Improving the Effectiveness of a Transportation Demand Management Program Through Evaluation: A Case Study

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Evaluations are an important source of information for improving the effectiveness of transportation demand management (TDM) programs. Evaluations of the TDM program at Bishop Ranch, California, provide insight on how to improve services by strengthening the link between the commuter and the operation of a TDM program. Thorough evaluation requires both essential core data (commute distance, home location, commute mode, and arrival time) and supplemental information about topics such as the flexibility of work hours, analysis of subgroups, and attitudes toward various incentives and disincentives. Key issues include problems with the use of the current mode as a measure of effectiveness, lack of knowledge about the effect of flexible work hours on mode choice, and the importance of the initial design for time-series comparisons.

Continued expansion of transportation facilities is no longer economically or environmentally feasible. As a result, transportation demand management (TDM) programs have emerged as a potentially important component of the solution to urban traffic congestion (*1*). TDM is a relatively new and untested approach; little is known about its long-term effectiveness (*2*). A significant amount of research will probably go into the evaluation of TDM programs in the near future.

This research can serve two related but distinct purposes. The more traditional purpose is that of monitoring the effectiveness of the program (e.g., the number of vehicle-trips reduced or shifted to off-peak hours). A second purpose is that of providing the TDM program staff with information needed to improve services and develop strategies for marketing those services to commuters.

In simplified terms, TDM is changing commuters' behavior to make better use of existing transportation facilities. Although the commuter is the ultimate consumer of services, a direct link does not exist between the commuter's satisfaction and the operation of the TDM program. The commuter's purchase of services does not fund the program's operation. Consequently, the relationship between the effectiveness of a TDM program and a thorough understanding of the commuters it is designed to serve is often overlooked.

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The collected data and the analysis process will be analyzed from the perspective of providing the TDM staff with useful information about commuter behavior. This approach to selecting and presenting information on the commuter can be incorporated directly into the operation of a commute management program. The analysis uses 3 years of evaluations at the Bishop Ranch business park in San Ramon, California, as an example. A self-administered questionnaire has been distributed annually to all employees. This 585-acre business park employs about 14,000 people in a low-density suburban setting. The TDM program is operated through a transportation management association (TMA) and staffed by two full-time employees.

The Bishop Ranch evaluations are not displayed here as examples to be emulated, but as starting points from which to discuss the potential of the evaluation process to support the work of a TDM program. The shortcomings, as well as the strong points, make the evaluations valuable examples. Because the merits of the TDM program at Bishop Ranch and the characteristics of that site are not discussed, the analysis can be applied to a broad range of settings.

A discussion and example format will be followed. The merits of collecting specific data are discussed and, when applicable, examples from the Bishop Ranch evaluation are used to further illustrate the discussion. Questionnaire and sampling design, although critical components of the evaluation process, are omitted in order to focus on the analysis process.

Several pieces of information on commuter behavior are identified as the core of the evaluation: commute distance, home location clustering, commute mode, and arrival and departure times. Supplementing these core data with information on the flexibility of work hours, analysis of subgroups, and attitudinal questions provides a more complete evaluation.

DISTANCE

For discrete data on distances traveled to work to be useful to the TDM program staff, the data must be aggregated into

TABLE 1 ONE-WAY COMMUTING DISTANCES

Year	0 to 5 mi	6 to 10 mi	11 to 20 mi	>20 mi
	Percent			
1986	18.1	8.5	40.7	32.7
1987	20.9	9.3	40.4	29.4
1988	23.1	7.9	41.5	27.6

ranges. From the perspective of a statistician, ranges containing roughly an equal proportion of respondents might be created. However, from the TDM program's perspective, ranges that represent unique commute situations are most useful. The Bishop Ranch evaluation uses four ranges (Table 1).

With the exception of the >21-mi category, these ranges were chosen somewhat arbitrarily. The point at which vanpooling becomes economically feasible is 21 mi. The lower end of the 0- to 5-mi group might be considered a good target group for the nonmotorized commute options, such as walking and bicycling. The 6- to 10-mi group might be looked at as having a high potential for transit use; because of short driving times, it might also be seen as the most difficult group to deter from driving alone. The 11- to 20-mi group is probably where carpooling starts to become attractive; the inconvenience of meeting a carpool becomes offset by savings in cost and the fatigue of driving every day.

The points at which commute distances define commute options may not always be clear; appropriate ranges may also differ from one geographic location to another. Defining these ranges on the basis of the merits of potential mode choice will provide the most meaningful data for the TDM project staff. Distance alone is obviously insufficient for geographic analysis; home location needs to be added to the equation.

HOME LOCATION CLUSTERING

Home location clusters identify concentrations of commuters in specific geographic areas. In the case of Bishop Ranch, approximately 14,000 home locations are reduced to 14 clusters (Figure 1). Each cluster is identified as an aggregation of zip codes. Zip code data collected on the questionnaire are recoded through a customized subroutine to the appropriate location. Although elaborate for a single evaluation, writing the subroutine is well worth the effort if the project will be evaluated periodically; comparing changes in home location patterns provides the TDM staff with a preview of where to concentrate future efforts. The following excerpt from the Bishop Ranch evaluation helps demonstrate the utility of cluster analysis.

> In order to examine in greater detail employee home locations and temporal changes, zip codes were aggregated into groupings along major commute corridors (Figure 1). Areas H and J, which are directly north and south of Bishop Ranch along the 680 corridor, house almost 50 percent of the Ranch's employees. Area H is remarkably stable when compared with 1987 densities (up only 0.2 percent); area J accounts for the majority of the increase in short-distance commute (up 1.2 percent). Area M, south of Interstate 580, appears to be where most of the decrease in medium-distance (6- to 10-mi) commutes occurred.

Cluster analysis is highly dependent on the geography of the region. Areas should generally be oriented along commuter corridors, considering major access routes and transit service. Because the concentration of employees will be greater closer to the work source, the areas will tend to increase in size further out. Keeping the number of areas manageable without combining areas with unique characteristics is the most challenging part of defining areas.

COMMUTE MODE

Current commute mode is probably the most basic piece of information collected for the evaluation. Unfortunately, accurate information is sometimes difficult to gather because commuters use different modes on different days or multiple modes on the same day. Asking for the normal commute mode often elicits a multiple response, which generally must be eliminated from the data file. Figure 2 shows one approach that seems to elicit an accurate response in a suburban setting. Multiple answers with an explanation are precoded for data entry. Multiple answers without an explanation must be eliminated; however, these cases have been relatively rare at Bishop Ranch.

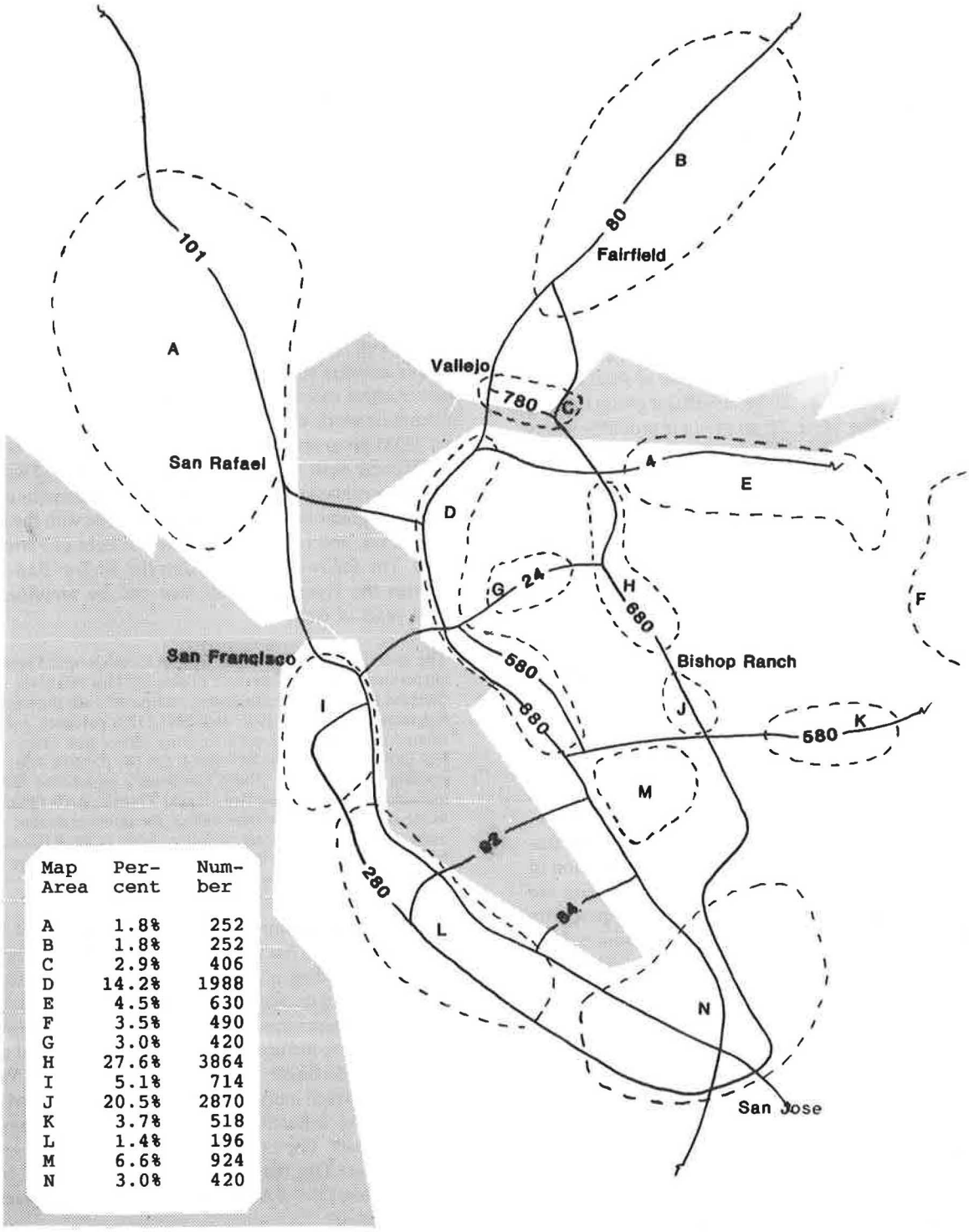
Commute mode data are not particularly useful for improving a TDM program's effectiveness when viewed in isolation. They become most meaningful when (a) compared with numbers from previous years, (b) compared with the results achieved by other programs in a similar environment or with the region's normal level, and (c) when examined in light of various subgroups. The following excerpt from the Bishop Ranch study illustrates the types of trends that can be identified from several years of data.

> The overall drive-alone rate at Bishop Ranch is up 2.5 percent; carpooling is down 2.2 percent (Table 2). This relatively small increase in solo driver commutes, compared with the substantial increase between 1986 and 1987 (12.6 percent), may be related to the population's stabilizing (fewer new employees, less movement of home locations). On the positive side, vanpooling is up slightly. There has been a significant shift of individuals from the Bay Area Rapid Transit (BART)/Shuttle mode since 1986. More than half of the individuals that were using that mode in 1986 are no longer using it. With the exception of club bus riders, this is a much greater percentage shift than found in any of the other modes.

One of the shortcomings of the data collected at Bishop Ranch is that it does not identify intermodal shifts. For example, in the preceding paragraph a significant shift from the BART/Shuttle mode was pointed out. What is not known is to which mode these former BART/Shuttle users have switched. A more complete picture, including both former and current modes, would facilitate a more complete analysis. Without knowledge of which individuals changed modes and what factors might have influenced that change, many unanswered questions remain. For example, did a large percentage move their residence? Did they all switch to vanpooling? Is there something about the BART/Shuttle option with which they were dissatisfied?

A second comparison that adds perspective is modal use at comparable sites. Without this comparison to provide some sort of benchmark the progress of a TMA is difficult to put into perspective. An excerpt from the Bishop Ranch evaluation follows.

> In order to place the mode split characteristics of Bishop Ranch in some perspective, Table 3 provides information on other



Map Area	Per-cent	Num-ber
A	1.8%	252
B	1.8%	252
C	2.9%	406
D	14.2%	1988
E	4.5%	630
F	3.5%	490
G	3.0%	420
H	27.6%	3864
I	5.1%	714
J	20.5%	2870
K	3.7%	518
L	1.4%	196
M	6.6%	924
N	3.0%	420

FIGURE 1 Employee home locations.

suburban locations around the Bay Area. With the exception of the San Francisco Airport, the drive-alone rate at Bishop Ranch is lower than at the other projects. All of the sites listed here are involved in some type of traffic mitigation efforts.

Although these sites might be ranked in order of drive-alone rate, with the lowest being most effective, the "why" portion of the equation remains unanswered. An in-depth understanding of the setting and the organizational structure is needed to understand why one may be more effective than another. For this reason, a comparison with the ambient level (which the Bishop Ranch evaluation does not include) may be more useful. In many regions, however, a current ambient level may be difficult to find.

Even the comparisons of modal change from year to year within the project site have some inherent error. Along with changes influenced by the efforts of the TDM program, other variables, such as gas prices, congestion, home relocations, and employee turnover, exert considerable influence on the choice of commute mode. Because so many factors affect mode choices, the success of a TDM program should not be evaluated solely on the basis of observed changes in mode split.

Thus, a significant gap in the evaluation remains. What should be used as a basic measurement of a program's success? One approach might be to measure the level of awareness of the services or incentives offered through the TDM program. Another, which might be complicated in terms of questionnaire design, would be to identify individuals that made mode changes and determine whether the program's services influenced those changes.

TABLE 2 NORMAL COMMUTE MODE

	1986	1987	1988
Drive Alone	55.1%	67.7%	70.2%
Carpool	26.6%	18.5%	16.3%
Vanpool	7.7%	8.3%	8.7%
Club Bus	2.8%	0.8%	0.7%
BART/Shuttle	6.2%	3.3%	2.5%
Other	1.3%	1.4%	1.7%

MODE AND DISTANCE COMBINED

Strong relationships have become apparent from examining the combination of mode and distance characteristics. Along with highlighting some of the obvious characteristics (e.g., the drive-alone rate decreases as mileage goes up), the excerpt following includes some of the most valuable insights provided by the evaluation.

> As noted in the earlier surveys, the drive-alone rate decreases as commute distance increases. Both carpooling and vanpooling rates are at their highest for the >21-mi category. Table 4 presents mode and distance changes between 1986 and 1988 (1987 was omitted to keep the table "reader friendly"). The increase in number of individuals driving alone is fairly even across the mileage ranges (i.e., it is not simply carpoolers moving closer and deciding to drive alone that has pushed up the drive-alone rate). The 11- to 20-mi group shows the sharpest increase in driving alone, and its share of the Bishop Ranch population has remained relatively constant. The sharp decrease in BART/Shuttle use noted earlier is most evident among the medium- and long-distance commuters.

Although large amounts of data are commonly digested and discussed at length without any practical recommendations resulting, the data from the mode-by-distance analysis can be directly linked to recommendations at Bishop Ranch. The increase in drive-alone rate across all mileage categories, as well as the sharp increase in the 11- to 20-mi category, both led to recommendations to the TDM program staff.

ARRIVAL AND DEPARTURE TIMES

For some TMAs, spreading the peak may be as important as increasing vehicle occupancy. Data collection and analysis for

How do you normally commute to work?

a. ___ Drive alone
b. ___ Carpool
c. ___ Vanpool
d. ___ Dropped Off
e. ___ Walk (3 blocks +)
f. ___ Bus
g. ___ BART
h. ___ Bicycle
i. ___ Shuttle
j. ___ Other

If you checked more than one method of commuting, please explain: _____

_____

FIGURE 2 Sample format for eliciting commute mode.

this purpose are relatively straightforward. Information on normal arrival and departure times are adequate for estimating the spread of the peak.

A more difficult issue relating to work hours is that of flextime and its effect on vehicle occupancy. Studies at Bishop Ranch and nearby Pleasanton (*3*) have provided some interesting insights into this issue. An initial examination of the data indicates that flexibility has a negative influence on the propensity to share rides. As flexibility increases, so does the drive-alone rate (Table 5).

Unfortunately, a literal interpretation of these data may not be accurate. A subsequent test of the question used in the survey indicated that the wording may have caused some confusion. The question was whether respondents' daily work hours were fixed, flexible up to 30 min, or flexible by more than 30 min. Some respondents may have indicated that their hours were fixed, not because of company policy, but because their carpool or vanpool required them to have a fixed schedule. Consequently, a higher percentage of those who were ride-sharing appeared to have inflexible hours. Because of this ambiguity, what might have proved to be one of the evaluation's clearest recommendations may be premature. The question needs to be reworded to ask specifically about company policy and flexibility of work hours in relation to commuting (Figure 3).

An alternative approach to considering the merits of flextime is to assume that those employees arriving outside the peak hour (i.e., 7:00 to 8:00 a.m.) are exercising a flextime

TABLE 3 DRIVE-ALONE RATES AT OTHER SUBURBAN LOCATIONS

	1986	1987
Santa Clara County Civic Center	81%	77%
Contra Costa Center (Pleasant Hill BART)	78%	81%
Concord (Downtown Area)	80%	80%
City of Pleasanton	84%	86%
Hacienda Business Park (1988)	--	75%
P.I.B.C. (South San Francisco)	--	88%
San Francisco Airport	--	66%
Bishop Ranch	**68%**	**70%**

-- = data not available

TABLE 4 MODE AND DISTANCE

	0 to 5 mi		6 to 10 mi		11 to 20 mi		>20 mi	
	Percent							
Mode	1986	1988	1986	1988	1986	1988	1986	1988
Drive alone	77	86	70	81	57	74	36	48
Carpool	17	9	25	16	28	16	30	23
Vanpool	0	0	1	1	4	5	19	23
Club bus	0	0	0	0	0	0	9	2
BART/Shuttle	0	0	0	2	9	4	6	2

TABLE 5 FLEXIBILITY BY MODE

	Fixed	Flex To 30 Min	Flex More 30 Min	Other
Drive Alone	65%	69%	73%	83%
Carpool	19%	18%	14%	11%
Vanpool	12%	7%	8%	6%
Club Bus	1%	1%	0%	0%
BART/Shuttle	3%	3%	2%	0%

option. Then, mode can be compared with arrival time, as in the following table.

Arrival Time, a.m.	*Percent Driving Alone*
Before 6:30	89.3
6:30 to 7:00	69.3
7:00 to 7:30	57.4
7:30 to 8:00	65.6
8:00 to 8:30	77.8
8:30 to 9:00	82.9
After 9:00	87.0

The data clearly show an increase in the drive-alone rate outside the peak hour. There are two potential interpretations. One is that the higher drive-alone rate outside the peak period demonstrates that employees are taking advantage of the flextime privilege to drive alone at a more convenient hour. The other interpretation is that it is more difficult to make ridesharing arrangements outside the peak period, because fewer individuals commute at those times. Because the Bishop Ranch TDM program's goals are currently for a peak-period reduction, moving trips out of the peak is valuable. If the emphasis should change to a more narrow vehicle occupancy perspective, this analysis would provide useful input into the development of an appropriate flextime policy.

SUPPLEMENTARY DATA

The information discussed to this point represents the core of the evaluation. The possibilities for supplementing these core data are infinite. No attempt is made to create a comprehensive list of supplementary data. However, if the Bishop Ranch TDM program is representative of other programs, the supplementary data identified will provide strong support for the evaluation of other TDM programs. Two potentially important topics that the Bishop Ranch survey does not address are parking and the need for vehicles for noncommute purposes (e.g., midday errands or dropping off and picking up children).

SUBGROUPS

As is the case with distance categories, subclassifications of commuters are of little value unless there is a practical way for the TDM program to target each group, such as a direct line of communication or a distinct service area. The two subgroups highlighted are based on job classification and employer.

Among the most common but least useful subgroupings is that of job classification. A person's perception of his or her own job classification often differs from another's perception, which results in inaccurate data. But more important, the TDM program staff has limited ability to affect the commute decisions of individuals from different job classifications. In a primarily white-collar setting such as Bishop Ranch, the differences in commute habits noted between people in different job classifications have been minimal.

Would your employer allow you to adjust your work hours for commuting purposes?

___ no, my hours are fixed

___ yes, but by no more than 30 minutes

___ yes, pretty much as needed

___ not sure

FIGURE 3 Proposed format for flextime research.

> Between the three major categories of employees (executive or manager, clerical or administrative, and professional or technical), the propensity to drive alone is not different, although clerical or administrative employees are somewhat more likely to ride-share. The executive or manager group appears less likely to vanpool, but more likely to carpool.

In a multitenant setting such as Bishop Ranch, examining the data by subgroups of employers is useful. Apart from providing input to the TDM program, employer data are useful for checking the validity of the sample. Because the actual number of people employed by each employer is generally known or can be estimated by the TDM staff, a comparison of the survey response with the population is a good check of the sample's representativeness. Grouping people by their employer is done on the assumption that there is a difference in commute habits of employees at different employers. At Bishop Ranch, the evaluations have indicated notable differences.

Combining employer information with the core data enables the TDM staff to have an individual profile of each major employer. The example presented in Table 6 compares commute habits by employer and mode. The data are difficult to interpret if too many individual employers are identified. Because Bishop Ranch houses two large employers and numerous small employers, all responses were grouped into three categories. Part of the analysis from the Bishop Ranch evaluation follows.

> Table 6 presents a comparison of the mode for respondents from three major groups at Bishop Ranch. Company B is holding steady in the drive-alone category and actually increasing in the carpool and vanpool categories. Company A shows the largest increase in driving alone and decrease in carpooling, but their drive-alone rate is still well below that of the other two groups. The lower drive-alone rate at Company A is caused by a much higher carpool rate than at Company B; their vanpool rates are nearly equal.
>
> The All Others group appears to be a potential target for vanpooling. Their distance characteristics are similar to those of the other two groups, but their vanpool use is well below that of Companies A and B. However, they tend to start work somewhat later (only about half are at work before 8:00 a.m., compared to over 60 percent of Company A and B employees), and vanpools tend to arrive quite early.

Another useful comparison at Bishop Ranch is location within the park. Similar to the preceding employer analysis, the ultimate usefulness of this analysis is based on the ability to treat each location as a separate market. Commuters from individual home locations are another subgroup that the TDM staff may find useful.

ATTITUDE VERSUS FACTUAL QUESTIONS

When providing information to a TDM program on how to better design and market services, there will always be a need

TABLE 6 SELECTED EMPLOYERS BY MODE

	1986	1987	1988
	Drive Alone		
Company A	48%	59%	63%
Company B	**63%**	**73%**	**73%**
All Others	71%	78%	80%
	Carpool		
Company A	32%	26%	22%
Company B	**19%**	**11%**	**13%**
All Others	19%	13%	12%
	Vanpool		
Company A	9%	11%	11%
Company B	**8%**	**9%**	**10%**
All Others	4%	4%	3%

to go beyond factual commute patterns and explore personal opinions, attitudes, and preferences. Responses to these questions have a potentially larger margin of error because of the dynamic nature of commute behavior and the subjective nature of the questions. Small differences mean little in response to attitudinal questions.

Two distinct types of attitudinal questions have been used in the Bishop Ranch evaluations. One investigates the reason behind current behavior, e.g., What is the main reason you commute the way you do? Question design is an important consideration with attitudinal questions because of the legitimacy of multiple answers and the legitimacy of different answers under slightly different conditions. Most commuters do not choose a commute mode for only one reason and can not quickly rank their reasons in terms of importance. The second type of attitudinal question asks about potential future behavior, e.g., During the upcoming highway reconstruction project would you consider the following alternatives? This type of question can place options on a relative scale and help the TDM staff decide where to focus their effort.

COMPARISONS OVER TIME

Time-series comparisons add a new dimension to an evaluation. A table with the commute distances of 1 year provides a good reference point, but a table with 3 or 5 years of information identifies trends and leads to insights that would not be obvious from a single year's data. In addition, TDM is a relatively new, evolving field, and commute behavior is constantly changing. Its dynamic nature and the value of time-series comparisons underscore the need for careful initial design. The time to expend extra effort, get a second opinion, and think problems through thoroughly is at the questionnaire and sampling design stage.

RECOMMENDATIONS TO THE TMA

After developing pages of detailed analysis of commuter behavior, pages of insightful recommendations might be expected. Although conclusions have been reached about the effectiveness of the program at Bishop Ranch (e.g., vehicles removed from the peak period), not until the 3rd year of data had been analyzed were any substantial recommendations for program direction offered. The following two recommendations are the first to directly provide input on improving the effectiveness of the TDM program's work.

1. The low vanpool participation rate of the All Other companies (i.e., not Company A or Company B) indicates that they are a high-potential group at which to direct vanpool formation efforts. Two characteristics of the All Other group are important to remember. They tend to start work a little later, making vanpool formation more difficult, and they have a higher BART/Shuttle rate than the other groups. Encouraging vanpooling with this group may move trips from the BART/Shuttle mode.
2. The 11- to 20-mi commuters may be the key group to work with in the near future. They are the largest group—their size has actually increased over the past 2 years. They have shown the largest increase in driving alone of all the mileage ranges. The long-distance group has high motivation to rideshare, and there are few tangible incentives to offer the short-distance commuters (plus, it can be argued that they are already part of the solution). This reasoning leads to the 11- to 20-mi group as an excellent audience for targeted marketing and potential new services.

CONCLUSIONS

Two objectives inspired this look at the data collection and analysis process. First, TDM is a young and largely unproven field; good data collection and analysis are critical to its future. Second, it is too easy for the process to become mechanical. The same data can be collected and observations and even recommendations can be made without enlisting the creative thought process. Some of the questions raised here may strengthen the link between the service provided by the TDM program and the needs of the commuter. Commute distance, home location, commute mode, and arrival and departure times are identified as the core elements of a commute program evaluation. These data alone, however, would make for an unimaginative analysis. Supplementing this information with variations, such as flexibility of hours, analysis of subgroups, and attitudinal questions, can provide the insights needed to suggest ways to improve a TDM program's effectiveness.

As several years of data on a TDM project are accumulated, the temporal comparisons become much more valuable than the individual data sets. In order to ensure that subsequent data sets are comparable, it is important to start with a good design.

The geographic variables—commute distance and home location—are a key to orienting the evaluation. Both commute distance and home location clustering are indicators of the potential of various modes. The process of defining distance ranges and cluster components brings the evaluation to a more practical level. Defining distance ranges and home location areas that can be targeted as separate markets is the key to making these data useful.

Current commute mode is the basic element in a TDM program evaluation. Often the evaluation of a program's success is tied to this measurement. Unfortunately, the dynamics of observed change are not well understood for three reasons. First, it is sometimes difficult to interpret the response of a commuter who uses multiple modes or different modes on different days. Second, it is difficult to find control projects or an ambient modal split level with which to compare measurements at the project site. Finally, a great number of variables beyond the control of the TDM program exert influence on commute behavior, making even periodic comparisons of the same program inaccurate. More detail is needed on the motivation behind individual changes in commute behavior and their relationship to services offered by the TDM program to accurately assess their effect.

Another illustration of the immaturity of TDM programs is the lack of knowledge about the effect of flexible work hours on mode choice. For some time, it was assumed that fixed work hours were a deterrent to ridesharing, making it difficult to coordinate ridesharing hours. However, some recent evidence has suggested that too much flexibility may actually discourage ridesharing. Further study is needed, and with the appropriate questionnaire design, the TDM program evaluation is a good vehicle with which to determine an appropriate flextime policy.

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