollution reduction are increasing the pressure to do something about this situation. In some metropolitan areas, mandatory programs to reduce travel have been imposed. For example, large employers are now required to reduce the number of vehicles their employees bring to work. However, employers are having difficulty in meeting this requirement, because their employees don't think commute alternatives are competitive with the car. It is increasingly apparent that a different approach is needed if we are going to make headway.

In analyzing why it is so difficult to change people's driving habits, two factors are repeatedly uncovered. First, many people say the alternatives need to be much improved before they will be serious competition to the private automobile. And indeed, where there are good transportation alternatives (such as to downtown San Francisco) the number of people who use the alternatives greatly increases. But major transportation improvements are expensive, and the funding that is currently available for transportation falls short of identified needs.

A second factor is that drivers do not pay the full cost of driving their cars, particularly in areas where there is serious congestion or air pollution. In addition, many drivers are provided with parking free of charge, even though providing the parking is a major expense. As a result, driving alone appears to be much cheaper than it really is.

These two points have led some policy-makers to look for strategies that would make the price paid by drivers more fully reflect the costs of driving. Charging drivers more also would generate revenues, which could be used to improve alternatives, and perhaps to offset inequitable impacts. So far, four options have been proposed:

- congestion pricing
- vehicle registration fees which vary with pollution and energy use
- gas tax increases
- parking charges.

Studies and experience indicate that these options could be quite effective in reducing auto use and providing the funds needed to improve travel alternatives. But their public acceptability remains an open question.

Here is an overview of how the strategies might work:

Congestion pricing refers to prices, or tolls, which are charged only at those times of day when congestion is a problem. The toll would be set high enough to induce some travelers to use other routes, switch to other modes, or travel at a less congested time of day. Congestion pricing might be implemented on a facility that already has a toll, such as the bridges in the Bay Area and the new toll roads in Orange County, or it might be installed when a new lane is added to a freeway (you'd pay the toll in order to use the additional lane.) Some have suggested allowing solo drivers who pay a toll to use extra capacity in HOV lanes. New "smart card" technologies, already in use in Texas and on the new Orange County toll road, make it possible to pay the toll without stopping at a toll booth - an electronic reader detects whether the car has the required card, and if not, triggers enforcement. Over the long run, these new tolling technologies would allow <u>any</u> road equipped with toll card detectors to have congestion pricing. Congestion pricing not only would reduce congestion, but also would reduce fuel use and emissions somewhat. Revenues from the program could be used to improve the highways, improve transit and ridesharing programs, or perhaps to provide lifeline rates for low income people.

Vehicle registration fees currently are based on a flat fee charged to all vehicles, plus a license fee of two percent of the market value of the vehicle. This strategy would add a fee based on the total estimated emissions from the vehicle over the year, and perhaps based on the vehicle's fuel efficiency as well. The fee might be based on the vehicle's age, make, and model information, or might also take into account the odometer mileage and emissions measurements, read during the vehicle's emissions test. A car that is very clean and energy efficient would pay no fee, whereas the dirtiest, most gas-guzzling cars might pay several hundred dollars more than at present. Over time, car owners would take steps to clean up their cars, reduce their use, or replace them with cleaner, fuel efficient models. Super-polluters and gas guzzlers would be driven less and scrapped sooner. The funds generated from the higher fees could be used to improve transportation options, offset the

impact on low income people, or perhaps to give a discount to people whose cars are especially clean and efficient - actually lowering their fees from present levels.

Gas tax increases would be the most direct way to reduce fuel consumption. Increased fuel prices also would reduce emissions and congestion, because some would drive less or shift to other travel modes. Fuel-efficient vehicles would be more popular and gas-guzzlers would be less so. Gas tax increases could range from a few cents a gallon, for example, to cover the costs of air pollution and fund energy conservation programs, to as much as several dollars per gallon if prices similar to those in Japan or Europe were introduced or if revenues were to pay for other major costs of auto use such as the costs of accidents. Another possibility would be to substitute a gas tax for other transportation funding sources which are less directly related to auto use, such as sales taxes and property taxes.

Parking charges would be designed to reduce the subsidy to motorists who now are provided with free parking. For example, at present about 85% of commuters park for free, although the parking space they occupy is a significant expense. A new state law requires certain employers who pay for commuter parking for their employees to offer the employees a cash equivalent. This policy could be extended or modified to make it apply to more broadly. One strategy would be to extend the cash-out policy to everyone, that is, require every employer who provides employee parking to offer all employees a cash payment of the equivalent amount. Another strategy would require employers either to charge for parking at its actual cost (typically $25-50/mo. in industrial areas and the suburbs, and up to $200/mo. in downtown areas), or to report the value of the parking space as income to the employee. Charging the actual cost for parking would reduce drive alone commuting by 10-15%, increase the use of alternative modes of travel, and potentially reduce fuel use, emissions, and congestion. On the other hand, revenues would not necessarily be available for other uses.

QUESTIONS (90 minutes)

1. (15 minutes)

   To get the discussion started, I'd like to hear your general reactions to the problems that we are trying to solve - congestion, air pollution, dependence on petroleum.

a) On a scale of one to ten, where one is not important at all and ten is very important, how important an issue is congestion, to you personally? How about to the public as a whole?

   show scale - poll each participant - encourage participants to say why they feel the way they do

b) On the same scale of one to ten, where one is not important and ten is very important, how do you rate air pollution

- to you personally?

- and how important do you think it is as an issue for the public as a whole?

poll each participant using scale

c) And finally, how important an issue is dependence on petroleum

- to you personally?

- and how important do you think it is as an issue for the public as a whole?

poll each participant using scale

2. (60 minutes for questions 2-5)

Now I'd like to turn the discussion to the strategy on which we have been asked to focus our attention: _____. Let's take another look at that option.

Review story boards on the focus strategy - add detailed boards

What are your initial reactions to this strategy?

3. What do you see as the biggest benefits, if any, resulting from this strategy? What do you see as the biggest problems, if any?

4. Some variations on how the strategy might be implemented were presented.

Review story boards on the options for the session's main strategy

- Which of these ways of proceeding do you think is preferable?

- Why?

5. Do you feel that this policy would lead you to change your behavior? If so, how and why? Or if not, why not?

6. (20 minutes for questions 6 and 7)

   Let's now take another look at the four strategies we discussed initially.

   Review story board on all four strategies

   How do you rate each of these strategies? On a scale of 1 to 10, where 1 is terrible, or unacceptable, and 10 is a great idea that should be strongly supported, how do you rate:

   Show scale - poll each participant for each strategy in turn:

   congestion pricing

   vehicle registration fees

   parking charges

   gasoline taxes

7. If you could send a personal message to the policy makers concerning the ideas we have discussed here tonight, what would it be?

That concludes our discussion for the evening. We thank you for coming.

(Any housekeeping tasks go here)

E.4 List of Support Graphics

1. California Traffic Problems
2. Current strategies have helped .....
3. ..... but voluntary programs to change travel modes are only part of the answer
4. Driving Habits are Hard to Change
   4a. Mode Shares (CA Metro Areas)
5. Pricing Strategies Could Address These Concerns
6. Congestion Pricing
7. Congestion Pricing Options
   7a. New Toll Technologies (show toll tags etc.)

7b. How Big Would a Congestion Toll Be?
8. Vehicle Registration Fees
9. Registration Fee Options
9a. How Much Does a Dirty Car Pollute?
9b. How Much Fuel Does a Gas Guzzler Consume?
10. Gas Tax Increases
11. Gas Tax Options
11a. Current Gas Taxes in California
12. Parking Charges
13. Parking Charge Options
14. Importance Scale for Question 1
15. Desirability Scale for Question 6