Sensitivity Analysis of Selected Transportation Control Strategies

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The relative potential of 13 different transportation control strategies for reducing projected regional vehicle kilometers of travel in the San Francisco Bay Area is analyzed. Through the use of a series of representative home-based work trips, it is possible to analyze mode-choice sensitivities directly by means of additional runs of the recently developed set of mode-split models for the region. These mode-split models are stratified by three automobile ownership categories for both primary and secondary workers. Ranges of potential mode-split shift for automobile, transit, and shared-ride modes are established for each transportation control strategy. Four combinations of strategies are examined. Graphs that help to depict relative mode shift potentials are developed by using stepwise incremental testing of various control measures. Mode-split sensitivities for representative trips are generalized to the regional level.

Continuing concern about the air quality and energy consumption implications of current urban travel patterns has led to a growing interest in the potential effectiveness of transportation policies that might reduce overall vehicle travel. A wide range of such potential policies designed in one way or another to induce travelers to make greater use of multiple-occupancy vehicles (transit and car pooling) have been advanced. The general idea is to maintain current levels of personal mobility while reducing the number of vehicles and vehicle kilometers necessary to provide that mobility (7, 8).

A number of studies have been conducted in recent years to investigate the relative potential for different transportation control strategies to stimulate such mode shifts. A Los Angeles study (9) that examined three broad tactics—bus system improvements, car-pooling incentives, and economic disincentives—is most similar to the work reported here. Other efforts (1, 3, 4) have specifically emphasized car-pooling incentives and disincentives. Some studies have relied on more conventional zone-based mode-split models (9), and others have used recently developed disaggregate models calibrated at the household level (1, 3). Another promising approach has used a quantitative marketing model built around consumer preference surveys (4).

The purpose of this paper is to describe the results of a mode-split sensitivity analysis conducted for 13 different transportation control strategies in the San Francisco Bay Area. This work has been carried out for the Metropolitan Transportation Commission (MTC) as a part of the air quality maintenance plan being developed for the region (2). The different transportation control strategies were identified by MTC based on earlier transit, parking management, and air quality planning efforts.

METHODOLOGY

Forecasts of 1985 mode-split changes that might be stimulated by the different strategies were prepared by using the new set of travel demand models recently developed by MTC (5). Logit-form models of mode choice have been calibrated on disaggregate (household level) data and are stratified by three income categories. Separate models were developed for the trip-making behavior of primary and secondary workers for the home-based work trip. For each of the three income levels, separate models for work-trip mode choice have been developed for each of three modes: transit, drive alone, and shared-ride automobile. Together with other trip generation and distribution models, the overall modeling system is fully compatible with the urban transportation planning system (UTPS) package. Twenty-one different models are included, and UTPS network assignment routes are used.

Only home-based work trips were examined to obtain a sample of origin-destination district interchanges across the region. Five different origin districts were identified, and trip interchanges between these districts and the San Francisco central business district (CBD) as well as an industrial area of Oakland were investigated. These two destinations are meant to generally represent CBD and non-CBD trips respectively. This district-based analysis of representative trips is intended to provide only an approximate picture of mode-choice sensitivities and does not make use of disaggregate, household-level travel data. A random sample enumeration method that uses a considerably larger representative sample of areawide households could provide a more statistically acceptable basis for analysis (1, 3).

Potential changes in mode split for automobile, transit, and shared-ride trips for each of the strategies tested were analyzed parametrically. Projected shifts in mode split for representative trips were converted to an estimated range of impacts at the regional level. This more generalized range of impacts covers work trips primarily oriented toward both CBD and non-CBD destinations. Conversion to shifts in vehicle kilometers of travel and estimates of changes in air pollutant emissions were made subsequently by MTC; a preliminary estimate of the impact of vehicle kilometers of travel is given here.

It was originally intended that the sensitivity analyses described here be carried out through the use of elasticities and cross elasticities (6). These mathematical expressions, which are derived for a specific mode-split forecast and for specific zone-pair interchanges (or household trip records), allow one to estimate what the percentage change in mode split would be for a 1 percent change in a given service characteristic such as travel time and travel cost.

But, because the control strategies tested amounted to major proportional changes in service characteristics (for example, some amounted to more than a 100 percent change in a component service feature such as walking time), and because elasticities must be computed for each of six different mathematical models (primary worker and secondary worker models, each stratified by three income categories), it was decided to develop procedures to compute mode-split changes directly. This more direct approach was made possible because of the flexibility of the new MTCFCAST computer system. Additional computer software was written that will permit a wide variety of additional sensitivity analyses to be conducted. This software is set within the UTPS UMODEL framework and focuses on the series of prespecified representative trips.

In the past, to test major changes in particular service variables, elasticities have been emphasized in sensitivity analyses of this type because of the expense and difficulty of complete runs of the travel demand model system. Elasticities were used instead of additional model runs. However, by using the new procedures developed here, it is possible to analyze mode-split sensitivities more easily and directly in terms of partial model runs (mode-split models only for representative trips only).

REPRESENTATIVE TRIPS

To determine the effect on vehicle travel that might result from the various transportation control strategies proposed by MTC, the shift in mode split among transit, shared-ride, and single-driver automobile trips must be addressed in an efficient way. Efficiency in this case can be translated into the development of a set of representative trips that reflect the effect on regional travel in a prototypical fashion. The prototype regional trip chosen in terms of travel purpose was the home-based work trip, which represents the travel category most susceptible to modal service influences and also represents the trip purpose that can potentially yield the highest dividends in terms of improved air quality (because of the relation between the work trip and the morning and evening peak traffic hours).

To represent the region in a geographic sense, five origin districts were developed (Figure 1):

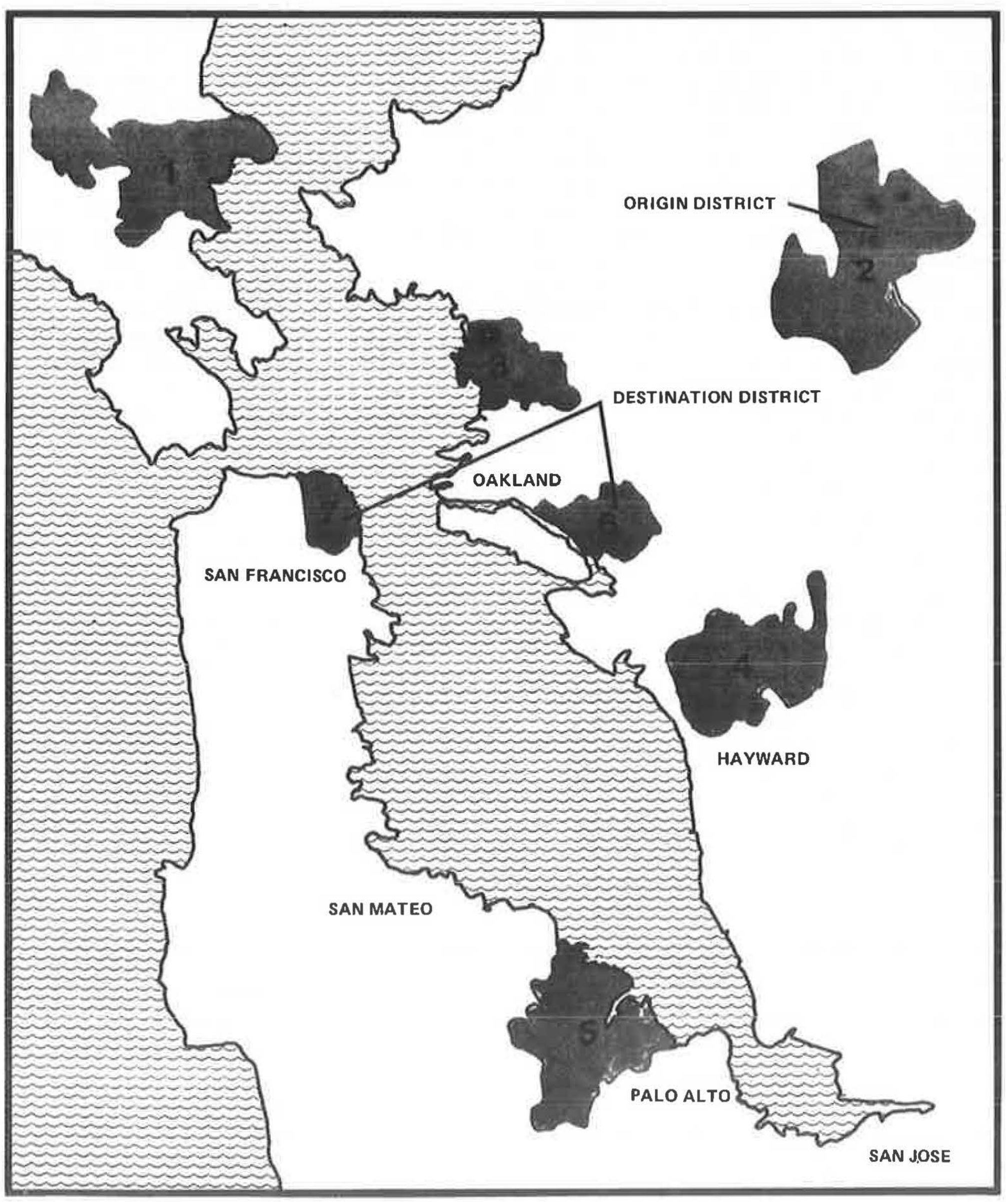
1. District 1: Larkspur, San Rafael—zones 8 through 15;
2. District 2: Concord, Walnut Creek—zones 96 through 104;
3. District 3: Berkeley—zones 125 through 132;
4. District 4: San Leandro, Castro Valley—zones 176 through 184; and
5. District 5: Redwood City—zones 319 through 324.

Two destination districts were developed to represent CBD and non-CBD travel (Figure 1):

1. District 6: South Oakland—zones 156 through 161 (non-CBD); and
2. District 7: San Francisco—zones 382, 383, and 417 through 437 (CBD).

The zonal information required to compute mode

Figure 1. Representative Bay Area origin and destination districts.



split was developed at the district level by computing the weighted average of the zonal data. The network-related data were computed on a district-to-district interchange basis based on the weighted aggregation of zone-based highway and transit network data. All weighting was done on the basis of total work trips per zone or trip interchanges per zone pair.

TRANSPORTATION CONTROL STRATEGIES

The transportation control strategies that were tested and the means of representing each strategy are given in Table 1.

RESULTS FOR SINGLE-STRATEGY TESTS

A computer program was written to print out the productions and attractions for each of the seven (five origin and two destination) districts for the two modes that relate directly to vehicle use: automobile driver and transit. In this case, automobile driver includes the drivers of the shared-ride mode as well as drive-alone drivers. By analyzing the modes in this way, the effect on the key factors that relate to air pollution and energy consumption (number of vehicles and vehicle type) can be directly determined.

Table 1. Transportation control strategies.

Strategy	Means of Representing Strategy
Limit on number of parking spaces	Increase walking time at destination end of trip by 5, 10, and 15 min
Preferential parking for car pools	Increase walking time at destination end of trip by 5 min for drive-alone only
Automobile-free zone	Increase walking time by 5 min for automobile modes at destination end of trip for zones 419 through 423, 429, and 430 (minidistrict within San Francisco CBD)
Parking cost increases	Increase daily parking cost by $1.00 and $2.00/d
Limit on long-term parking	Increase daily parking cost by $3.00/d
Area license	Increase automobile operating cost by 50 and 100 percent
Gasoline tax	Increase automobile operating cost by 50 and 100 percent
Toll increase	Increase bridge tolls by 100 percent
Parking cost incentive for car pools	Use shared-ride parking cost of zero and shared-ride parking cost of zero with drive-alone parking cost increase of $2.00/d
Toll reduction for car pools	Use zero bridge toll for shared ride
Additional transit service	Double service (halved headways) by reducing initial wait and transfer wait by factor of 50 percent
Bus lanes with ramp metering	Reduce transit in-vehicle times by 10, 20, and 30 percent
Paratransit alternatives	Not tested because of extensive network modifications required
Car-pool lanes with ramp metering	Reduce highway travel time for shared-ride mode by 10, 20, and 30 percent

Table 2. Effect of strategies on mode choice.

	Change in CBD Trips (%)			Change in Non-CBD Trips (%)		
Strategy	Number of Automobiles	Transit Ridership	Shared Ride	Number of Automobiles	Transit Ridership	Shared Ride
Limit on number of parking spaces						
Walking time increased by 5 min	-7	+23	-6	-3	+25	-3
Walking time increased by 10 min	-14	+47	-13	-7	+56	-6
Walking time increased by 15 min	-22	+75	-21	-12	+104	-18
Preferential parking for car pools (drive-alone walking time increased by 5 min)	-9	+10	14	-6	+18	+19
Automobile-free zone (walking time for affected zones increased by 5 min)	-3	+12	-4	None	None	None
Increase in parking cost						
$1.00/d	-5	+7	+5	-3	+14	+5
$2.00/d	-9	+16	+6	-6	+29	+11
Limit on long-term parking (parking cost increase of $3.00/d)	-13	+28	+5	-9	+47	+14
Area license and gasoline tax						
Automobile operating cost increased by 50 percent	-1	+1	+1	None	+2	-1
Automobile operating cost increased by 100 percent	-1	+2	+1	-1	+6	-2
Toll increase of 100 percent	-6	+11	+4	None	None	None
Parking cost incentive for car pools						
Zero shared-ride parking cost	-2	-1	+9	None	None	None
Zero shared-ride parking cost and drive-alone parking cost increased by $2.00/d	-11	+1	+24	-7	+2	+25
Zero toll for car pools	-1	-4	+6	None	None	None
Additional transit service (all headways cut in half and waiting time reduced by 50 percent)	-16	+53	-15	-12	+94	-11
Bus lanes with ramp metering						
In-vehicle transit time reduced by 10 percent	-2	+4	None	None	+3	-3
In-vehicle transit time reduced by 20 percent	-3	+9	-1	-1	+8	-2
In-vehicle transit time reduced by 30 percent	-5	+16	-4	-1	+9	None
Car-pool lanes with ramp metering						
Shared-ride highway travel time reduced by 10 percent	-1	-3	+6	None	-2	+3
Shared-ride highway travel time reduced by 20 percent	-2	-6	+12	-1	-4	+4
Shared-ride highway travel time reduced by 30 percent	-3	-8	+17	-1	-6	+13

Person-trip attractions and productions were also printed for each district, which enabled the number of "shared riders" to be computed by subtracting transit and automobile driver from total person trips. For each of the 13 strategies that were individually tested, a base case and the modified situation as well as the differences in productions and attractions computed for each district arc printed. Trip interchanges among the districts are also printed. All results are computed by summing the primary and secondary work trips for all three income levels. The actual equations used the number 18, i.e., 2 (mode choice models) × 3 (income levels) × 3 (modes) = 18.

The strategies described above range in individual (single-strategy) effect from reducing by less than 1 percent the number of automobiles used for work trips to a potential reduction in work-trip automobiles of greater than 20 percent. Under the general heading of incentives versus disincentives, the strategies can be categorized as follows:

1. Cost increases versus cost reductions,
2. Service improvements versus service reductions, and
3. Car-pool incentives versus transit incentives.

Exactly which strategy or combination of strategies or strategy category is eventually chosen will depend on a number of factors that include political and public acceptance and the degree of air quality improvement required. The purpose of this initial analysis was to point out the potential of each individual strategy for causing a shift in mode choice.

The range of potential decreases in the number of work-trip automobiles attributed to each strategy is given in the table below:

	Reduction in Number of Work-Trip Automobiles (%)	
Strategy	CBD Travel	Non-CBD Travel
1	7-22	3-12
2	9	6
3	3	NA
4	5-9	3-5
5	≥13	≥9
6	≥1	0-1
7	≥1	0-1
8	≥6	No effect

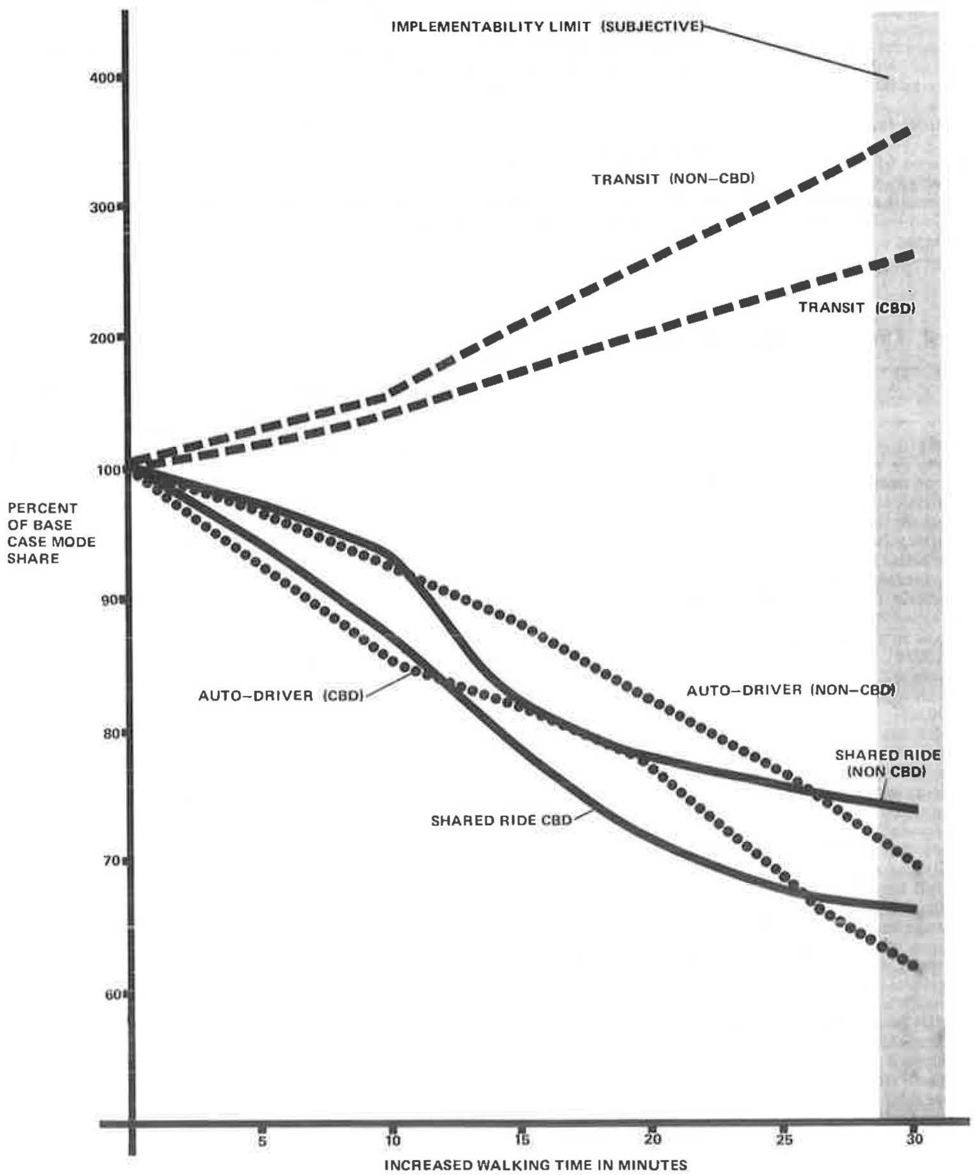


Figure 2. Percentage mode shift versus reduced availability of parking (increased walking time).

Strategy	Reduction in Number of Work-Trip Automobiles (%)	
	CBD Travel	Non-CBD Travel
9	2-11	0-7
10	≥1	No effect
11	≥16	≥12
12	2-5	0-1
13	Not tested	Not tested
14	1-3	0-1

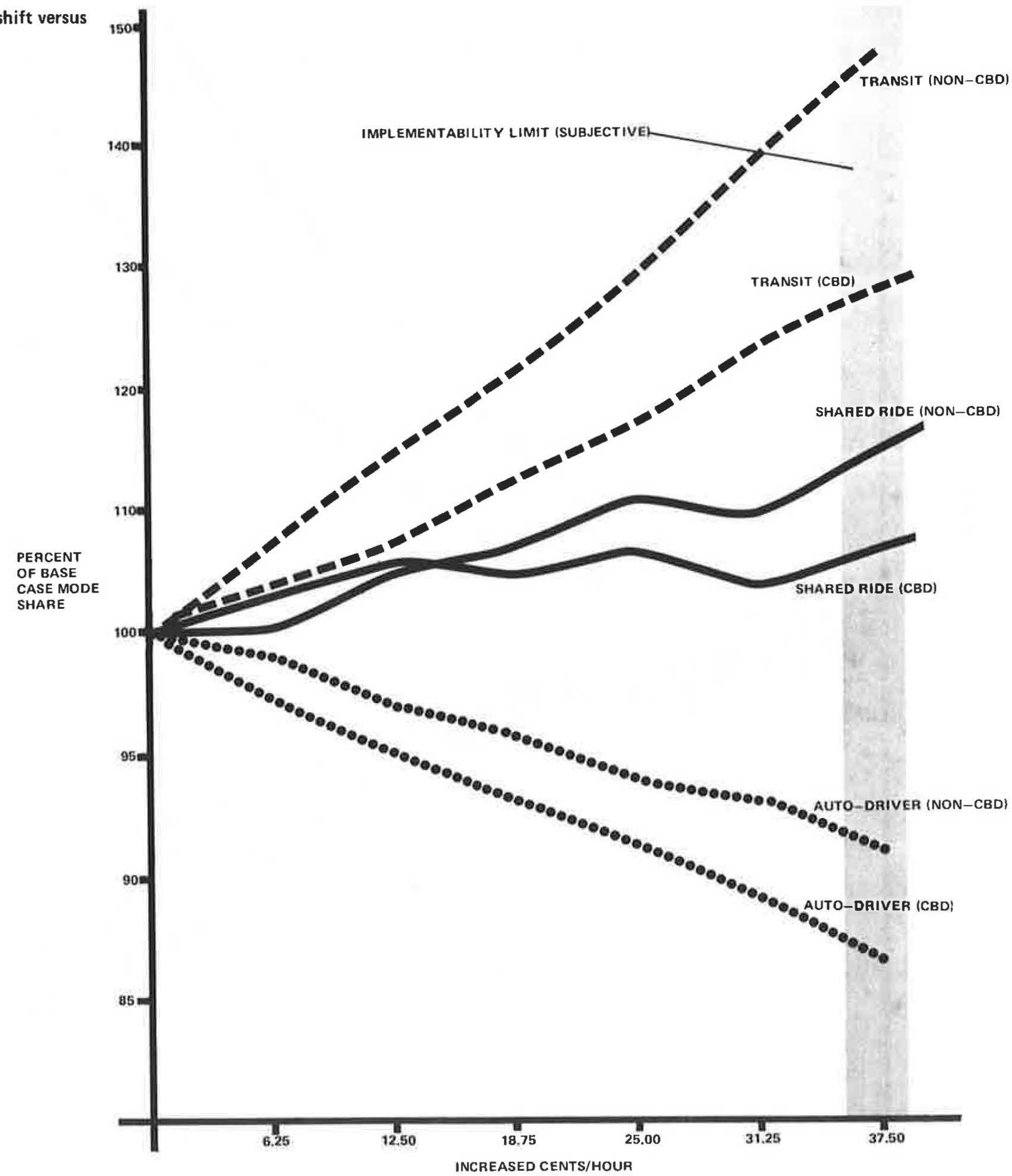
This table represents results based on the range of variable modifications used in the analysis; the exact value for each affected variable (e.g., walking time) will, of course, affect the shift in mode split. The ranges displayed therefore represent a comparative evaluation of those strategies that could potentially have the greatest effect on automobile use. The analysis is broken down by CBD and non-CBD trip orientation to show the varying effect of the strategies on different parts of the region.

For each individual transportation control strategy, the decrease in work-trip automobiles is reflected by an increase in transit or shared ride or both. Table 2 gives a detailed picture of the effect on each mode for each strategy and each policy level tested within that strategy.

In summary, the strategies that have the highest potential for reducing the number of work-trip automobiles making single-driver work trips are (a) limiting the number of parking spaces, (b) increasing transit service, and (c) increasing parking cost. The strategies that have the greatest potential for increasing transit use are the same because the competitive position of transit is strengthened the most.

The strategies that have the greatest potential for increasing car pooling are (a) reducing shared-ride parking cost and increasing the parking cost for driving alone, (b) reducing shared-ride travel time through exclusive car-pool lanes and ramp metering, and (c) preferential parking for car pools.

Figure 3. Percentage mode shift versus increased parking cost.



COMPARISON OF STRATEGIES

The computer program written for these analyses has the capability to systematically test prespecified incremental shifts in each control strategy (e.g., successive 3-, 4-, or 5-min increases in walking time from parking facilities). By using this capability, it was possible to test a wider range and number of policy levels for each strategy beyond the specific levels for which testing was requested. For 9 of the 13 control strategies, these systematic incremental variations were examined and plotted in the form of a graph. Figures 2, 3, and 4 show the percentage changes in mode share obtained for each of the three modes and for CBD and non-CBD work trips for the three most promising strategies: limiting the number of parking spaces, increasing transit service, and increasing parking cost.

The maximum level for each control strategy shown in Figures 2, 3, and 4 was treated as an "implementability limit," defined purely for further analysis purposes. For eight of the nine control strategies examined in this way, this implementability limit is on the order of 1.5 to 2.0 times greater than the most ambitious policy levels tested in Table 2. The exception is increased parking costs, for which it was felt that previously tested levels were probably already at maximum feasible limits. Because all of the remaining implementability limits would pose serious implementation problems from a political standpoint, these broader

Figure 4. Percentage mode shift versus reduced transit headways.

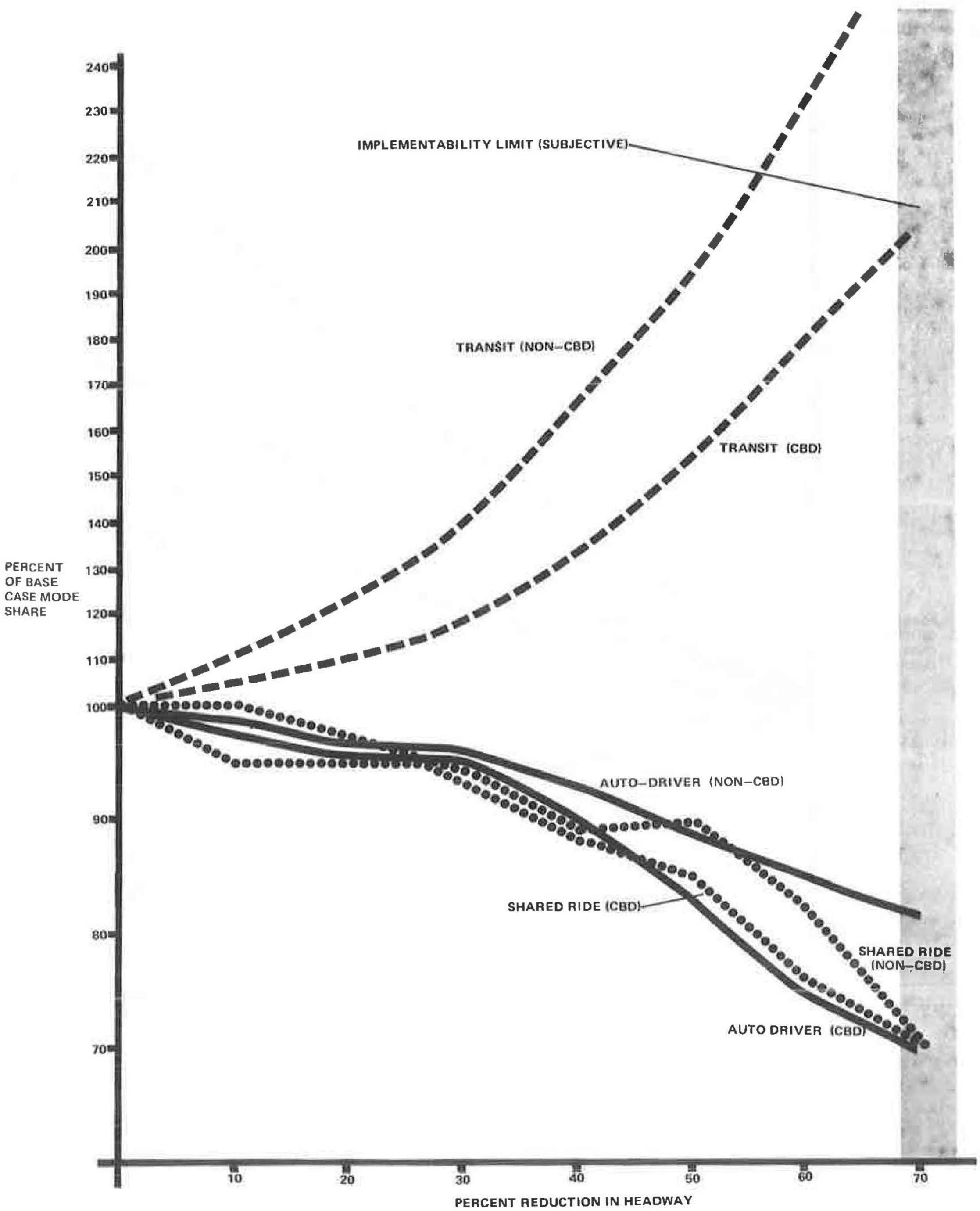


Table 3. Comparative index of effectiveness of strategies.

Strategy	CBD-Oriented Work Trips: Automobile Driver	CBD-Oriented Work Trips: Transit	CBD-Oriented Work Trips: Shared Ride	Non-CBD-Oriented Work Trips: Automobile Driver	Non-CBD-Oriented Work Trips: Transit	Non-CBD-Oriented Work Trips: Shared Ride
Reduce parking availability	-0.38	+1.60	-0.33	-0.30	+2.50	-0.24
Preferential parking for shared ride	-0.18	+0.20	+0.24	-0.13	+0.34	+0.42
Increase parking cost	-0.14	+0.27	+0.06	-0.08	+0.46	+0.14
Increase automobile operating cost	-0.01	+0.06	+0.05	-0.02	+0.09	+0.04
Toll increase	-0.19	+0.18	+0.03	-	-	-
Parking cost differential	-0.13	+0.13	+0.35	-0.15	+0.38	+0.51
Reduce transit headways	-0.32	+1.05	-0.29	-0.20	+1.50	-0.28
Improve transit operating speed	-0.18	+0.30	-0.11	-0.03	+0.20	-0.02
Shared-ride lanes and ramp metering	-0.06	-0.20	+0.41	-0.03	-0.15	+0.39

feasibility ranges are estimated in a purely technical or engineering sense.

By establishing judgmentally this broader theoretical range for each variable tested for the various control strategies, it was possible to compare them more consistently. These larger ranges were assumed to be approximately equal in terms of technical implementability, and a normalized index of potential impact was computed. This index reflects the percentage of change in mode use for an equivalent "1 percent of implementability" change in the variable being tested. This admittedly judgmental index number allows a generalized view of strategy effectiveness to be developed that would not be possible otherwise because the range of previously tested values for one variable may involve a 200 percent change (e.g., parking cost) or only a 20 percent change (e.g., reduction in transit travel time). By normalizing over the implementable range, a more accurate (though generalized) comparison can be made. Table 3 gives these index values for each combination of mode and strategy.

For CBD travel, the control strategy that will decrease single-driver automobiles to the greatest extent is still to reduce the number of parking spaces available and thereby increase walking distance and hence walking time for automobile drivers and passengers. The second most effective control strategy in reducing the number of single-driver automobiles for CBD travel is to improve transit service by cutting transit headways. It is significant, however, that, because of major implementation difficulties that have emerged in the development of possible parking management plans for different portions of the region, increasing parking cost shows much less potential effectiveness than was initially observed. The third most effective means of reducing the number of automobiles in the downtown area is reflected by either of two individual strategies: (a) providing preferential parking for shared-ride vehicles or (b) improving transit service by providing preferential treatment for transit vehicles, which would reduce in-vehicle transit travel time.

For non-CBD travel, the strategies that will reduce the number of work-trip automobiles are essentially the same: (a) reduce parking, (b) improve transit service by decreasing headways, (c) provide a preferential parking cost for shared ride, and (d) provide preferential parking locations for shared-ride vehicles.

RESULTS FOR COMBINATION STRATEGY TESTS

Four combination strategies were developed and tested for their effectiveness in terms of realizing potential mode shifts and hence reductions in vehicle kilometers of travel in the region. The four combination transportation control strategies are given in Table 4. Table 5 indicates the relative change in mode use that could result from each of these combination strategies.

The four strategies were developed to represent a generally realistic set of transportation control options. Results given in Table 5 suggest that the option that combines factors of both travel time and cost has an expected cumulative effect in terms of reducing the number of automobiles. That is, the reduction in single-driver automobiles for the time-and-cost option is very nearly the sum of the reductions in the number of automobiles for the strategies that emphasize travel time and cost. This additive relation does not hold, however, for transit ridership or for car pooling. Significantly higher increases in car pooling could be achieved under strategy 3, whereas increases in transit ridership under this strategy are only slightly greater than those obtained under the travel-time strategy alone.

Table 5 also indicates that very little if any improvement results for CBD-oriented trips from implementing the maximum-effort strategy versus the combination time-and-cost strategy. This suggests that the assumed policy levels that go into the time-and-cost transportation control strategy already realize the upper limit on mode-split shifts that can be expected for CBD-oriented travel. For non-CBD trips, however, the maximum effort does realize greater decreases in the number of automobiles than does the combination time-and-cost control strategy, which indicates that room still exists for further reduction in vehicle travel to non-CBD areas perhaps beyond that achieved by the time-and-cost and maximum-effort strategies.

For CBD travel, a reduction of 27 percent in the number of automobiles used for the work trip could potentially be accomplished by a realistic transportation control strategy that involved both time and cost factors. In terms of impact on total regional travel, it has been found that the work trip accounts for approximately 23 percent of the total trips made in the region but involves approximately 33 percent of the vehicle kilometers of travel. Specifically, the CBD work trip represents about 15 percent of total work trips. Therefore, a 27 percent reduction in the number of automobiles for CBD-oriented work trips would result in a commensurate decrease of 1 percent in regional vehicle kilometers of travel. If similar computational logic is used for the non-CBD-oriented work trip, a reduction in regional vehicle kilometers of travel of 2.5 percent could potentially be realized.

Therefore, transportation control strategies aimed at the work trip, which is, of course, a primary target for such control measures, could realize a total potential decrease in regional vehicle kilometers of travel of approximately 3.5 percent. This impact is applicable for a combined control strategy that involves both time and cost factors over what is considered to be initially a relatively realistic range of control. Greater decreases in vehicle kilometers of travel may be realized by developing other combination strategies based on the sensitivity analyses (and further sensitivity analysis capabilities) developed in the project.

Table 4. Combination transportation control strategies.

Strategy	Type	Combination of Measures
1	Travel time	Increase drive-alone travel time by 20 percent
		Decrease transit in-vehicle time by 10 percent
		Decrease shared-ride travel time by 10 percent
		Increase walking time at destination for drive alone by 200 percent
		Reduce initial transfer and transit wait time by 10 percent
2	Travel cost	Increase drive-alone parking cost by \$1.00/d
		Decrease shared-ride parking cost by 80 percent
		Reduce shared-ride toll cost to zero
		Increase drive-alone toll by 150 percent
3	Time and cost	Combine all policy levels used in strategies 1 and 2
4	Maximum effort	Decrease transit in-vehicle travel time by 20 percent
		Decrease shared-ride travel time by 20 percent
		Increase drive-alone travel time by 20 percent
		Increase walking time at destination for drive alone by 500 percent
		Decrease initial and transfer transit waiting time by 20 percent
		Decrease shared-ride parking cost by 80 percent and increase drive-alone parking cost by \$2.00
		Reduce shared-ride toll to zero
		Increase drive-alone toll to \$2.00

Table 5. Potential effect of combination strategies on mode choice.

	Change in CBD Trips (%)			Change in Non-CBD Trips (%)		
Combination Strategy	Number of Automobiles	Transit Ridership	Shared Ride	Number of Automobiles	Transit Ridership	Shared Ride
Travel time	-14	+22	+14	-5	+19	+14
Travel cost	-13	+11	+20	-3	+10	+12
Time and cost	-27	+25	+42	-9	+32	+24
Maximum effort	-27	+28	+39	-18	+68	+48

The transportation control strategies examined here will, of course, also have some impact on nonwork travel. Though nonwork travel was not examined explicitly in the study, other work (1) suggests that those policies that tend to reduce the number of single-driver work trips also tend to increase the number of nonwork trips. In the short run, at least, this is because the automobile normally used for the single-driver work trip (for those who shift to transit or car pooling) is now available at home for use by other family members. These other family members tend to make additional discretionary or nonwork trips.

For example, in Washington, D.C. (1), it was found that a daily parking cost increase of \$3.00 would reduce the number of drive-alone work trips by 15.6 percent and the number of work-trip vehicle kilometers by 10.2 percent. However, nonwork vehicle kilometers would increase by 2.3 percent for a combined net impact on total vehicle-kilometer reductions of 2.5 percent. Similar balancing impacts might be expected in other urban areas so that the 3.5 percent reduction in Bay Area regional vehicle kilometers of travel because of work-trip mode shifts might be offset somewhat by accompanying increases in nonwork travel.

CONCLUSIONS

Several general conclusions can be drawn from these analyses:

1. Although the various transportation control strategies examined here, either singly or in combination, could reduce the number of automobiles used for work trips by about 20 percent or more, the potential impact on total regional vehicle kilometers of travel is considerably lower—perhaps a 5 percent reduction or less. This is consistent with the findings of other studies.

2. The most promising single transportation control strategy involves limiting the number of close-in parking spaces available for work trips at both CBD and non-CBD destinations. Such a strategy could significantly increase peak-hour transit ridership although, without selective treatment for car pooling, car pooling might also be reduced.

3. The second most promising single transportation control strategy involves additional improvements in transit service, which are reflected in major reductions in waiting time. For significant impact, such a strategy would call for major capital and operating investments in additional transit equipment, labor, and operating schedules.

4. Although increased parking cost also shows significant potential for inducing mode shifts, the levels of increase necessary to achieve a major impact on work trips appear to face serious difficulties of implementation. When these difficulties are considered, this control strategy appears to be of less potential effectiveness.

5. An upper limit on potential mode-shift impact for CBD work trips for various combination transportation control strategies may lie in the area of 25 to 27 percent reduction in single-driver automobile use. For non-CBD work trips, the existence of such an upper limit is less clear; it could exceed an 18 to 20 percent reduction in single-driver automobile use.

6. A series of representative CBD and non-CBD work trips does provide an efficient method for analyzing the sensitivity of a wide range of transportation control strategies. Emphasizing work-trip analysis appears to be an adequate means for drawing general conclusions regarding the impact on overall regional travel and potential reductions in vehicle kilometers of travel.

7. The additional computer software developed in association with the UTPS UMODEL program provides considerable flexibility for further sensitivity analyses and permits a wide variety of combination control strategies to be tested. This software has been incorporated in the MTC travel demand forecasting system.

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Evaluation of Road and Transit System Requirements for Alternative Urban Forms

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Research was performed for the purpose of evaluating the road and transit system requirements of a range of cities that have different density and spatial patterns and thereby assessing the effects of varying urban forms on transportation investment and service measures. The assessment is conducted in the context of a proposed policy evaluation framework that uses the end-state transportation and land-use plan for policy guidance and the time stream of benefits and costs as the object of evaluation. For the analysis of the transportation implications of a number of urban forms, a two-mode network generation model is developed and applied to six hypothetical city types of 2 million population. The comparison of the transportation requirements for these urban forms indicates a range of transit use among the city types of from 8 to 34 percent and wide differences in the need for high-capacity service routes. In terms of person hours of travel and mean trip length, the multicentered city in particular and the centrally oriented cities in general have the lowest requirements. These conclusions have important implications for the use of horizon-year transportation and land-use plans within the proposed framework of dynamic evaluation.

The current emphasis in urban planning on a more comprehensive and open process and an orientation to strategic choices among a wider range of alternative policies has placed new demands on the transportation planner. In spite of the ability of the transportation planner to simulate travel demands on a complex multimodal network, there is a notable lack of success in responding to currently relevant planning issues and alternatives. In general, existing transportation planning models are expensive and cumbersome to use and difficult to interpret, and their attention to the detail of system performance is too restrictive in scope (1, 2).

Perhaps the best way to exemplify the deficiencies of current transportation modeling is to define a comprehensive three-level hierarchical structure of the planning process against which present achievements can be compared (3, 4). The three components of the structure are defined as follows:

1. Policy planning—Policy planning is a political exercise concerned with the broad issues of urban development and the authority and constraints relating to the resolution of these issues within a public forum. This process provides the contextual setting within within which transportation system alternatives may then be assessed.
2. Systems planning—For transportation planners, this process is concerned with the analysis and evaluation of multimodal networks that consist of major transportation facilities and associated terminals from the point of view of location, operation, and regulation.
3. Project planning and programming—The third level of the structure involves those activities required to design and implement a particular component or link of the system plan and includes engineering design, right-of-way acquisition, and capital programming and budgeting.