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Travel Surveys: Current Options

EMILY BRASWELL PETERSON AND JOHN R. HAMBURG

The underlying factors that form the basis for travel survey design and their relationship to the most common options currently available for collecting travel data are described. A comparison of the advantages and disadvantages of each of the options is also included.

The term travel survey covers a multitude of data collection strategies and efforts. To consider all of the current options for collecting travel data in general is a task much too broad to undertake in this paper, although the development of a taxonomy of travel data and survey methods would be well worthwhile. The factors to be considered in selecting a travel survey methodology will be addressed, and the alternative options available for undertaking a survey of travel by household residents will be discussed.

TRAVEL SURVEYS

A review of such basic considerations as the following is necessary before a discussion of travel survey methods:

- Purpose of inquiry,
- Data element required,
- Collection location,
- Collection duration,
- Mechanics of collection, and
- Expansion and validation.

Purpose of the Survey

There are many purposes for undertaking a survey of travel.

1. How much of the travel on streets adjacent to an existing shopping center can be attributed to travel to or from the shopping center itself?
2. How many people ride a specific bus route on an average weekday, and from or to where are they coming or going? For what purpose are they traveling?
3. What is the total patronage of the public transit system for an average weekday, Saturday, or Sunday?
4. How much of the traffic on the streets of a metropolitan area can be attributed to travel by nonresidents of the metropolitan area? How much to residents?
5. How much of the traffic on the streets of a metropolitan area is truck travel and what are the geographic and temporal patterns of that truck travel?
6. What are the geographic and temporal patterns of an amusement center? An urban university? A downtown medical center? An industrial park? A parking garage?
7. How much travel takes place between City A and City B?

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Data Element

Another important factor is the choice of the data element. What is the basic unit of travel data to be collected? There is a widely held belief that travel is composed of discrete elements known as trips that have both a beginning and an ending, which overlooks the movement of goods. Many followers of this doctrine assert that trips are "produced" in the home and are "attracted" out of the home. Trip ends, neither of which are at home (about one-quarter to one-third of all person travel), are split 50/50 between productions and attractions. The trip is often considered the basic element; however, for trip-generation studies (a major focus of travel surveys), the trip end is the basic unit. But is the unit the vehicle trip or vehicle trip end, or is it the person trip or person trip end? For many site traffic trip-generation studies, the basic unit is the vehicle attraction.

Surveys often collect trip clusters by sampling trip makers and inventorying all trips by the trip maker or households and collecting all trips made by all members of that household.

Collection Location

If the person trip is the basic collection unit, the household may be a cost effective way to collect a cluster of trips. Alternatively, establishments can be sampled and the trips arriving at the establishment sampled (the establishment survey, workplace survey, or special generator survey). Another collection location may occur during the actual trip and is called an intercept survey that collects travel data from travelers actually in motion. The cordon survey, the on-board survey, and the intercity screen line survey are all examples of the intercept survey.

Collection Duration

The period over which the travel data is collected is also significant. Most home-interview surveys are for 24-hr periods with Saturdays and Sundays excluded. Traffic counts can range from periods of as short as 15 min to periods of 24 hr, or 3 days, weekday and continuous. The shorter the time, the lower the cost, but the higher the error. Duration is a function of purpose and level of precision.

Mechanics of Data Collection

The mechanics of data collection depend on the data element, the survey methodology, and the survey purpose. The various mechanisms are

1. Mechanical counts;
2. Manual counts;
3. Questionnaire (self-enumeration); and
4. Questionnare (personal interview), which includes
   a. Telephone at home,
   b. At home,
   c. Intercept, and
   d. Establishment.

The self-enumeration questionnaire is potentially the least expensive technique of the simple counts; the personal interview at home is the most expensive. Self-enumeration runs the greatest risk of nonresponse bias and must be limited in both the duration and the complexity of questions.

Expansion and Validation of Travel Surveys

Most travel surveys are sample surveys and must be expanded to represent the population or universe from which the sample was drawn. Whenever possible, there should be a validation process to verify that the expanded sample survey estimate corresponds to an independent estimate for the universe. An example of such a procedure involves the expansion of the sample origin-and-destination surveys, assigning the expanded trips to the network, and comparing the areawide vehicle miles of travel (VMT) based on link estimates of highway volumes to areawide VMT based on highway link counts. In an establishment survey (attractions), the completed interviews and questionnaires are factored up to the count of people arriving at the establishment.

DATA FOR MODELING TRAVEL

Travel modeling is one of the most powerful tools available in the transportation planning battery and can be used at the local, regional, state, and national levels to provide the data necessary for the development, evaluation, and implementation of future transportation systems, and for the allocation of current and future resources for creating and maintaining those systems. The value of travel modeling lies in the ability to test the efficacy of possible alternative solutions without the expense of implementing each alternative in the real-world system.

Stopher and Meyburg (*1*) define the urban transportation planning process in three stages:

1. Inventory of existing land uses, socioeconomic characteristics, travel facilities, and travel characteristics for the area;
2. Forecasting of future land uses and travel demand; and
3. Detailing a set of alternatives for changes in transportation and land uses that will provide the basis for future policy and decision making.

The transportation planning process can be viewed as a seven-step sequence:

1. Inventory (land use, population, travel, and transportation facilities);
2. Land-use forecasts;
3. Trip generation;
4. Trip distribution;
5. Modal split;
6. Network assignment; and
7. Evaluation.

Travel modeling is used in Steps 3 through 6 and the specific models are calibrated to the local survey data. Current travel surveys—unlike their forerunners of the 1950s and 1960s that collected massive amounts of travel data including the zone-to-zone trip tables—are designed to provide calibration data for trip generation, trip distribution, and mode choice.

CURRENT OPTIONS

In the selection of travel survey methodology for travel characteristics to be used to calibrate travel models, there are several methods currently in practice:

1. Mail-out/mail-back survey [Houston–Galveston Area Council of Governments (H–GAC)];
2. Mail-out/telephone-back survey [Denver Regional Council of Governments (DRCOG)];
3. Telephone interview (Minneapolis–St.Paul area);
4. Intercept interview [North Central Texas Council of Governments (NCTCOG) special use];
5. Telephone/home interview (Charlotte, North Carolina); and
6. Home interview (NCTCOG).

Each of these surveys embodies certain advantages and disadvantages that make them suited to certain applications. In general terms, the primary differences are in collection cost and accuracy. It has been assumed over the years that there is a direct correlation between collection cost and data accuracy, but very little has been done to establish the precise form or the validity of this correlation beyond the obvious relationship of accuracy and sample size.

The six types of travel survey methodology listed represent four basic methods of data collection and transmission:

1. By mail, self-enumeration;
2. By telephone;
3. By home interview; and
4. By intercept interview, self-enumeration.

Although these four methods are listed separately, the distinctions between them are not rigid and allow for numerous combinations.

Mail Interview

The mail-out/mail-back survey is considered to be the least expensive and, by some, the least reliable form of travel survey

data collection. In its most primitive form no verbal contact is made between the surveyor and householder surveyed. This method can be refined by a prequalification telephone interview to ensure willingness and to obtain socioeconomic data about the household. Further variations include a follow-up call to thank the households and to check questionable information. The advantage of this form is its alleged inexpensiveness. Its major disadvantages are the lack of personal contact between surveyor and the household members being surveyed, and the ease with which a household can either not respond or respond incorrectly or incompletely.

Telephone Interview

This method is more labor intensive than the mail-out/mail-back survey and requires greater use and coordination of staff resources. The primary advantage of the telephone interview survey is that it does allow personal contact between the surveyor and the householder, which allows for greater staff interaction and control of the quality of the data collected. Some of the disadvantages of the telephone interview are its relatively greater expense, the potential bias of excluding households without telephones, and loss of personal verification of data which is possible with the face-to-face home interview.

Home Interview

The home interview method is the most labor-intensive method. Its advantage is the greater quality control that is possible when trained interviewers interact personally with the householder at home. The disadvantages are the cost of training and maintaining a staff of proficient interviewers, the security risk to those interviewers involved in entering the homes of strangers, the security risk to the householder of allowing a stranger to enter the home, and the consequent bias that can result from householder refusal—particularly in the case of single members, female heads of household, or elderly households. One means of minimizing this latter bias is to allow for telephone interviews in the case of one-person households, or two-person households in which the head is female, elderly, or both.

Intercept Survey

The intercept survey is conducted by interviewing the trip maker en route. This may involve having the traveler recall all of the travel for a particular day, or concentrating solely on the intercepted trip. If the interception takes place at the entrance to a sampled establishment, the trip maker can be requested to relate data for all travel going to, while at, and leaving the establishment. If all persons entering the building are counted, the sampled trips can be expanded to include total arrivals. This is similar to the cordon-type trip-generation studies done for specific sites.

The advantage of this approach is to obtain better attraction trip-generation rates than are typically obtained from the household survey. Trip attraction rates derived from household surveys are subject to a variety of omissions and larger sample errors. The disadvantage of the establishment survey is the difficulty of factoring the travel to obtain a picture of total travel produced in the region. It is probably best used as an adjunct to the household survey to obtain special-use data rather than as a substitute for the household survey.

Computer Survey Technology

A survey method that has only begun to be explored is the use of computers in collecting travel survey data. In recent surveys in Denver, Colorado, and Charlotte, North Carolina, a management information system designed at Barton–Aschman Associates was used to manage, coordinate, write letters, maintain quotas, prepare progress reports, evaluate interviewing productivity, check trip rates by stratum, and maintain the initial household and survey data before, during and after the survey. In Seattle, the computer was used more directly to record the data during the interview process. As computers and their interface with other communication systems, such as telephone and television, became more common, new methods of data collection will become available to the transportation professional. As these methods become available, it is important for the transportation professional to integrate these new techniques with the experience gained from conducting surveys over the past 33 years.

CONCLUSION

One of the lessons learned in the massive travel surveys of the 1950s and 1960s was that valid statistical assumptions could be made from a smaller sample than had previously been considered acceptable. As interviewing techniques, and computer technology were refined, travel surveys were further streamlined to meet the more stringent economic conditions prevailing in the 1970s and 1980s.

One of the studies that should be made as a result of recent and ongoing travel survey efforts is the clarification of the relationship among the travel survey methods and the quality of the data produced. Comparative studies of cost per interview, household trip characteristics by travel survey method, sample household characteristics by travel survey method, and other such comparisons among the variables for each travel survey might reveal valuable methodological insights. However, this kind of cross-method comparison could prove to be difficult. A cross index of recent travel survey results would be a worthwhile endeavor especially where longitudinal data are available from studies conducted at different times in the same place with and without a change in method. The local, regional, state, and national environments in which people work are likely to become more complex and more costly; decisions will become more critical. An effort should be made to unify and develop the best aspects of the methods discussed here for a survey methodology that takes full advantage of the power of minicomputers and management software.

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Telephone Interviews: Cost-Effective Method for Accurate Travel Surveys

JOHN F. ANDERSON, MARSHA A. NIEBUHR, ANN BRADEN, AND STEPHEN R. ALDERSON

A residential travel survey of a seven-county regional area was designed and conducted by Anderson, Niebuhr & Associates, Inc. for the Metropolitan Council of the Twin Cities Area, Saint Paul, Minnesota, between September 1982 and March 1983. A random sample of households was selected from directories of listed telephone numbers using computer generated random digits. Preliminary telephone interviews were conducted. If the household member agreed to have the household participate in the survey, general household data were collected and a day for logging travel information was selected. A cover letter, travel cards, and instruction cards were mailed to the households participating in the travel survey. Reminder calls were made to these households on the evening preceding the selected travel day to remind them to complete the travel diaries and to answer any questions. On the day after the travel day, households were again called to collect the travel data. The survey data were edited and coded by the staff of the Metropolitan Council. The primary purpose of the survey was to update, not repeat, a previous 1970 survey. Questions were limited to key data needed to verify findings of the earlier survey. Both the brief survey content and the method of data collection resulted in substantial cost savings while retaining acceptable representation and accuracy.

The Twin Cities Regional Transportation Planning participants include the Minnesota Department of Transportation, the cities and counties in a seven-county 3,500 sq mi region, and the Metropolitan Council of the Twin Cities Area, Saint Paul, Minnesota. The Metropolitan Council is an areawide regional planning body that serves as the metropolitan planning organization (MPO) as provided for in the federal UMTA/FHWA guidelines. A key role of the council is long-range travel forecasting for the region. The council also prepares a plan for land use known as the Regional Development Framework.

The region's planned 595 mi of metropolitan freeways and expressways, along with its transit system, have been shaped to the Regional Development Framework provided by the Metropolitan Council. During the 1970s this combined transportation system was expected to provide extremely good mobility to the year 2000 and beyond; however, planners are no longer certain of this. A phenomenon more commonly remarked in the faster growing sunbelt states is beginning to occur in the Twin Cities as well. This is what Orski (*1*) has identified as the coming crisis in suburban mobility. The problem is highway congestion in the suburbs which is partly due to the general growth in development adjacent to freeways and partly due to the emergence of specific suburban megacenters. Such suburban development attracts many more automobile trips than development counterparts in the older center city. In the Twin Cities this relationship was not fully reflected in the travel data collected in previous surveys (1958, 1970) and has heightened awareness of the need for better information on which to base transportation planning for the late 1990s and beginning decades of the 21st century.

The Twin Cities' regional planners approach to one aspect of this data need was to conduct a low cost microsample origin-destination (O–D) survey. The travel behavior inventory (TBI) update was designed and executed in a tight-budget environment. Sample selection and interview technique for representative accuracy were primary concerns because few dollars meant few interviews—far fewer than had been attempted before.

DESIGNING AND SELECTING THE TBI PROCESS

Planning for the 1982 TBI update (*2*) began in the mid–1970s. It was determined that a travel update should be conducted to coincide with the 1980 census. Early consideration of information needs was comprehensive and addressed a number of issues beyond ordinary travel behavior data. The Twin Cities' Transportation Policy Plan outlined goals, policies, and standards for regional highway and transit systems. In order to track the implementation of the plan, the Metropolitan Council commissioned a study of policy and goal measures called the Performance Measures and Travel Behavior Inventory Study.

The study developed a methodology for determining performance measures and developed a list of approximately 150 such performance measures, plus 20 summary performance measures (*3*). The study also outlined the data requirements for obtaining performance measures (*4*). Measures included such items as percent of population with access to transit. Data sources included O–D matrices, land records, automobile occupancy surveys, and many other types of inventories.

Many of the performance measures were derivative of common travel data sets so information needs were not so staggering as suggested by 150 measures; however, the total time and effort for putting the performance measures system into operation was still judged to be considerable. The consultants that prepared the study were asked to develop strategies for data collection, including estimates of time and cost. These were prepared for several alternative data collection strategies and for three budget levels. Expressed as multiyear continuing data inventory programs for the 1981 to 1990 period, the cost totals ranged from $205,000 to $680,000. That much money or more had been previously spent in the Twin Cities, and in less time. Nonetheless, consultations with state and federal officials indicated less than $100,000 would be available for actual data collection in 1981–1983.

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This budget constraint was one of two major constraints that had to be dealt with; the other was time. The research on performance measures carried beyond the time of the 1980 census and was deemed necessary to begin the travel inventory. As it was, the inventory was finally conducted in 1982–1983. The low potential funding forced planners involved to look closely at their priority data needs.

From other evidence gathered during the 1970s it was known that certain key travel factors were probably changing. Chief among those were the overall rate of travel in trips per person, and the vehicle occupancy. Traffic assignments using estimated current socioeconomic data and models based on 1970s trip rates and mode shares were not successfully replicating ground counts. It was determined therefore to conduct as large a sample as possible with only those priority questions needed to update the trip generation and mode choice models. It was known that the data would possibly not be adequate to revise trip distribution models.

CONDUCTING THE TBI SURVEY

The sampling approach used to update the travel behavior inventory of 1970 differed from typical travel survey methods in four ways: (a) the type of sample drawn, (b) the source from which the sample was drawn, (c) the size of the sample, and (d) the manner in which representativeness of response was achieved. These differences are detailed as follows:

1. Type of sample—Cluster sampling is sometimes used to survey households in a region because of its efficiency. However, an equal probability simple random sample was used for the travel survey. The simple random sample was chosen because the precision of data collected from simple random samples is easily and accurately determined. This served the objective of obtaining a selected number of data items needed to update the travel forecasting models with as much representative validity as possible. Also the simple random sample was chosen instead of a cluster sample because some of the assumptions for using cluster sampling appropriately could not be met in such a study.

2. Source of the sample—Equal probability random samples for telephone surveys can be drawn from listings of households with telephones or by using random digit dialing. For the travel survey, directory listing of households with telephones were used. Research has shown that a large percentage of the numbers dialed using random digit dialing are not working telephone numbers of households. The use of directories reduces the cost of calling these nonworking numbers. In addition, it is impossible to assess the extent to which nonresponse is a problem in random digit dialing because it is not certain if an unanswered call is to the number of a household, a business, or a nonworking number. The use of directories reduced this problem in assessing nonresponse. In using telephone directories, the exclusion of unlisted numbers was recognized. However, research has shown that data using listed numbers yield substantially the same results as data from unlisted numbers because unlisted numbers represent such a small proportion of the total numbers. Research has shown that the Midwest is an area of the country that contains the smallest proportion of unlisted numbers. One additional benefit of selecting a sample from current telephone directories was that family names were listed. Addressing the respondent by using the family name encouraged cooperation in the survey. Attention to such details of the population being interviewed can improve response rates (*5*).

3. Size of the sample—A common misconception in survey research is that surveying a large percentage of a population will yield more accurate data than surveying a smaller percentage. In travel studies used to establish baseline data, it is customary to draw samples that are 1 percent of the population. The purpose of this travel survey was to update baseline data; therefore, the need for such a large sample was not necessary and possibly would not have yielded data as accurate as that obtained. Another common problem in determing sample size is the manner in which sampling error is expressed. The relationship between sample size and sampling error is frequently expressed as a percentage. However, in this study the relationship was expressed in trips because trips were the units being measured in the study. Considering the need to update baseline data and report sampling erro in terms of trips, a minimum sample size of 2,000 households was selected from approximately 721,000 households in the area. A total of 2,581 surveys were actually completed. This size ensured that all work-trip data were accurate within ±0.14 trips. The random sample accurately represented all geographic segments of the area within ±2 percent at a 90 percent confidence level.

4. Representativeness of response—Because of time and cost considerations, the following approach is frequently used in survey research: (a) a limited number of contacts is made to reach the original sample, (b) those unable to be reached with minimal effort are replaced, and (c) the response rate is either not reported or does not take into consideration the replacement of the original sample. In this travel study, numerous follow-up procedures were used. Extensive callbacks were made to each household in the original sample before replacements to the sample were made. Calls were made at varying times of the day and night, and on different days of the week to increase the likelihood that the original sample was contacted. Replacements were made by randomly selecting a replacement household from a second listing of households generated in the same manner as the first listing. Of the 2,581 households for which surveys were completed, 151 provided household information, and 2,430 provided information on all aspects of the survey. This resulted in an overall response rate of 91 percent. Response rates of 90 percent or more of the original sample are routinely achieved by Anderson, Niebuhr & Associates, Inc. in similar studies by using these follow-up procedures.

The purpose of the 1982 travel behavior inventory (*2*) was to update socioeconomic and travel data gathered in a 1970 home-interview survey. To successfully complete the survey, the following criteria had to be met: (a) the survey had to be conducted within the designated time frame, (b) the survey had to be conducted within the approved budget, and (c) the study needed to produce data that were valid and useable in the Metropolitan Council's travel forecasting models.

The survey met the first two criteria related to the time frame and costs for completing the survey. To ensure the validity of the data, the results were compared to several key census and geographic indices to check for accurate representation of households.

SURVEY RESULTS AND APPLICATION

The 1970 data socioeconomic and travel base gathered from a home-interview survey was used to develop mathematical models to predict future regional travel patterns. From these, in part, the appropriate regional transportation policies, plans, and programs were developed.

From 1970 to 1982, significant changes in the Twin Cities occurred in the distribution of population and employment, energy costs, female labor participation, family size and age structure. Consequently, some 1970 data (e.g., proportion of automobile drivers, average trip length, average number of vehicles per household, and average automobile occupancy rates) became outdate. The 1982 TBI update revealed the magnitude of those changes and the extent to which 1970 travel models needed to be adjusted.

To confirm that the 1982 survey data accurately represented current socioeconomic data, key survey results were compared to analagous 1980 U.S. Census statistics *(2)*. Comparisons were made with geographic representation of the sample, selected age distribution, household size, household employment, and household income. These comparisons are summarized in Table 1.

TABLE 1 SURVEY VALIDATION SUMMARY TABLE

	1980 Census	Metropolitan Council 1982 Estimates	1982 TBI
Geographic representation of households, %			
Hennepin	50	47.0	51.0
Ramsey	23.0	22.9	22.0
Anoka	9.0	10.1	9.0
Dakota	9.0	10.1	8.0
Washington	5.0	5.8	5.0
Carver	2.0	1.9	3.0
Scott	2.0	2.3	2.0
Total	100	100	100
Selected age distribution, percentage of population 5 yr or older	92.8		91.8
Average household size	2.64	2.70	2.68
Household employment, percentage of population employed	51		52
Household income, $	24,785[a]		24,752

[a]Inflation adjusted.

Between 1970 and 1982 the most significant change in travel behavior of Twin City residents was the overall increase in mobility: more people made more and longer trips by both car and public transit. This is expected because of current (older) age structure for which the trip rate is greater.

Peak-period travel, for both morning and evening rush hours, has increased relative to off-peak tripmaking. This reflects the increase in the number of people in the labor force who have taken jobs and is indicative of these people placing priority on the trip to work.

Per capita automobile ownership continued to increase, while the vehicle occupancy rate continued to decline. This does not bode well for regional policies intended to increase ridesharing and use of public transit.

Since 1970 travel to and within suburbs has increased, while the proportion of all trips destined for central Minneapolis and St. Paul has declined. Travel to the downtown areas has remained essentially stable in absolute numbers. Since 1970 the average trip distance has increased by eight-tenths of a mile or 16 percent; however, the trip travel time still averages about 17 min.

A new trip purpose appears to be emerging—the non-home-based work trip. These are work-generated trips that are not made directly between the home and workplace (for example, stops at day care centers on the way to and from work). This explains a significant proportional decrease in home-based work trips since 1970, despite the increase in the number of workers.

The total cost of the TBI update was $180,500. This included the initial design of the survey, collection of data, editing, coding, and preparation of summary data files for analysis and evaluation. Of this amount $70,000 was spent with the consultant to prepare the final survey plan and collect the data. This figure amounts to $28.00 per household to collect the travel behavior data. The cost for processing completed interviews was $45.00 per household, which covered agency staff charges and computer costs; the total was $73.00 per household surveyed.

CONCLUSIONS

The basic approach, using a mail-out trip log and collecting data by telephone, was very workable. The cost per interview for actual data collection by the consultant was reasonable. The response rate from the selected sample was high and appeared to be due to careful design and pretesting, as well as to well-conceived and persistently applied follow-up technique.

The changes in basic understanding of travel patterns and behavior have been highly significant to the region's planners. Most of the inaccuracies in the 1970 models have been corrected. The changes between 1970 and 1982 were dramatic enough to suggest that travel data should be updated every 5 years if possible. Reduced cost per interview can help achieve that.

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A Small Sample Mail-Out/Telephone Collection Travel Survey

DAVID L. KURTH

The development, application, results, and costs of a small-scale mail-out/telephone collection travel survey conducted in the Denver metropolitan area from April to May 1985 are described. Steps taken to minimize the survey administration costs are discussed. Methods used to include households with unlisted telephone numbers, collect the travel data, and adjust the survey results to ensure that they matched observed distributions of households across various socioeconomic data are also discussed.

As the metropolitan planning organization (MPO) for the Denver metropolitan area, the Denver Regional Council of Governments (DRCOG) maintains the travel modeling capabilities for the region. The current regional travel model is based on a large-scale travel survey taken in 1971. Because the Denver area has experienced tremendous growth, two gasoline shortages, and a substantial reinvestment in and reemphasis on public transportation since 1971, the acquisition of current travel data is necessary to update and validate travel models. The acquisition of current travel data began in 1982 with the purchase of the 1980 Urban Transportation Planning Package (UTPP) data for the Denver area from the U.S. Census Bureau. This data has been used for validating portions of the current regional trip distribution model and for calibrating portions of subarea transportation models (*1*). However, because the UTPP data contain information on only the journey-to-work and is of marginal use in calibrating trip-generation models due to differences in the way travel questions were asked in the 1980 census and the way travel questions are normally asked in travel surveys, the need for a travel survey to supplement the UTPP data was obvious.

Based on the results of the 1971 travel survey, it was determined that at least 1,600 samples would be required to provide the statistical accuracy desired for the survey results (*2*). The need to ensure statistical accuracy and maintain consistency with normal travel survey procedures were in direct conflict with the limited budget available for outside consulting services. These constraints were satisfied using the following means:

- Much of the sample design was performed by DRCOG staff with review by the consultant;
- A simple random sample rather than a quota sample was used;
- A mail-out/telephone collection survey instrument was used to reduce the cost of surveying while maintaining the personal contact necessary to ensure full reporting of trips; and
- DRCOG performed the survey editing and geocoding.

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Use of these methods resulted in obtaining the required number of samples at a reasonable cost. Preliminary summary statistics from the travel survey are reasonable when compared to the results of the 1971 travel survey.

Several aspects of the survey methodology are emphasized in this paper, and a brief overview of some of the survey results is provided. Under survey methodology, the process for obtaining sample households, including households with unlisted telephone numbers, innovations in the survey form/travel diary, and the importance of the pretest will be discussed. The brief overview of the survey results will include discussions of response rates, geocoding problems, the need for weighting of survey results, the differences in travel characteristics between households with listed telephone numbers and unlisted telephone numbers, and the total cost per sample.

SURVEY METHODOLOGY

Development of a Random Sample

One key to obtaining an unbiased travel survey is the selection of a random set of households from which the actual samples are drawn. Because it was predetermined that the survey data would be collected via the telephone, the development of a random set of households was reduced to the generation of a random set of telephone numbers. Several well-known options were available: random digit dialing, random telephone-book search, or purchase of a list from a third party.

Random digit dialing was rejected as a methodology because of the survey cost involved with dialing invalid or commercial numbers. The random telephone book search was less costly in terms of invalid numbers, but had the drawback of a possible bias because of failure to account for households with unlisted telephone numbers. In the Denver area it is estimated that about 28 percent of working telephones have unlisted numbers, so the possible bias was substantial.

Fortunately, a company was found that solved the aforementioned problems and that eventually reduced the cost of drawing a sample. The company was able to draw a random sample of telephone numbers from a computerized listing of the telephone directories covering the survey area. The random sample provided included telephone numbers, names, addresses, and zip codes. In order to supplement the original list for unlisted telephone numbers a set of random telephone numbers was generated in such a way that only numbers in working exchanges were included. Also, the block of numbers (100 consecutive numbers) that bounded the random number had to include at least one valid working number. This list was compared to the listed numbers in the region to remove possible duplications and was also compared to a data base of commer-

cial numbers to reduce the likelihood of reaching a commerical firm. Therefore, the probability of each of the random digit telephone numbers being a valid household was increased substantially.

The cost per telephone number from the third party was about 30 cents, or approximately $1,500 for the entire sample. However, later cost savings were substantial. These savings were a result of the name, addresses, zip codes, and telephone numbers of each sample household being transmitted on computer tape. After the data were transferred to floppy diskette, the consultant was able to write a survey management program to generate surveyor assignment sheets, track the outcome of the initial contact, and, if the household agreed to participate in the survey, to generate mailing labels and track the progress of the data collection.

Methods to Maximize Survey Participation

The initial contact was very important in increasing participation in the survey. Because the surveyor assignment sheets were generated by the data-base management program, it was possible to contact most households by name (except the households with unlisted telephone numbers). Initial contact included a brief explanation of the purpose of the survey, several brief questions including household size, automobile ownership, and whether or not the address was still valid. Travel dates were assigned and the fact that the household would be receiving a travel packet with diaries and instructions several days before their travel day was explained. The initial telephone contact did not include the question, "Are you willing to participate in this survey?" This removed one readily available reason to decline participation.

Travel survey packets were mailed to participating households so that they arrived several days before the assigned travel day. The packets included travel diaries, a form listing the household questions that would be asked, simple instructions, and a letter urging participation in the survey that was signed by the governor.

Telephone collection of the survey data began 1 or 2 days after the actual travel day. Collection forms were identical to the household questionnaire and travel diaries mailed to participating households to minimize confusion in the collection process. The survey pretest indicated that there was a possibility of under-reporting trips, therefore several memory-jogger questions were added to the final survey. For example, surveyors asked if any trips were made while the person was at work on the travel day. If the response was yes, surveyors made sure that at least one nonhome-based trip had been recorded for that person. In addition, surveyors were instructed to probe for trips that are easily forgotten.

The Travel Diary

Travel diaries were sent to each participating household in an effort to ensure the full reporting of travel. The diaries were printed on card stock (front and back) for durability and designed to fit easily into a coat, pocket, or purse (Figure 1). Several innovations in the diary made it easy to use. First, a "cascading destination" recording process was used to eliminate the duplication of effort caused by recording both the origin and destination of each trip. Because the destination of one trip is generally the origin of the subsequent trip, no information was lost by recording only trip destinations. However, a space for recording the origin of the first trip of the day was necessary.

The second innovation was the method of coding destinations of trips. Four methods of coding destination locations were accepted: the actual address, nearest intersecting streets, an actual place name, or home. In the actual survey, about 52 percent of the recorded destinations were home. Since home addresses were available from the data-base management program, coding home substantially reduced coding time, keypunch costs, geocoding costs, and data recording and entry errors.

BASIC SURVEY RESULTS

Response Rates

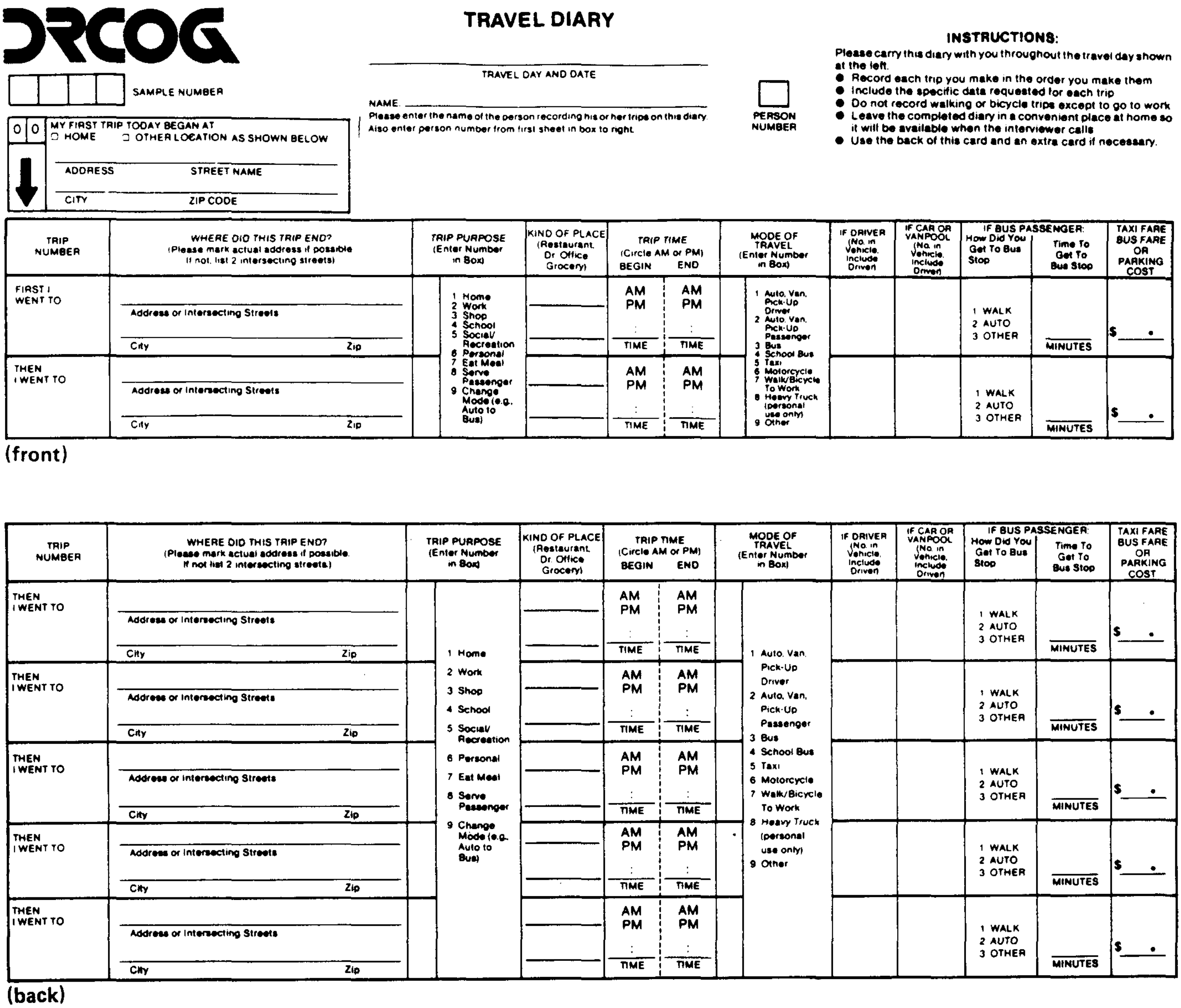
The outcome of the random sample of telephone numbers contacted for the travel survey is summarized in Table 1. Over 40 percent of the households initially contacted agreed to participate (or, more precisely, did not refuse to participate) in the travel survey, and about 34 percent of the initial contacts resulted in successful interviews. Therefore, about 83 percent of the households that agreed to participate in the survey completed successful interviews.

The survey was scheduled to run from April 15 through May 23. Because the disposition of each sample was monitored continually throughout the survey using the data-base management system, the consultant was able to schedule surveyors quite effectively. The current information on the status of samples to date enabled the consultant to complete the survey on schedule.

Geocoding

In order to maximize the amount of money available for actual surveying, editing and geocoding of the travel survey were performed by DRCOG staff. Geocoding is an expensive and time-consuming process even when computer programs such as UNIMATCH are used. In small sample surveys, it is important to resolve as many errors and geocoding problems in order to avoid losing samples. Therefore, when one trip record listed only the name of a restaurant chain as the destination, it was believed acceptable to expend the time necessary to track down the actual location of the only feasible restaurant of that chain based on travel time from the traveler's last stop.

As was mentioned previously, four different methods were used for recording addresses: the actual address, nearest intersection, place name, and home. The distribution of the various address-recording methods on the household and trip portions of the travel survey along with the percentage of addresses automatically geocoded is given in Table 2. Based on Table 2, out of 20,373 actual addresses requiring geocoding, 79 percent were automatically geocoded. The remaining 4,210 addresses



TRAVEL DIARY

TRAVEL DAY AND DATE

NAME

Please enter the name of the person recording his or her trips on this diary. Also enter person number from first sheet in box to right.

PERSON NUMBER

SAMPLE NUMBER

0 0 MY FIRST TRIP TODAY BEGAN AT ☐ HOME ☐ OTHER LOCATION AS SHOWN BELOW

ADDRESS STREET NAME

CITY ZIP CODE

INSTRUCTIONS:

Please carry this diary with you throughout the travel day shown at the left.

- Record each trip you make in the order you make them
- Include the specific data requested for each trip
- Do not record walking or bicycle trips except to go to work
- Leave the completed diary in a convenient place at home so it will be available when the interviewer calls
- Use the back of this card and an extra card if necessary.

TRIP NUMBER	WHERE DID THIS TRIP END? (Please mark actual address if possible. If not, list 2 intersecting streets)	TRIP PURPOSE (Enter Number in Box)	KIND OF PLACE (Restaurant, Dr. Office, Grocery)	TRIP TIME (Circle AM or PM) BEGIN	END	MODE OF TRAVEL (Enter Number in Box)	IF DRIVER (No. in Vehicle, Include Driver)	IF CAR OR VANPOOL (No. in Vehicle, Include Driver)	IF BUS PASSENGER: How Did You Get To Bus Stop	Time To Get To Bus Stop	TAXI FARE BUS FARE OR PARKING COST
FIRST I WENT TO	Address or Intersecting Streets; City Zip	1 Home 2 Work 3 Shop 4 School 5 Social/Recreation 6 Personal 7 Eat Meal 8 Serve Passenger 9 Change Mode (e.g., Auto to Bus)		AM PM : TIME	AM PM : TIME	1 Auto, Van, Pick-Up Driver 2 Auto, Van, Pick-Up Passenger 3 Bus 4 School Bus 5 Taxi 6 Motorcycle 7 Walk/Bicycle To Work 8 Heavy Truck (personal use only) 9 Other			1 WALK 2 AUTO 3 OTHER	MINUTES	$.
THEN I WENT TO	Address or Intersecting Streets; City Zip			AM PM : TIME	AM PM : TIME				1 WALK 2 AUTO 3 OTHER	MINUTES	$.

(front)

TRIP NUMBER	WHERE DID THIS TRIP END? (Please mark actual address if possible. If not list 2 intersecting streets.)	TRIP PURPOSE (Enter Number in Box)	KIND OF PLACE (Restaurant, Dr. Office, Grocery)	TRIP TIME (Circle AM or PM) BEGIN	END	MODE OF TRAVEL (Enter Number in Box)	IF DRIVER (No. in Vehicle, Include Driver)	IF CAR OR VANPOOL (No. in Vehicle, Include Driver)	IF BUS PASSENGER: How Did You Get To Bus Stop	Time To Get To Bus Stop	TAXI FARE BUS FARE OR PARKING COST
THEN I WENT TO	Address or Intersecting Streets; City Zip	1 Home 2 Work 3 Shop 4 School 5 Social/Recreation 6 Personal 7 Eat Meal 8 Serve Passenger 9 Change Mode (e.g., Auto to Bus)		AM PM : TIME	AM PM : TIME	1 Auto, Van, Pick-Up Driver 2 Auto, Van, Pick-Up Passenger 3 Bus 4 School Bus 5 Taxi 6 Motorcycle 7 Walk/Bicycle To Work 8 Heavy Truck (personal use only) 9 Other			1 WALK 2 AUTO 3 OTHER	MINUTES	$.
THEN I WENT TO	Address or Intersecting Streets; City Zip			AM PM : TIME	AM PM : TIME				1 WALK 2 AUTO 3 OTHER	MINUTES	$.
THEN I WENT TO	Address or Intersecting Streets; City Zip			AM PM : TIME	AM PM : TIME				1 WALK 2 AUTO 3 OTHER	MINUTES	$.
THEN I WENT TO	Address or Intersecting Streets; City Zip			AM PM : TIME	AM PM : TIME				1 WALK 2 AUTO 3 OTHER	MINUTES	$.
THEN I WENT TO	Address or Intersecting Streets; City Zip			AM PM : TIME	AM PM : TIME				1 WALK 2 AUTO 3 OTHER	MINUTES	$.

(back)

FIGURE 1 DRCOG travel diary.

TABLE 1 DISPOSITION OF TRAVEL SURVEY TELEPHONE CONTACTS

Item	Number	Percentage of Initial Contacts
Initial contacts	4,871	100
Refused to participate	1,302	26.7
Agreed to participate	1,988	40.8
Disconnected numbers	640	13.1
Moved	137	2.8
Commercial[a]	220	4.5
Continually busy or no answer[b]	370	7.6
Outside of survey area	214	4.4
Successful interview	1,646	33.8
Interview pending	30	0.6
Refused to report trips	312	6.4

[a]From random digit dialing for unlisted numbers.
[b]After three attempts.

required manual geocoding. This manual geocoding took about 400 hr, or about 6 min per address.

Sample Biases and Corrections

As with any survey, there was a possibility of bias in the travel survey. There were two possible sources of error: error in the original sample frame and error introduced due to refusals to participate in the survey. When the travel survey was compared to regional distributions of households by income group, household size, automobile ownership, and geographic location the undersampling of low-income households, low-automobile-owning households, one- and two-person households, and households in the central city was obvious.

In order to correct for the biases in the survey, a marginal weighting technique (3) was used to calculate survey expansion factors. Under this technique, the number of samples in each

TABLE 2 ADDRESS CODING METHOD RESULTS

Method	Number of Addresses	Percentage of Addresses	Percentage of Addresses Automatically Geocoded
Household records			
Actual address	1,645	100	71
Trip records			
Actual address	3,493	18.7	65
Intersection	5,353	28.6	57
Place name	190	1.0	0
Home	9,691	51.7	100
Total	20,372	100	79

cell of the distribution of households by income group, household size, and automobile ownership was summarized. Expansion factors for households in each cell were then calculated so that the expanded samples matched the marginal distributions of households in the region for each of the three strata. Expansion factors varied from 251 for two-person households with two automobiles and an annual income between $25,000 and $34,000 to 1,531 for one-person households with no automobiles and an annual income of less than $10,000. For reference, if every sample had been weighted uniformly so that the total reflected the actual number of households in the region, the expansion factor for each sample would have been 398. After the expansion factors were applied, the distribution of sampled households by geographic location also matched the observed regional distribution even though the calculated expansion factors did not explicitly account for this bias.

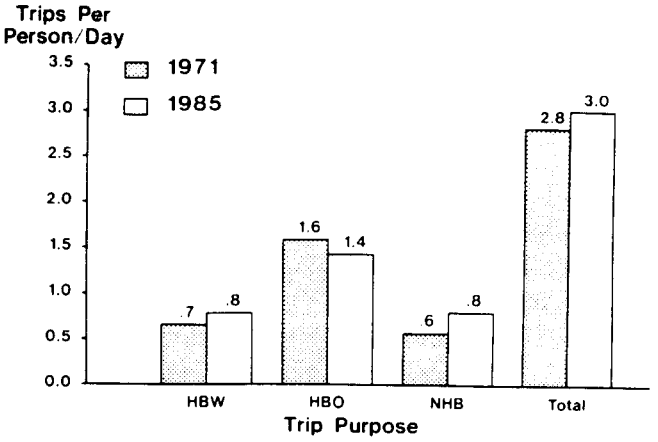


FIGURE 3 Average trips per person.

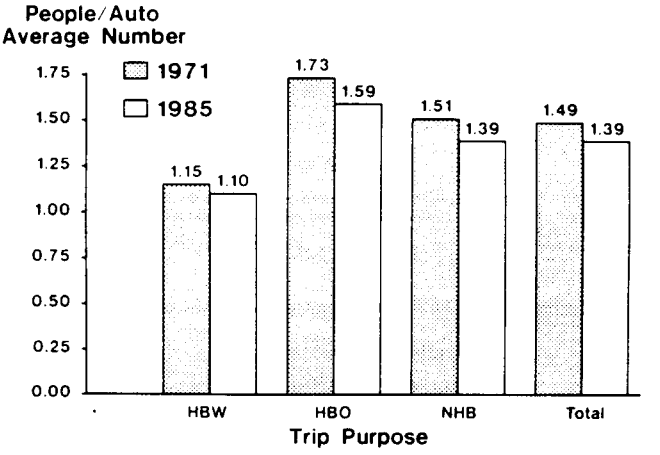


FIGURE 4 Average automobile occupancy.

Preliminary Survey Results

Some of the preliminary survey results are compared to results from the large-scale origin-destination survey taken in the Denver region in 1971 (*4*) in Figures 2 to 5. As can be seen in Figures 2 and 3, travel habits in Denver have changed since 1971. An increasing proportion of daily travel is associated with work. This should be expected due to the increasing number of multiworker households in the region. In addition, the proportion of home-based other travel has decreased, being replaced, instead, by nonhome-based travel. The substitution of nonhome-based travel for home-based other travel is also probably due to the increase in multiworker households in the region.

Total trip making per person has increased by about 7 percent in the 14 years since 1971. This fact, along with the increase in population, has increased personal travel in Denver from 3,155,000 trips per day in 1971 to 5,012,000 trips per day in 1985. Although the number of person trips per day increased 58.9 percent between 1971 and 1985, the number of vehicle trips per day increased 81.2 percent from 2,099,000 trips per

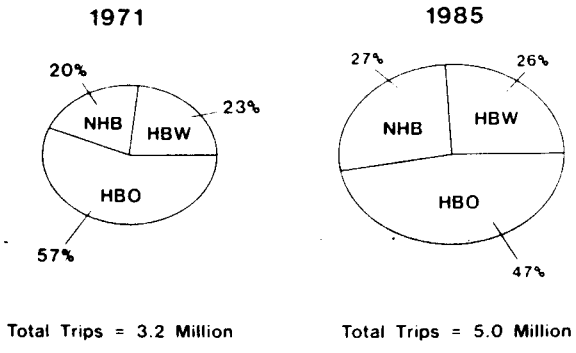


FIGURE 2 Trip making by trip purpose.

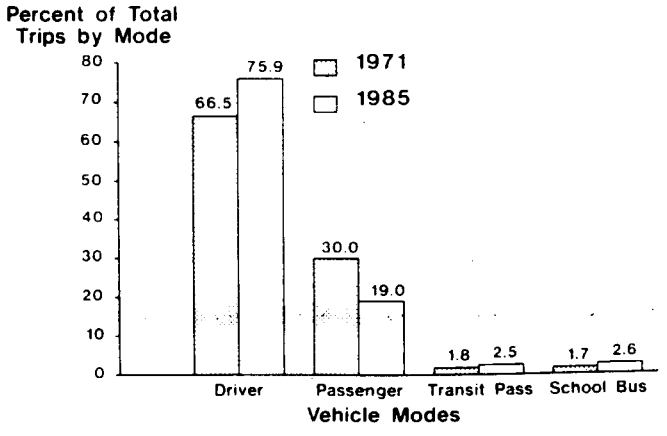


FIGURE 5 Percentage of trips by mode.

day to 3,803,000 trips per day. This increase is due mainly to a shift to more single-occupant automobile trips being made each day.

Average automobile occupancies for 1971 and 1985 are shown in Figure 4. Average automobile occupancies for work trips have decreased about 4 percent, and average automobile occupancies for nonwork trips have decreased about 9 percent in the past 14 years. During the same period, the average number of automobiles per household has increased 8 percent from 1.69 vehicles per household to 1.83 vehicles per household, while the average household size has decreased from 3.10 persons per household to 2.54 persons per household. Because more vehicles are available per household on the average, a general decrease in automobile occupancy should be expected. In addition, because nonwork carpooling is highly related to family travel, and the average household size is decreasing, a larger relative decrease in average automobile occupancy for nonwork trips is reasonable.

The percentage of daily trips carried by mode in 1971 and 1985 is shown in Figure 5. Although automobile-driver and automobile-passenger modes are reported here, it is probably more interesting to look at carpooling versus driving alone. Because there must be an automobile driver for each automobile passenger, carpooling should be about 1.5 times the automobile passenger percentage for 1971, and 1.4 times the automobile passenger percentage for 1985. Therefore, in 1971 about 45 percent of total daily trips involved carpooling and only about 52 percent of the trips involved driving alone. In 1985, carpooling has decreased to about 27 percent of total daily trips and driving alone has increased to about 68 percent of total daily trips.

The percentage of travel carried on public transit has increased since 1971 from about 1.8 percent to 2.5 percent of the total daily trips. About 126,000 transit trips are carried per day (not counting transfers) with 40 percent of the trips being home-based work while 60 percent are for other purposes. The Regional Transportation District (RTD) estimates that it carried about 150,000 riders per day [exclusive of the central business district (CBD) mall shuttle] with about 19,000 transfers during April through May 1985. Therefore, RTD estimates that about 131,000 transit trips were carried daily during the survey period.

As shown in Figure 5, more trips are made on school buses than on RTD buses on the average day. To verify this, the public school districts in the Denver area were asked to provide their daily scheduled school bus ridership. This independent survey showed that about 84,800 students are scheduled to ride school buses daily, which implies that there are over 169,000 school bus trips scheduled per day. The travel survey suggests that around 129,000 school bus trips are made on the average day. This is reasonable considering absenteeism, missed rides, and temporary switching to other modes (e.g., walk, bicycle, automobile passenger, etc.).

The share of trips carried by transit varies substantially with the orientation of the trip. In Figure 6 the percentage of special-purpose trips carried by transit to the CBD is compared with the percentage of special-purpose trips carried by transit to nonCBD destinations. The percentage of trips carried on transit is 10 to 15 times higher for trips with one end in the CBD than for trips with neither end in the CBD. This should be expected

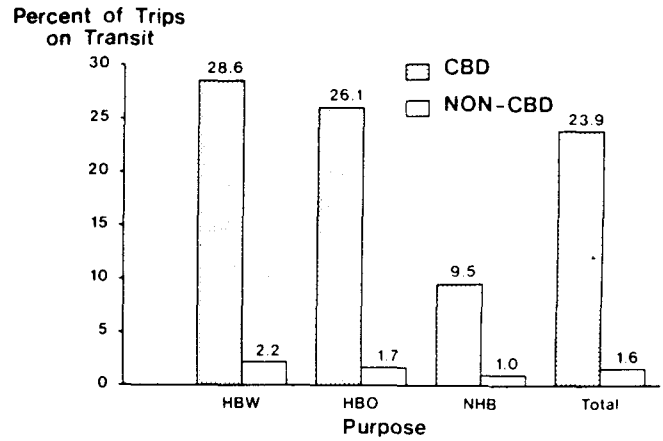


FIGURE 6 Transit share by trip destination.

because the CBD is the focus of most transit lines, experiences high congestion, and has parking costs.

The distribution of travel over an average day is shown in Figure 7. Both the morning and afternoon peak periods are obvious. The morning period begins between 6:30 a.m. and 7:00 a.m. and is over between 8:00 a.m. and 8:30 a.m. The afternoon peak period is somewhat longer, starting between 2:30 p.m. and 3:30 p.m. and ending between 6:00 p.m. and 6:30 p.m. The early beginning of the p.m. peak period is due to school trips (as evidenced by the small peak between 2:30 p.m. and 3:30 p.m.). Factoring those trips out (because many take place in school buses) leaves a 3-hr afternoon peak period from 3:30 p.m. to 6:30 p.m.

The composition of trips during the day is also shown in Figure 7. The morning peak period is primarily work trips and secondarily home-based other trips (mainly school trips). Work trips decline dramatically after 8:00 a.m. and home-based other trips decline slightly. Nonhome-based travel grows throughout the morning and peaks between 11:30 a.m. and 1:30 p.m. Home-based other travel has a small midafternoon peak at 2:30 p.m. through 3:30 p.m. (school trips) and a plateau between 4:30 p.m. and 7:30 p.m. This home-based other plateau is a major factor contributing to the 3-hr duration of the afternoon peak period.

Differences Between Households With and Without Listed Telephone Numbers

One of the unique aspects of the travel survey was the sampling of homes with unlisted telephone numbers. Overall, 9 percent of the households interviewed in the travel survey had unlisted telephone numbers (Table 3). Although this percentage of unlisted telephones is substantially lower than the 28 percent unlisted telephone numbers estimated for the Denver region, it might be reasonable considering the number of unlisted commercial telephone numbers due to multiple extensions within an office.

As shown in Table 3, the average trip rate per household for households with listed telephone numbers is substantially less than the trip rate per household for households with unlisted telephone numbers. This difference in trip rates might be totally explained by the differences in socioeconomic charac-

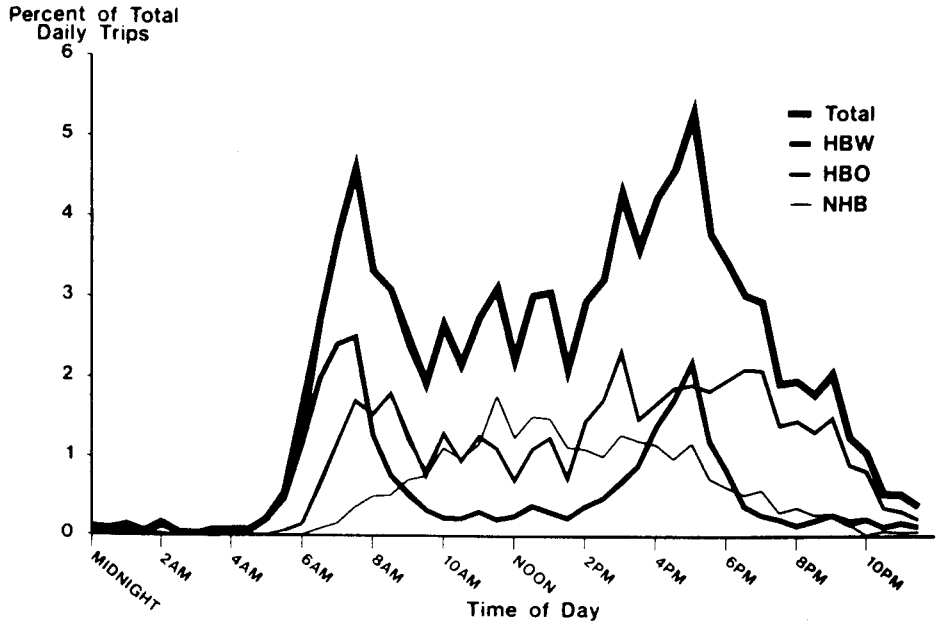


FIGURE 7 Trips by time of day.

TABLE 3 CHARACTERISTICS OF HOUSEHOLDS BY LISTED AND UNLISTED TELEPHONE NUMBERS

	Listed	Unlisted
Number of samples	1,503	142
Percentage of samples	91.4	8.6
Trip rate[a]	7.8	7.3
Average household size[a]	2.54	2.47
Average automobiles available[a]	1.83	1.77

[a]Based on weighted data.

teristics between households with and without listed telephone numbers. The fact that the average household size and average automobile availability for households with unlisted telephone numbers is less than the average household size and automobile availability for households with listed telephone numbers support this hypothesis. However, more detailed analysis is necessary to determine if the differences in travel characteristics can be fully explained by differences in socioeconomic characteristics.

Travel Survey Costs

Costs for the travel survey can be broken into two components: the cost of the actual data collection and in-house costs for contract administration, preliminary survey design work, and geocoding and data editing. The cost of the actual data collection (contractor costs, postage, printing, supplies, and additional telephones) was about $40 per sample. The in-house costs cannot be calculated as accurately as the data collection costs but are estimated to be about $45 per sample.

SUMMARY AND CONCLUSIONS

DRCOG was successful in developing a 1985 travel survey in the Denver region. Data on travel characteristics were obtained for low outside contracting costs through judicious use of DRCOG staff time to design various parts of the travel survey and innovations in survey instrument design and data collection procedures. Although there were biases in the sampled households when compared to regional distributions of households by various socioeconomic and geographic strata, the biases were easily correctable through well-documented techniques. Based on a comparison to 1971 data and other more recent observed data, the weighted survey results appear to be reasonable.

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Mail-Out/Mail-Back Travel Survey in Houston, Texas

ALAN C. CLARK AND CELIA GOLDSTUCKER

During the fall of 1984, a mail-out/mail-back travel survey was conducted on Houston area households. Designed to obtain household, tripmaker, and detailed trip characteristics, the survey was completed by 1,596 of 6,941 households contacted by telephone. The procedure used was to telephone selected households and request their participation. A survey form was mailed to each participating household on which each trip made by members of the household for a given day was recorded. The forms were then returned by mail and analyzed. The mail-out/mail-back survey procedure was chosen because it best met the constraints of project funding, time available for data collection, data needs, and staff availability and training. Based on statistical evaluation of the quantity and variability of travel by household type, it was determined that reliable estimates of tripmaking characteristics could be obtained with a stratified sample of 1,200 households. Although tending to under-represent household categories with small percentages of the total population, the sample was representative of the population in those household categories with the greatest proportions of Houston area travel.

In the 1970s and early 1980s the Houston urbanized area experienced explosive growth. To maintain and improve the mobility of residents, major transportation improvements are being planned and implemented which include: rail transit systems, tollways, busways, and beltways. To properly plan for these improvements, reliable forecasts of travel are essential.

The current models used to estimate travel within the urbanized portion of the Houston–Galveston Area Council (H–GAC) planning region were developed using travel survey data obtained in the 1960s and supplemented with more recent travel characteristics developed from other urban areas in Texas and the United States. Because of the rapid growth of the urbanized area, changes in household size and composition, increasing levels of congestion of the transportation system, and Houston's polycentric urban form, increasing concern has been raised about the need for up-to-date information for developing Houston's travel models.

As a result, H–GAC—in cooperation with the Texas State Department of Highways and Public Transportation, the Metropolitan Transit Authority of Harris County, FHWA, and UMTA—has undertaken a comprehensive review and update of the region's travel forecasting models.

As an important first step toward improved travel forecasts, the need for up-to-date travel characteristics specific to the H–GAC region was identified. In particular, data was needed to estimate

- How many trips were being made,
- What the trip purposes were,
- Where trips were made,
- What modes of travel were used,
- What distances were traveled, and
- When trips were made.

In early discussions, transportation staff of all participating agencies agreed about the need for some form of residence-based travel survey. With the availability of the 1980 U.S. Census Bureau's Urban Transportation Planning Package (UTPP) data on journeys to work for the Houston Consolidated Metropolitan Statistical Area (CMSA), it was felt that a small sample home-interview survey would be sufficient to provide additional information on travel (for other purposes than work), as well as to supplement and update the census travel-to-work data.

SAMPLE DESIGN AND SELECTION

A stratified sampling method was chosen in order to obtain usable results while maintaining a manageable sample size. Using household size and vehicle availability, a stratified sample was estimated to require about 1,200 responses. This number was based on modified coefficients of household trip variation in each household size/vehicle ownership cell weighted by the proportion of households in each category. The categories used and the resulting sample requirements are shown in Table 1.

TABLE 1 SURVEYS REQUIRED BY HOUSEHOLD SIZE AND VEHICLE AVAILABILITY

Vehicle Availability	Household Size 1	1	3	4+	Total
0	6	4	3	5	18
1	109	74	47	82	312
2	21	185	106	194	506
3+	8	68	94	194	364
Total	144	331	250	475	1,200

To improve the probability of obtaining an adequate sample size in cells expected to have a low response rate and to allow for belated rejection of surveys, a goal of 1,500 usable surveys was set. To determine the total number of households required to be contacted in order to get 1,500 usable surveys, the results of a pilot study performed in the spring of 1984 were used.

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	Percentage	*Factor*
Contact rate	65	1.54
Agreement rate	55	1.82
Response rate	40	2.50
Usable rate	95	1.05

Only 65 percent of the telephone numbers on the sample list could be contacted, largely because no one was home during the evening hours when calls were made. Of those contacted, only 55 percent agreed to participate and of those, 95 percent were usable. Therefore, the required number of households needed to be contacted is: $1,500 \times 1.54 \times 1.82 \times 2.50 \times 1.05 = 11,036$.

For simplicity's sake, the sample size was set at 12,000 households. Because of the uncertainty of the actual overall return rate and the return rates for particular cells, the survey was divided into 10 subsamples or replicates of 1,200 samples each. Therefore, the survey results could be monitored while the survey was in progress, and adjustments made as necessary. The selection of samples for each replicate was designed so that each was chosen independently using the same procedures.

PROJECT CONSTRAINTS

Several major factors influenced the selection of survey collection procedures:

1. Data needs—Complete travel data for all members of the household over the age of five for the selected day was needed, as well as household and trip-maker characteristics.
2. Time for data collection—The fall of 1984 was selected for the survey period. Therefore, the survey had to be collected between the beginning of classes in early September and Thanksgiving in late October.
3. Staff availability and training—The level of experience with travel surveys varied widely among the H–GAC transportation staff. Moreover, relatively little nonadministrative manpower was available.
4. Project funding—A total of $200,000 was budgeted for the entire process of survey design, collection and tabulation.

DATA COLLECTION

Once the decision was made to perform a residence survey, three data collection strategies were examined:

1. Traditional home interview—A trained interviewer collects the travel survey data at the residence either through interviews with the household members or by collecting a survey form previously sent to the household.
2. Telephone interview—The travel data is retrieved through a telephone conversation with the household either through interviews with the household members or by having a survey previously sent to the household read over the telephone.
3. Mail-out/mail-back survey—The survey is sent to the participating household and is completed and returned through the mail.

The traditional home interview approach was rejected for several reasons. Early discussion with survey consultants indicated that the use of trained interviewers sent to the household would require approximately twice the funds allocated, as well as increased training, supervision, and data collection time.

HGAC HOUSTON·GALVESTON AREA COUNCIL

REGIONAL TRAVEL SURVEY

INSTRUCTIONS

This survey has two parts. Part 1 (on the next page) contains information about you and your household. Some of the information has already been filled in based on our telephone conversation with a member of your household. Part 2 consists of a Trip Record for your travel. Please fill out one line for every place you went on the travel day.

FOR EXAMPLE:
YOU LEAVE HOME AND DRIVE TO WORK (1)
THEN DRIVE TO LUNCH (2)
NEXT DRIVE TO A STORE (3)
THEN DRIVE BACK TO WORK (4)
AND FINALLY RETURN HOME (5)
IF YOU MAKE NO ADDITIONAL TRIPS THAT DAY, YOU SHOULD FILL OUT FIVE LINES.

If you have any questions at all, call the Travel Survey Coordinator at (713) 627-3200.

Please give a separate Trip Record to every member of your household who is 5 years of age or older and who made trips on the Travel Day. All your answers are strictly **confidential**.

Please enclose all Trip Records in this questionnaire, and mail in the pre-paid envelope provided.

THANK YOU.

FIGURE 1 Regional travel survey cover letter.

Because the earliest project start date was August 15, 1984, the time required to recruit and train surveyors may have been prohibitive. Moreover, concern was expressed about the difficulty of scheduling interviews and the willingness of households to permit an interviewer into their home.

The telephone interview was considered to have significant promise. In evaluating preliminary versions of the travel questionnaire during the pilot study, it was found that households with more than two trip makers required an excessive length of time to complete the questionnaire over the telephone. Unless the survey form was sent to the household and completed before the telephone call, problems arose with obtaining complete travel data for all trip makers in the household. However, this technique did provide the personal interaction between survey respondent and survey personnel important for ensuring an accurate understanding of the survey questions and complete information.

A modified version of a mail-out/mail-back survey process using telephone screening and follow-up was selected because it best met the critical constraints of funding and time, as well as providing for the important link between survey personnel and the survey respondent necessary for an accurate comprehension and completion of the survey. The steps followed in this process are now discussed.

MAIL-OUT/MAIL-BACK SURVEY PROCEDURES

The survey (Figures 1–3) was conducted during a 7-week period between September 10, 1984 and October 26, 1984. Staff and consultants working on the project felt that travel behavior after Thanksgiving may be affected by holiday trip making. Therefore, surveys should not be taken during the period between Thanksgiving and New Year's.

The procedure used was to telephone selected households and request their participation. The pilot test showed that many people would agree to participate as a means of terminating the conversation. Therefore, another purpose of the initial call was to explain the nature and extent of the effort required to complete the survey and thereby obtain higher response rates after obtaining an agreement. If telephone contact was made with a household in the sample, the number of persons in the house-

PART 1: HOUSEHOLD INFORMATION

1. Address _____
   Label _____ _____

Remember, your travel day is ____/____ (MONTH / DAY)

The label above includes your home address, and the number of persons and the number of vehicles reported in our initial telephone conversation. If any of these are incorrect, please write the correct information directly on the label.

We would now like some information on each household member.

2. Please assign a "Person Number" to each person residing in your household who is five years or older, starting with yourself as "Person Number 1." (Fill in appropriate box for each question for each person.)

Person Number	Age	Sex	RELATIONSHIP TO PERSON NUMBER 1 (Check one)				Is he/she employed? If yes, full or part-time?			Did he/she travel on the "Travel Day"?		Form to be used for Trip Record
		M / F	Spouse	Child	Relative	Not Related	Full Time	Part Time only	No	Yes	No	
1	____	____	PERSON NUMBER 1				☐	☐	☐	☐	☐	Continue on Attached Page
2	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Blue
3	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Yellow
4	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Green
5	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Tan
6	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Pink
7	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Gray
8	____	____	☐	☐	☐	☐	☐	☐	☐	☐	☐	Orange

3. If you add up the annual incomes of all household members, into what range does it fall? (Check one)

Under $10,000 ☐ $10,000 - $20,000 ☐ $20,000 - $30,000 ☐ $30,000 - $40,000 ☐ Over $40,000 ☐

This completes the household information needed. Please fill out the attached travel questionnaire for **yourself** and ask every other household member over 5 to complete the enclosed trip record of the color indicated in question 2 above. For example, person number 2 use blue form, person number 3 use yellow form, etc.

FIGURE 2 Regional travel survey Part 1.

hold and the number of vehicles available were determined before seeking survey participation.

Results of the screening calls are given in Table 2. The contact rate of 72 percent was higher than the expected 65 percent. This higher rate was due to a more vigorous follow-up program, as identified in the pilot test. The higher contact rate resulted in reducing the required sample from 12,000 to 9,585.

MAIL-OUT SURVEY

On the day following the screening call, questionnaire packets were assembled and mailed to those households agreeing to participate in the survey. The packets had different cover letters and number of trip records, depending on household characteristics (e.g., zero vehicle availability, spanish-speaking, and size). Daily mailings were made with an assigned travel survey date 8 days after the screening call. During the height of the survey, an average of 970 packets were mailed each week.

FOLLOW-UP CONTACTS

It was determined during the pilot survey that a follow-up telephone call would increase the response rate and possibly enhance the quality of the information. As many as three follow-up contacts were made. The initial call would determine whether the questionnaire had been received and whether there were any questions. A common reaction was that the individual had agreed to participate but changed their mind after seeing the questionnaire. Frequently, people could be convinced that it really was quite simple, particularly when individuals recorded

(a)

PART 2: TRIP RECORD

FOR PERSON NUMBER _1_ (write number from question 2)

Please fill out this form for one person only.
Do NOT report walking or bicycle trips.
Please enter your travel day ____/____ (MONTH / DAY)

On this day, did you travel outside the home? (check one)
☐ NO — Return questionnaire
☐ YES — Continue below

MY FIRST TRIP TODAY BEGAN AT
☐ Home ☐ Other Location (fill in) _____

BEGIN	THIS LOCATION	STARTING AT THIS TIME	FOR THIS PURPOSE (Check one)	BY MEANS OF (Check all that apply)	NUMBER OF OTHER PERSONS IN VEHICLE
FIRST I WENT TO: 1	Address, Building or Nearest Intersection _____ City _____	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ____
THEN I WENT TO: 2	Address, Building or Nearest Intersection _____ City _____	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ____
THEN I WENT TO: 3	Address, Building or Nearest Intersection _____ City _____	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ____
THEN I WENT TO: 4	Address, Building or Nearest Intersection _____ City _____	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ____

CONTINUE TRIPS 5 THROUGH 10 ON REVERSE SIDE. THANK YOU.

FIGURE 3 Regional travel survey Part 2: (a) trip record front and (b) trip record back.

(b)

	THIS LOCATION	STARTING AT THIS TIME	FOR THIS PURPOSE (Check one)	BY MEANS OF (Check all that apply)	NUMBER OF OTHER PERSONS IN VEHICLE
THEN I WENT TO: 5	Address, Building or Nearest Intersection City	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ___
THEN I WENT TO: 6	Address, Building or Nearest Intersection City	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ___
THEN I WENT TO: 7	Address, Building or Nearest Intersection City	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ___
THEN I WENT TO: 8	Address, Building or Nearest Intersection City	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ___
THEN I WENT TO: 9	Address, Building or Nearest Intersection City	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ___
THEN I WENT TO: 10	Address, Building or Nearest Intersection City	___:___ am pm	☐ Return Home ☐ Work ☐ Work Related ☐ School ☐ Shop or Meal ☐ Other (Social Recreation, Personal)	☐ Driver - Car or Truck ☐ Passenger - Car or Truck ☐ Bus ☐ School Bus ☐ Taxi ☐ Other	→ ___

IF YOU MADE MORE THAN 10 TRIPS, HOW MANY MORE? ____

FIGURE 3 *continued*

TABLE 2 RESULTS OF INITIAL SCREENING

	Number	Percentage
Completed calls	6,941	72.4
Agreed to participate	3,912	40.8
Refused	2,857	29.8
Dropped	172	1.8
Business/government	129	
Deaf/language	43	
Incompleted calls	2,644	27.6
Telephone disconnected	1,419	14.8
No answer after three calls	1,225	12.8
Total	9,585	100

their own trips. The second call was to determine whether people had completed the questionnaire, answer any remaining questions, and remind them to mail it back. The third call was a reminder to make sure the completed questionnaire had been mailed back. The first-call script is shown in Figure 4.

Follow-up calls were made to approximately 3,900 persons who had initially agreed to participate in the survey. Out of the original participants, about 2,100 (56 percent) reported that they had received the survey form and were willing to participate. A small percentage, generally running between 12 to 16 percent, claimed they had never received the questionnaire. Some of these may have been due to mailing problems with the post office. In other cases, the questionnaire had been received

Hello, may I please speak to **(NAME ON SCREEN)**? (If not in, ask for best time to reach tonight. If not available this evening,) **ASK:**

Did you **receive** the Travel Survey the Houston/Galveston Area Council of Governments mailed to you? (If NO, get correct address, Name, Zip Code and check against list, if same,) **SAY:**

You will probably receive the envelope tomorrow. We will call you back.

If They received packet, **SAY:**

Your travel survey is for tomorrow, **(DATE SHOWN).** Have you had a chance to look over the survey?

If NO, ask that they look it over and you will call back later.

If YES, **ASK:**

Do you have any **questions** which I might be able to help you with now?

If NO, **SAY:**

Thank you. I will call you tomorrow to see if you have any questions.

If they say they can handle it, **SAY:**

Thank you very much.

If YES, **SAY:**

How can I help you?

I/We do not have a car.	We realize many people do not have cars, and we are interested in their travel as well. If you go with someone else, take public transportation or (walk or ride a bicycle), we would like to have the information. I will call you back tomorrow and we can go over your/your family's travel for **(DATE AND DAY INDICATED).**
I/We do not go anywhere tomorrow.	That is alright, many people do not travel every day of the week. We still need the information in order to estimate the total travel for the County.
I don't understand how to fill it out.	Let's go over the forms. Once you see how it is done, we can either call you back tomorrow night and take the information over the phone, or you can fill it out and mail it in. We do need your help on this survey.
My children only go to school on the bus, should I fill it out for them?	Yes, we are interested in everyone in the household over the age of five, even (if they ride their bike) or are in a car pool.
We don't want to participate.	We need your participation. Your help will make it easier for the Houston/Galveston Area Council of Governments to plan for traffic inmprovements.
Who do we call to verify this call and survey.	You may call _____.

FIGURE 4 Script for follow-up calls.

but had been discarded by another household member. This may also have been a convenient excuse for refusing to participate in the survey. A second mailing to persons interviewed in the first replicate who agreed to participate if they received a questionnaire elicited a very low response. Therefore, it was decided that the expense of a second mailing was not justified by the results. The follow-up calls also produced additional refusals by people who decided too much work was required or who had agreed earlier as an excuse to hang up the telephone.

UNDER-REPORTED HOUSEHOLDS

Following the completion of eight replicates, it was determined that the projected total response appeared to be in line with the survey goals but that four individual categories would be substantially below the quota. These were

- Zero-car households with four or more persons,
- One-car households with three persons,

- One-car households with four or more persons, and
- Three- (or more) car households with four or more persons.

Because the number of such households, which would occur on the average in further replicates, was low, and the overall response rate was low, it was decided to do more intensive follow-up among households in these categories that had already received the questionnaire and promised to return it. This was combined with an offer of a $10 cash incentive for target households in the zero- and one-car category. All willing households in this pool that had not yet returned questionnaires were contacted and, if necessary, mailed a duplicate questionnaire.

The result was a significant increase in responses within each category for a total of 52 additional completed questionnaires. The effect of this intensive follow-up was particularly marked for the one-car household. The three-person category increased from 21 to 38, and the four- (or more) person household response increased from 23 to 39. In these two categories alone, the response rate was increased by 75 percent. Incentive payments were sent to the 33 respondents in one-car household categories. There were no respondents in the zero-car households although they were offered the incentive payment. There were 19 additional respondents in the three- (or more) car households. This was a 15 percent increase and resulted in a total of 143 responses in that category.

RESPONSE RATE

If telephone contact was made with the household in the sample, certain information about the household was requested before seeking survey participation. Therefore, the household size/vehicle availability category was identified for 4,548 households contacted. The response rate for households in each of these categories is given in Table 3. According to these figures, the rate of participation tends to decrease as household size increases, and the rate for households with no vehicles is much less than for households with at least one vehicle.

TABLE 3 RESPONSE RATES BY HOUSEHOLD SIZE AND VEHICLE AVAILABILITY

Vehicle Availability	Household Size 1[a]	1[a]	3[a]	4+[a]	Average[a]
0	13	12	8	11	12
1	40	29	29	21	34
2	34	41	31	28	34
3+	41	38	37	28	33
Average	37	37	32	27	33

Note: Includes only those sample households for which household size/vehicle availability category information was obtained (n = 4,548).
[a]Figures in percentages.

TABLE 4 HOUSEHOLD SIZE AND VEHICLE AVAILABILITY DISTRIBUTION OF SAMPLE AND POPULATION HOUSEHOLDS

Vehicle Availability	Household Size 1	1	3	4+	Total
0					
Responses	10	6	1	2	19
Sample (%)	1	1	1	1	1
Population (%)	4	1	1	1	7
1					
Responses	248	100	38	38	424
Sample (%)	17	7	3	3	28
Population (%)	17	9	5	6	37
2					
Responses	22	342	148	211	723
Sample (%)	1	23	10	14	48
Population (%)	3	15	7	12	37
3+					
Responses	7	72	109	142	330
Sample (%)	1	5	7	9	22
Population (%)	1	4	5	10	19
Totals					
Responses	287	520	296	393	1,496
Sample (%)	19	35	20	26	100
Population (%)	24	29	18	29	100

SUMMARY

The number and percentage of sample households in each household size/vehicle availability category and the corresponding percentage of the population households belonging to each category are given in Table 4 for comparison.

Usually, the more significant the category (the larger percentage of the total) the better the sample matched the total population. The sample tends to under-represent the categories with small percentages of the total. For those categories, part of the difference may be due to errors in estimating the population from the 1980 U.S. Census Bureau's journey-to-work data. It is clear, however, that the sample does represent the population in those categories generating the most travel in Houston.

Special-Purpose Travel Surveys

BAHAR B. NORRIS AND GORDON A. SHUNK

Regional travel forecasting models often assume that trip-generation rates are stable over time. Though the validity of this assumption is confirmed with regard to overall trip rates per household, the assumption is less applicable to disaggregated trips. It is the contention of this paper that because of the demographic and labor-force transformations of the 1970s and 1980s, the composition of person trips has changed through a relative decline in the share of home-based/nonwork trips, as well as through an absolute drop in the average number of these trips per household. Paralleling this decline has been a rise in the shares and numbers of home-based work and non-home based trips. A comparison of the results with other metropolitan areas suggests that, in general, rates for special-purpose trips are more likely to be stable cross-sectionally than intertemporally. According to the 1984 Dallas–Fort Worth travel survey, an average household made 8.68 trips per day, a rate that has remained fairly stable since 1964. Person trips per person and vehicle trips per person, however, have had a pronounced increase since 1964 reflecting the smaller household size and lower automobile occupancy rates of the recent decade. The results of the 1984 travel survey also indicate that *(a)* the average trip length in the metropolitan area is about 7 mi, *(b)* the average trip duration is 17 to 19 min, *(c)* the automobile occupancy rate is 1.13 for work trips and 1.5 for nonwork trips, *(d)* the transit mode share is 1.7 percent, and *(e)* the peak-hour travel time is between 7–8 a.m. and 5–6 p.m.

The North Central Texas Council of Governments (NCTCOG) travel surveys were conducted in 1984 for the primary purpose of updating travel forecasting models to reflect changes in travel characteristics since 1964 when the Texas State Department of Highways and Public Transportation conducted a travel survey. Of special interest were changes in life-style and economic conditions that have occurred over the last 20 years. The primary concern was to identify changes in trip rates and trip lengths. Trip rate changes were of particular interest because the variability exhibited in data from the previous survey was a matter for concern and needed to be clarified or resolved.

Consequently the survey was designed to estimate the trip rates for the three trip purposes used in the NCTCOG models: home-based work, home-based nonwork, and nonhome based. The rates were estimated at the residential end of the trip using a home-interview survey. Trip rates at the destination end were estimated using workplace and special generator surveys.

Work trips to major employment centers were examined because of the tremendous employment growth in the Dallas–Fort Worth Metropolitan area in the last few years. It was considered necessary to obtain especially detailed information on trip attractions at employment centers and data about other trips made to and from activities at employment centers. A workplace survey was included in the survey program to obtain information about trips by workers and nonworkers at each survey location.

Better information about the potential use of the transit system was the focus of a third survey. This interest was strongest on the part of the two transit authorities approved in Dallas and Fort Worth in 1983. Dallas Area Rapid Transit in particular wanted information for use in planning a light rail transit system that is scheduled to start operating in the early 1990s.

Before designing the survey, the NCTCOG data base and models were carefully reviewed to identify weaknesses and deficiencies. The principal areas of concern were related to work-trip attraction rates. Other areas considered in need of additional information were attraction rates for other purposes and changes in household characteristics that affect home-based trip production rates.

The survey was designed to address the areas of weakness and deficiency and to answer additional questions being raised about travel forecasting activities by the various clients of NCTCOG. Another consideration in the survey design was to compare results and update the 1980 Census Journey to Work information for the Houston Consolidated Metropolitan Statistical Area (CMSA).

The home-interview survey was conducted in the spring and summer of 1984; the workplace survey was conducted in the summer; and the transit on-board survey was conducted in the fall. The surveys were funded with special grants of UMTA Section 9A funds and FHWA Section 112 funds.

HOME-INTERVIEW SURVEY

The principal objectives of the home-interview survey were to obtain information on trip generation and trip distribution, and to relate that to household characteristics, vehicle ownership, and vehicle occupancy. The Dallas–Fort Worth metropolitan area has grown rapidly in the preceding few years, and changes in traveler characteristics and travel conditions were believed to have influenced trip-making behavior. The area's population grew by 89 percent between 1964 and 1984, the year of the last survey, and by 16 percent in the period 1980–1984.

The survey was designed by the consulting firm that had reviewed and analyzed the NCTCOG travel models, therefore the firm was familiar with the needs for additional information relating to those models. The survey design was also based on information from the 1964 Texas Department of Highways and Public Transportation survey, the 1980 U.S. Census Bureau's journey-to-work data and several other data bases relating to travel characteristics. The design assumed that the trip-generation model would continue to be a cross-classification model using only the most robust independent variables, such as car ownership and household size. For reasons of available funding

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and the need to obtain a satisfactory error of estimate, the total sample size chosen was 2,800 completed samples. Ultimately 2,500 surveys were completed out of 16,500 samples selected.

The sample units were selected randomly from telephone directories in the respective jurisdictions. The sample was distributed geographically by selecting samples in proportion to population in individual political jurisdictions across the region. Household members were asked to participate in the survey. If they agreed, they were questioned briefly about the characteristics of their household; in particular, their location, their household size, and the number of passenger vehicles they owned. If the responding household fit into one of the cross-classification categories that had not been filled, the selection process continued.

When a cell on the cross classification was filled, no further samples in that cell were selected. A number of backup samples were obtained over and above the quota, to accommodate refusals and other uncompleted interviews. For cells that were difficult to fill, locations where households were more likely to have the desired characteristics were identified, and reverse directories were used to obtain telephone numbers of households in those areas.

When a sample was selected, the household was sent a confirmation letter indicating that it would be contacted in the near future to set an appointment for a personal interview. The selected households were later contacted by telephone to establish a travel inventory day on which travel information on all household members would be recorded. The household was sent a travel diary for recording respective trips. The telephone call and the diary included instructions on procedures for recording travel information. On the day before the designated travel day, the household was contacted as a reminder of the survey and to set an appointment for picking up the diary. The remainder of the interview would be completed in person at that time. When the household was visited, the information on the travel diary was reviewed and clarified to be sure that it was as complete and accurate as possible.

The principal problem encountered with the home-interview survey was the quality and turnover of the personnel conducting the interviews. At the time of the survey, the Dallas–Fort Worth Metropolitan area was experiencing a tremendous economic boom and was attracting new residents from economically depressed areas elsewhere in the country. The survey contractor used a temporary personnel agency to obtain interviewers. At the outset the agency sent many unqualified interviewers; when the agency screened applicants more rigorously, the number of interviewers provided decreased to less than adequate. Therefore the contractor had to resort to newspaper advertisements to obtain personnel. Not unexpectedly, the quality of the various interviewers was questionable at best, and they required very stringent training and supervision. Also, there was considerable difficulty keeping the personnel who were trained, partly because they did not like dealing with the home-interview situation, but also because they often found better-paying jobs after they were in the area a few days. The decision to use a temporary personnel agency rather than a survey firm with experienced and stable staff was a mistake.

The decision to conduct personal, in-home interviews was the cause of some of the personnel turn-over problems. This interview approach was chosen because it would replicate the procedure used in 1964 by the Texas State Department of Highways and Public Transportation. One reason for the in-home interview was that it was believed to provide better, more accurate information. Considering the personnel problems encountered, it is questionable whether this goal was achieved.

The result of this situation was that it caused a major cost overrun and extended the time of the survey beyond the end of May 1984 when it was supposed to have been completed. Because the survey was not finished until July, when school was not in session, the results had to be adjusted to account for differences in travel patterns when school trips were not being made.

WORKPLACE SURVEY

The workplace survey was probably the most important and interesting of the three surveys. It provided unique and useful information about off-peak travel to and from attraction activities. The workplace survey provided information about characteristics of the respective attraction activities and about generation rates, trip distribution, mode of arrival, vehicle occupancy, midday travel, parking usage, and transit accessibility. The principal reason for this survey was the tremendous amount of interest of local governments in the trip-generating potential of various kinds of activities. This interest was due to the amount of new and changing development in the metropolitan area, numerous requests for rezoning, and related consideration for traffic impact. Finally, the attraction-generation information would prove useful because the greatest amount of congestion occurs at locations of concentrated attraction activities.

The workplace survey was also designed to fill a cross-classification matrix. The factors for cross classifying activities were location and type of activity. For example, activities in central business districts, outer business districts, and suburban areas were cross classified by retail, basic, and service activities. A quota for each cell was established, and sample units were selected from a listing of employers by location. The survey design called for 400 sampled establishments; 366 successful samples were obtained.

The sample activity establishments received a letter from the chamber of commerce in their area, and another from the chairman of the metropolitan planning organization policy board. The letters were followed by a telephone call from a key person on the survey staff. If the owner of the selected establishment did not wish to participate in the survey, another sample unit was selected for that particular cell. The establishment owner was asked to identify a key contact person who would serve as a liaison for the survey activity. The contact person was then visited and briefed on the purpose and procedures for the survey.

The survey procedure called for a maximum of 300 workers at each of the 400 sampled establishments. The employees were given forms by the liaison person for their establishment; a survey staff person distributed forms at the smaller establishments where a liaison could not be provided. The employees were asked to fill out the survey form and leave it at their workplace or return it by mail if it was not possible to complete the form and leave it at the workplace.

Visitors to each sampled establishment were asked to fill out a survey form that differed from that completed by employees. The visitor forms were usually distributed by survey staff unless the number of visitors was so small that the task was not too burdensome for establishment employees. Delivery vehicles arriving at the sampled establishments were also surveyed in a similar manner.

Among the workplace survey samples were seven major generators at Dallas–Fort Worth Airport, a university, a high school, a truck terminal, a shopping center, a hospital, and an amusement park (Six Flags Over Texas). These generators were chosen for broader reasons than the remainder of the survey. Their unique and important nature represented special generators that had particular characteristics applicable in similar situations throughout the region.

Before administering the survey, nine pretests were conducted on a representative group of establishments to identify problems that might be expected to occur with either the survey forms or the procedures. The process of this survey was more successful than the home-interview survey. The generally accepted reason for this was that most of the personnel problems had been resolved by the time the home interview was completed. At the start of the workplace survey there was a smaller and more reliable cadre of interviewers, and the interview process was considerably less stressful than the home-interview survey.

ON-BOARD TRANSIT SURVEY

The on-board transit survey used is the traditional survey that has been conducted throughout the country for some time now. The purpose was to estimate current mode split for the transit operators and to identify any particular characteristics that could be useful in identifying the ridership potential for improved transit services in the future. The survey required a quota of runs of the major transit operators in Fort Worth and Dallas. The private bus operator, Texas Bus Lines, and airport bus operators were also included in the sample. However, the return rate was quite disappointing at only 22 percent; the reason for this lower-than-expected return has not been found.

CONCLUSIONS

The entire survey program cost approximately $750,000, which was 25 percent more than was originally intended. As discussed, this is attributed primarily to personnel turnover problems. Results were generally satisfactory; however, some of the procedures would be changed if the survey were conducted again. The main change would be to have a survey firm take full responsibility for the interviewing process. In the same situation an in-home interview would still be conducted, but it would be done by telephone. The home-interview should not have begun so late in the spring; it should have been postponed until the next year and begun earlier in the spring. Conducting the survey in the fall would not have allowed enough time to complete the survey before the Christmas shopping season. In general, the results and the procedures of the workplace survey were pleasing. Some of the coding for the on-board survey was disappointing. This seems to be attributable to the survey supervisor not being resident, and, therefore, being able only to spot check the coding process.

Puget Sound Council of Governments Origin-Destination Travel Survey, 1985

ELAINE MURAKAMI AND DONALD R. PETHICK

Travel behavior of 783 households was collected using a mail-out travel diary and a follow-up telephone interview for data collection. Data was keyed directly onto a computer file during the telephone interview. This technique allowed quick access to the interview data and improved the accuracy of data collection. The response obtained was sufficiently large to calculate trips per household and length of trips by income quartiles with acceptable accuracy levels.

The four-county region of the Puget Sound Council of Governments (PSCOG) has a total population of approximately 2.5 million. Travel forecasting models for the four-county area currently use data collected in 1971 from three of the four counties. The fourth county, Kitsap, was chosen as the first county from which to collect new travel data. Kitsap County's largest city, Bremerton, has an estimated population (in 1985) of 37,760. Bremerton and the surrounding vicinity is dominated by the presence of the Puget Sound Naval Shipyard (PSNS).

A survey of 783 households in Kitsap County from a total of about 60,000 households was conducted in April and May 1985. Information was collected on trip origins and destinations, time and length of trip, trip purpose, and method of travel. An initial telephone call was made to request participation, travel diaries were mailed to participants, and a local market research firm called to collect the information from 1 to 3 days after the diaries were completed. The interviewers keyed the responses directly into a computer. The data was then transferred to the PSCOG via magnetic tape 1 week after the last interview, and data analysis began only hours after receipt of the tape.

The response rate to the telephone interview was 60 percent, representing 783 completed responses out of 1,305 screened household candidates. The response rates achieved are given in Table 1. The cost per completed survey was $103; the total budget was $74,500.

The travel forecasting models use variation of trip making by quartiles of household income. The response obtained was sufficiently large to calculate the average number of trips per household and length of trips for Kitsap County as a whole for the desired 90 percent confidence level with ±5 percent accuracy. Because of the low participation by low-income households, the accuracy level by income quartiles ranged from ±3.6 to ±7.2 percent.

Puget Sound Council of Governments, Grand Central on the Park, 216 First Avenue South, Seattle, Wash. 98104.

TABLE 1 PERCENTAGE OF RESPONSE RATES ACHIEVED

	Initial Telephone Contact	Interview	Overall[a]
Estimated	65	85	55
Final	71.2	60.0	40.1

[a]Completed surveys (783) divided by initial supply of valid telephone numbers (1,951).

SAMPLE SIZE

Michael E. Smith's approach in "Small-Sample Home Interview Travel Surveys" (*1*) was chosen for determining sample size. The PSCOG also reviewed Peter R. Stopher's follow-up article (*2*) on modifications to this method.

For the PSCOG survey, samples were initally calculated for analyzing the county in two parts: Bremerton and nonBremerton. These calculations estimated a final sample of 1,714 completed surveys. Financial resources would not allow for a sample of this size; calculations for Kitsap County as a whole resulted in a total sample of 734 households.

It was hoped that 1,100 completed household surveys could be obtained, and if the coefficient of variation (CV) were lower than estimated, the two geographic areas could be separated when running the models.

SAMPLE SELECTION

Four approaches to obtaining a sample were considered: (a) residential customers from the local power company, (b) random digit dialing, (c) reverse directories, and (d) residential customers from the local telephone company.

Residential Customers from the Local Power Company

An initial attempt was made to get a list of households from the local power company. Although there were several advantages to obtaining a list from the company, its staff lawyers advised against releasing information partly because of current lawsuits related to confidentiality and release of information to police.

Random Digit Dialing

The firm, Survey Sampling in Connecticut, can provide lists of randomly selected telephone numbers generated from residential prefixes. Using random digit dialing avoids the problem of unlisted numbers, but increases the chances of dialing nonworking numbers, disconnected numbers, and new business numbers.

Provided with only a telephone number, the interviewer is required to ask the name and address of the interviewee on initial contact. This increases the number of nonparticipants.

Reverse Directories

Reverse directories were available only for the City of Bremerton, and this would account for about one-half the population. There would be no easy way to obtain similar information for the rest of the county.

Telephone Listings

Three telephone companies serve Kitsap County; Pacific Northwest Bell (PNB) is one that provides all directory assistance for the county. PNB has a standard fee structure and process for obtaining customer lists and provides a typed list with name, address, and telephone number.

It was known that the use of telephone listings had inherent problems, especially with unlisted numbers and households without telephones.

Unlisted Numbers

PNB reported that about 12 percent of households in Oregon and Washington have unlisted numbers. They also acknowledged that the percentage of unlisted numbers is higher in metropolitan areas than in nonmetropolitan areas.

It was assumed that the percentage of unlisted numbers in Kitsap County would be lower than the 12 percent figure for Oregon and Washington as a whole because of the county's rural nature.

Households Without Telephones

To estimate the number of households without telephones, data from the 1980 U.S. Census were examined. Summary Tape File 3 (STF3) Table 118, "Tenure by Telephone in Housing Unit" by census tract was used. For all of Kitsap County, about 5.5 percent of households do not have a telephone (Table 2); however, in one census tract there were more households without telephones than households with telephones. Renters are more likely than homeowners to be without a telephone.

Deciding on a Sample Source

The telephone listing service was chosen because by having the household name, a better response rate to the screening call could be expected. PNB was provided with a listing of communities and the number of households needed for each community. The number of households was determined using 1983 population estimates generated using PSCOG data bases and 1980 U.S. Census figures. The initial request was for 1929 households.

After obtaining the list the data was entered into the PSCOG computer. All addresses were geocoded to census tract. The distribution of addresses was examined by census tract and 110 additional names in areas that were under-represented from the random sample were requested.

TABLE 2 OCCUPIED HOUSING UNITS (STF3 TABLE 118)

	With Telephone		Without Telephone	
	No.	Percent	No.	Percent
Total	49,812	94.4	2,982	5.6
Renter	13,639	85.9	2,230	14.1

DETERMINING THE SURVEY METHOD

The next decision involved the method of data collection. This included the decision on what the process would be and who would implement it.

Process

Several options for the survey process were discussed: (a) mail out of log/telephone interview; (b) mail out/reminder call/mail back; (c) in-person interview; and (d) telephone screen/mail out/telephone interview.

Mail Out of Log/Telephone Interview

The origin and destination survey conducted in 1971 at the PSCOG was a blind mail out with a follow-up telephone call. A letter requesting participation was sent together with a number of travel log forms. A telephone interview was then conducted to collect the information.

This method has the potential of a very low response rate at the point of the telephone interview. Households that received the survey may not have completed them. Market research firms estimated the response rate using this method as 15 to 60 percent.

Mail Out/Follow-Up Reminder Call/Mail Back

Some research shows that this method can be an effective way to collect data. Werner Brög's research in Germany showing response rates to mail-back surveys ranging from 63 to 78 percent (*3*) was examined. Ohstrom, Ohstrom and Stopher (*4*) reported that a 58.5 percent response had been achieved for the mail-back portion of a travel survey in Oahu.

PSCOG staff felt that there were too many situations where it was confusing to report trips accurately, especially "change

mode" trips—that is, a trip to work that should be counted as two trips—involving a drive to the ferry terminal and a ferry trip, or a drive to a park-and-ride lot and a transit trip to work.

In-Person Interviews

A budget limitation of $80,000 eliminated the possibility of in-person interviews. Of the $80,000, only $20,000 was allocated for outside vendors. If the interviewing were contracted out and 1,100 completed surveys were required, the budget would allow only $18 per survey. An in-home survey could not be conducted for this amount.

Initial Telephone Screen/Mail Out of Log/Telephone Interview

The method of an initial telephone call, mail out of the travel diary forms, and a follow-up telephone interview was chosen. The initial telephone call requested participation in the survey, confirmed residential address, and requested the total number of household members. The number of trip diaries that were mailed was to be reduced, and a high return rate was wanted at the point of the interview, because that would be the most expensive task of the data-collection phase.

Travel diaries would then be mailed out with instructions and a telephone interview conducted to collect the information. It was believed that using an interviewer to collect the information, rather than using a mail-back survey, would facilitate correct trip counting. Careful interviewing would reveal otherwise unreported trips and help to check on seemingly irregular trips, such as one trip to work and no return trip home. It was at this point that on-line data entry became a point of discussion.

Implementing the Survey

After deciding on the process to be used, the staff had a brainstorming session on the procedures to be followed. The initial reaction was to conduct the survey in house and to have data entered on-line to the in-house computer. Two of the survey staff believed that considerable time, and therefore money, could be saved if data entry was completed concurrently with the telephone interview. There was a general feeling that this method should be pursued because it was a technological advance that could conceivably make the project very quick to shift from the data-collection phase to data analysis and thereby reduce a two-step process to one.

On-Line Data Entry

Several benefits of on-line data entry were identified:

1. Elimination of error between paper and keypunch;
2. Reduction of illegible responses on paper;
3. Programmed skip patterns;
4. Ability to track response by geographic location, interviewer, and so on; and
5. No boxes of primary data.

The disadvantages identified were that there would be no paper copy to compare keyed response for accuracy, and that there was no experience with this method.

Using either direct entry or delayed keypunching would likely have resulted in the same completion time for the project. Because the survey served as a test case for the larger region, it was an appropriate time to try something new.

In House or Contract Out

It was decided to conduct the survey in house, although this decision was later revised. The major advantage of this was that there would be complete control over handling of problems and of hiring and training interviewers. It was also believed that the in-house method might be cheaper. However, several major disadvantages were also identified:

1. Hiring and training part-time staff would result in more paperwork for administration, and more project-management time for PSCOG staff;
2. There was no software designed specifically for interviewing and keying to CRT; and
3. Staff would be inconvenienced by the use of office space and equipment by survey personnel.

Even considering the loss of some control over the survey during contracting out, several advantages of this method remain:

1. A firm that conducted many interviews would already have trained staff,
2. Software and hardware designed for surveying on CRT would be provided,
3. The firm could be monitored by PSCOG, and
4. There would be no staff interruptions at PSCOG offices.

Deciding on the Implementation

Current PSCOG hardware and software configuration was reviewed. Hardware was not a problem. The PSCOG has 20 terminals connected to an IBM 4331 and an IBM PC that can be used as a terminal; however, software was a problem. Programs could be written with existing software, but this would have been a time-consuming task. Another option was to purchase or lease additional software specifically for interviewing. Given the time constraints, adding new software before implementing this project was an administrative impossibility.

Local firms were called to find out whether they were using any interviewing software. Three firms were visited, each had the following different software and hardware configurations, respectively:

1. Nineteen terminals hooked to a Hewlett Packard 3000 (HP3000). Software from Computers for Marketing, Inc. Tape drive directly attached to computer.
2. Eight terminals hooked to DEC PDP-11. Software would be custom written because system was new.
3. Ten independent micros [Tandy Radio Shack (TRS-80)] with 5 1/4-in. disk drives.

KITSAP COUNTY TRAVEL SURVEY

APRIL-MAY 1985

TRAVEL DATE _____

STARTING POINT ADDRESS

NAME _____

ST _____

CITY _____ ZIP _____

STARTING POINT LAND USE

1. SINGLE FAMILY HOME
2. APARTMENT/CONDO
3. RETAIL SALES GEN.
4. SHOPPING CENTER
5. MANUF./IND. WRHSNG.
6. IND./BUS./RES. PARK
7. OFF./COM. SERVICES
8. SCHOOL - HIGH SCH.
9. SCHOOL - COL./UNIV.
10. MILT. BASE/FACIL.
11. PARK&RIDE LOT
12. FERRY TERMINAL
13. TRANSIT STOP
14. OTHER

TRIP #	DESTINATION ADDRESS	TIME LEFT	TIME ARRIVED	DESTINATION LAND USE	TRIP PURPOSE	METHOD OF TRAVEL	PERSONS IN VEHICLE	TRANSIT ROUTE	PARKING COST	CROSS/PASS THESE PLACES
EXAMPLE	CO ADMINISTRATION BLDG. ST 614 Division CITY Port Orchard ZIP 98366	8:45 AM / PM	9 10 AM / PM	(7) OFF./COM. SERVICES	(8) PERSONAL BUS.	(1) AUTO DRIVER	2		X FREE	(3) INTERSECTION SR-3 OLD BELFAIR HWY.
1	ST _____ CITY _____ ZIP _____	AM / PM	AM / PM						FREE	
2	ST _____ CITY _____ ZIP _____	AM / PM	AM / PM						FREE	
3	ST _____ CITY _____ ZIP _____	AM / PM	AM / PM						FREE	
4	ST _____ CITY _____ ZIP _____	AM / PM	AM / PM						FREE	
5	ST _____ CITY _____ ZIP _____	AM / PM	AM / PM						FREE	

TRIP PURPOSE

1. RETURN HOME
2. TO WORK
3. SHOPPING
4. SCHOOL
5. PERSONAL BUS.
6. WORK RELATED BUSINESS
7. SOCIAL OR RECREATIONAL
8. CHANGE METHOD OF TRAVEL
9. SERVE A PASSENGER
10. RIDE ALONG

METHOD OF TRAVEL

1. AUTO DRIVER
2. AUTO PASSENGER
3. TRANSIT BUS/VAN
4. PARATRANSIT BUS/VAN
5. FERRY AUTO DRIVER
6. FERRY AUTO PASSENGER
7. FERRY WALK-ON
8. SCHOOL BUS
9. WALK
10. TAXI PASSENGER
11. MOTORCYCLE
12. BICYCLE
13. OTHER

CROSS/PASS THESE PLACES

1. WARREN AVE BRIDGE
2. MANETTE BRIDGE
3. INTERSECTION SR-3 OLD BELFAIR HWY.
4. AGATE PASS BRIDGE
5. NONE

FIGURE 1 Sample for Kitsap County travel survey.

It was decided that the survey would consist of a mix of in-house work and work to be contracted out because there was no appropriate office space or software to conduct the data collection interview in house. The initial telephone contact would be made by the PSCOG.

A request for proposal (RFP) was let out for a maximum of $17,000 to conduct the telephone interviews and to transmit the data on magnetic tape within 4 weeks. The RFP listed such specifications as follows:

- Software must be able to handle (estimated) 760 variables per household or 170 variables per person, and
- Software must be able to target quotas for geographic areas (either zip codes or census tracts) and close interviews for those areas when quotas are met.

Three bids were submitted. Of the three companies, only one had both software and hardware operational at the time the contract was determined and this was the company selected.

RESULTS AND RECOMMENDATIONS

Initial Telephone Contact

The initial telephone contact did not use household selection techniques to identify quotas in appropriate cells (e.g., by number of vehicles, age of head of household, etc.) as in Ohstrom, Ohstrom and Stopher (*4*).

Because PSCOG models use income quartiles to differentiate trip-making behavior, a sample of households was wanted that would meet the income distribution of the population at large. It was believed, however, that the amount of household income could not be asked at the initial telephone contact, but that a sample sufficiently large, with the desired accuracy and confidence level, would be obtained.

Up to four calls were made to each household. The estimated positive response was 65 percent. A response rate of 71 percent (after subtracting disconnects and duplicate numbers, 1,390/1,951 = 71.2 percent) was achieved as given in Table 3.

TABLE 3 RESPONSES FOR INITIAL TELEPHONE CONTACT

Responses	Number	Percentage
Positive	1,390	68.0
Negative	408	20.0
No answer	153	7.5
Disconnected	91	4.4
Duplicates	2	0.1
Total	2,044	100.0

Survey Sampling, Inc., estimates a 13 percent disconnect rate for samples generated using directory-listed numbers. PSCOG disconnect rate of 4.4 percent is considerably lower. Nonetheless, even this low number of disconnects had not been allowed for in estimates for unusable numbers.

The Telephone Interview

Response

Of the 1,390 household numbers transmitted to the market research firm, 783 surveys were completed. The PSCOG estimated 85 percent completion rate for the interviews was unreasonable; a better estimate would have been between 60 to 80 percent.

After subtracting the pretest, undelivered trip diaries, and duplicates, the final response rate was 60.0 percent (783/1,305) as given in Table 4.

TABLE 4 TELEPHONE INTERVIEW

Completed	783
Incompleted and no answer	214
Terminated	308
Pretest[a]	41
Undelivered[b]	36
Duplicates	8
Total	1,390

[a]Testing of questionnaire on first two nights. None of the 41 households were included in the final sample.
[b]Returned by postal service. Reasons included: mailbox could not be found or was blocked, address was incorrect.

Problems

Although the survey admittedly had problems, PSCOG would not hesitate to use a procedure that included telephone interviewing with on-line data entry again. Generally speaking the results were satisfactory.

When the contractor debriefed the interviewers on their reaction to the survey the following observations were made:

1. Respondents were not aware of the level of detail required in filling out their diaries,
2. Respondents were confused over the definition of trip, and
3. The public was generally cooperative but lacked a clear understanding of the purpose of the survey.

PSCOG staff identified different problems:

1. Interviewers did not understand the "Suspend" function on the computer. At any point of the survey, the interviewer could type in the word "Suspend." This could be used if the interviewee had to leave the telephone and could not complete the survey at that time. The computer would automatically ask for a day and time for the call back to be scheduled. Unfortunately, several of the interviewers were unfamiliar with this computer option.
2. The interview was too long and too complex. Although inclusion of several questions was to satisfy various political and managerial requests, it cannot be stressed enough how the survey must be pared down to the barest requirements. The average interview took 20 minutes to complete on the telephone.

TABLE 5 OBTAINED ACCURACY USING 1979 INCOME DISTRIBUTION

Income Group	CV	Frequency	Factor	Weight	Optional Allocation[a]	Actual	Obtained Accuracy (%)
Low	0.77	0.234	0.180	0.237	148	54	8.3
Low middle	0.85	0.29	0.252	0.332	207	185	5.3
Upper middle	0.75	0.238	0.179	0.236	147	185	4.5
Upper	0.64	0.231	0.148	0.195	121	286	3.3
			0.759		623	710	

[a]Calculations for optimal sample sized for 90 percent confidence and 5 percent accuracy.

3. PSCOG needed to understand default call-back routine in the computer. PSCOG needed to know what the routine was, then work with the research firm's programmer to change it. The software was set to have five time periods and a call back for busy signals. The whole weekend (Saturday morning to Sunday night) was considered one time period, therefore no call backs were made until Monday if the first call was on Saturday afternoon. Because a timely call to collect the trip information was crucial to this project, it was critical that this be changed. Unfortunately, PSCOG did not realize this was a problem until 1 week into the project.

4. It was difficult to correct errors. Basically, the interview screen is set up to ask one question at a time. The interviewer can return to a previous question, but must then re-enter all the responses to the following questions. That is, there was no retention after moving backward. This is an artificial constraint that can be eliminated with different software.

Benefits

Benefits of using an interview process that included direct entry of responses to a computer file included: good skip patterns, good monitoring capability, and ease of transmittal of data on tape. The flow of questions is very smooth when the computer is programmed to jump to appropriate next questions based on the current answer. As an example, if the travel mode was automobile driver the interviewer was to ask how many people were in the vehicle, and what, if any, were the parking costs. If the travel mode was public transit the interviewer was to ask what route was taken. Otherwise, the interviewer skipped to the question: Did you cross any of these points?

The research firm was very accommodating in allowing PSCOG to monitor various interviewers during the process. Both the screen and the voice could be monitored during the interview. Although in some research projects it is extremely important that the wording of questions be entirely consistent, for the PSCOG survey it was more important to obtain complete information regardless of whether the questions were exactly worded or not.

The monitoring capability provided a good indication of which questions were inadequate and helped to provide additional training materials to assist the interviewers in correctly coding responses.

Use of a firm with fairly complex computer capability allowed PSCOG to specify how the data was to be transmitted to PSCOG offices at the end of the project. The information was collected as a household record (because tracking was by telephone number), but was transmitted as person records.

Validity and Use of the Data

All behavior surveys, including travel surveys, are liable to bias. Two sources of bias include error in selecting the sample households to be surveyed, and error caused by refusal of selected samples to participate in the survey.

An assessment of the survey results by household income indicated a substantial undersample of low-income households and an excess sample of the two upper-income groups. This distribution problem may be due in part to the fact that expected frequency by income group is based on 1979 dollars. During the last 6 years there has been a shift of people to higher-income groups creating smaller percentages in the lower-income group.

The goal of the survey was to achieve a desired accuracy

TABLE 6 OBTAINED ACCURACY ASSUMING 25 PERCENT INCREASE IN HOUSEHOLD INCOME

Income Group	CV	Frequency	Factor	Weight	Optional Allocation[a]	Actual	Obtained Accuracy (%)
Low	0.77	0.176	0.136	0.181	106	54	7.2
Low middle	0.85	0.281	0.239	0.318	187	185	5.1
Upper middle	0.75	0.253	0.190	0.253	149	185	4.6
Upper	0.64	0.291	0.186	0.248	146	286	3.5
			0.751		588	710	

[a]Calculations for optimal sample sized for 90 percent confidence and 5 percent accuracy.

TABLE 7 KITSAP COUNTY HOUSEHOLD SIZE DISTRIBUTION

Number of Persons in Household							Average Household
1	2	3	4	5	6	Total	Size
1980 households[a]							
11,265	17,835	9,031	8,724	3,815	2,171	52,841	
21.3%	33.8%	17.1%	16.5%	7.2%	4.1%	100.0%	2.71
1985 households[b]							
129	292	153	139	47	23	783	
16.5%	37.3%	19.5%	17.8%	6.0%	2.9%	100.0%	2.70

[a]1980 U.S. Census, STF-3, Report 18.
[b]1985 Kitsap Home Interview Survey.

TABLE 8 KITSAP COUNTY POPULATION BY AGE AND SEX

Age Interval (yr)	1980[a]						1985[b]					
	Male	Percentage	Female	Percentage	Total	Percentage	Male	Percentage	Female	Percentage	Total	Percentage
0–4	5,952	4.0	5,676	3.9	11,628	7.9	–	–	–	–	166[c]	
5–9	5,802	3.9	5,585	3.8	11,387	7.7	55	3.3	51	3.1	106	6.4
10–15	7,228	4.9	6,984	4.8	14,212	9.7	67	4.1	77	4.7	144	8.7
16–18	4,057	2.8	3,417	2.3	7,474	5.1	37	2.2	32	1.9	69	4.2
19–24	10,139	6.9	6,946	4.7	17,085	11.6	56	3.4	57	3.4	113	6.8
25–29	7,056	4.8	6,513	4.4	13,569	9.2	95	5.7	87	5.3	182	11.0
30–44	16,123	11.0	14,962	10.1	31,085	21.1	255	15.4	242	14.6	497	30.0
45–59	9,988	6.8	10,064	6.8	20,052	13.6	128	7.7	117	7.1	245	14.8
60–64	2,965	2.0	3,159	2.2	6,124	4.2	36	2.2	53	3.2	89	5.4
65+	6,190	4.2	8,338	5.7	14,528	9.9	105	6.3	105	6.3	210	12.7
	75,500	51.3	71,644	48.7	147,144	100.0	834	50.4	821	49.6	1,655	100.0

[a]1980 U.S. Census, STF-3 Report 15.
[b]1985 Kitsap Home Interview Survey.
[c]Not included in percentage calculations.

TABLE 9 KITSAP COUNTY HOUSEHOLD INCOME DISTRIBUTION

	1980 Households[a]	Percentage	1985 Households[b]	Percentage
Income ($)				
10,000	12,350	23.4	54	6.9
10,000–19,999	15,671	29.6	185	23.6
20,000–29,999	13,440	25.4	185	23.6
30,000–39,999	6,735	12.8	150	19.2
40,000–49,999	2,531	4.8	76	9.7
50,000	2,091	4.0	60	7.7
Response				
Refused to answer	–	–	45	5.7
Unknown income	–	–	28	3.6
Total	52,818	100.0	783	100.0

[a]1980 U.S. Census, STF-3, Report 68.
[b]1985 Kitsap Home Interview Survey.

level of ±5 percent at a 90 percent level of confidence. Based on unadjusted distributions and the observed CVs, the obtained accuracies are given in Table 5.

To adjust for increases in income over time an estimate of accuracies was made assuming a 25 percent increase in incomes over the 1979 to 1985 time period in order to find what impact this would have. As seen in Table 6, low-income accuracy improves significantly to approximately 7 percent.

Preliminary survey results were compared with 1980 U.S. Census data to assist in determining survey validity and accuracy. The biases indicated will be adjusted through marginal weighting techniques if it is determined to be necessary. Unadjusted comparisons with 1980 data illustrated relatively close similarity to expected population and household characteristics.

In Tables 7–12 some of the preliminary survey demographic results are compared to the 1980 U.S. Census information. Household size distribution in Table 7 is given as approximately the same household size as in 1980.

A comparison of the distribution of population by age and

TABLE 10 KITSAP COUNTY VEHICLE AVAILABILITY

Number of Vehicles None	1	2	3	Total Households	Total Vehicles	Vehicles Per Household
1980[a]						
3,843	17,638	18,568	12,607	52,656	96,377	1.83
7.3%	33.5%	35.3%	23.9%	100.0%		
1985[b]						
18	226	334	196	783	1,584	2.05
2.3%	29.2%	43.2%	25.3%	100.0%		

[a]1980 U.S. Census, STF-3, Report 123.
[b]1985 Kitsap Home Interview Survey.

TABLE 11 KITSAP COUNTY NUMBER OF WORKERS BY TRAVEL TIME TO WORK

Time (min)	Number of Workers, 1980[a]	Percentage	Number of Workers, 1985[b]	Percentage
< 5	2,539	4.2	21	2.9
5–9	6,735	11.0	70	9.7
10–14	9,880	16.2	108	15.0
15–19	10,083	16.5	151	21.0
20–29	12,609	20.7	134	18.6
30–44	9,529	15.6	149	20.7
45–60	2,965	4.9	53	7.4
> 60	6,648	10.9	34	4.7
Total workers	60,988	100.0	720	100.0
Average trip time (min)	24.9		24.0	

[a]1980 Census, STF-3, Report 41.
[b]1985 Kitsap Home Interview Survey.

TABLE 12 FREQUENCY OF TRIPS PER HOUSEHOLD BY INCOME

Income ($)	Trips Per Household
< 10,000	3.9
10,000–19,999	5.0
20,000–29,999	6.9
> 30,000	9.3
No income reported	4.5
All households	6.9

sex, between 1980 and 1985 in Table 8, shows a possible undersampling of the younger age groups and an oversampling of the older age groups. A possible explanation for the undersampling of the 19–24 age range is the large military population in Kitsap County that are not in households.

Vehicles per household increased slightly between 1980 and 1985 (Table 10). An underestimate of the number of trips taking longer than 60 min is indicated in Table 11. A problem may exist in those trips including the use of a ferry. Kitsap County has some unique travel characteristics because of the separation of the county from the mainland by Puget Sound.

The preliminary trip-production rates obtained from the survey are given in Table 12. As expected, the trip rates per household have increased over time, and upper income households take more trips.

The preliminary survey results described here are unadjusted or weighted. This information will be processed and used to update travel forecast models representative of travel characteristics in Kitsap County.

CONCLUSIONS

Origin-destination travel surveys will continually require a means of collecting accurate and timely information at a reduced cost. Using a small sample and direct input of responses to the computer during a telephone interview reduces time and effort needed for this kind of data collection. Computer hardware and software used in survey work will continue development toward ease of use, ease of programming, and attractiveness to nonprogrammers and the general public.

Data from this survey will be used to update travel forecasting models. More importantly, the survey provided valuable

experience that will greatly enhance data collection when the PSCOG conducts its much larger mainland survey in the next fiscal year.

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Nationwide Personal Transportation Study: Experiences with Previous Surveys and Options for the Future

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The Nationwide Personal Transportation Survey (NPTS) is a survey of travel patterns of U.S. households, with a focus on the amount and nature of travel activity. The survey provides a benchmark of travel activity and a measure of the impact of selected demographic factors on travel patterns. The survey was conducted in 1969, 1977, and 1983, with the next survey in the series scheduled for 1988. The surveys conducted to date have been home-interview surveys, but there are current plans to conduct a telephone survey in 1988. Some of the factors pointing to the use of a telephone survey are *(a)* decreased cost per interview, *(b)* expanded sample size, *(c)* centralized interviewing, and *(d)* the capability of on-line editing. Balancing these advantages are concerns of comparability with the previous surveys, biases inherent in telephone surveys, and whether the overall length and complexity of the data are appropriate for telephone interviewing. Despite these concerns, the telephone methodology will most likely be used for the next NPTS. Telephone surveys are the predominant method of conducting travel surveys today, probably because they provide acceptable response rates at a low unit cost and have the benefit of personal contact with the household.

The National Personal Transportation Survey (NPTS) has much in common with other urban area travel surveys. Data is collected on the economic and demographic characteristics of the sampled households, vehicle ownership patterns, and trips and travel by all modes of transportation. Like many of the urban area studies, a travel day concept is used in NPTS; that is, all trips and travel made by each household member in a given 24-hr period are collected. However, NPTS differs from urban area travel surveys in several important aspects, most notably

1. The survey area covers the entire United States,
2. Data collection extends over a 1-year period of time, and
3. The survey includes modes such as airplane, and intercity train and bus.

The vast coverage of the survey, both in terms of geography and time, creates problems that are unique to NPTS. The coverage considerations will, of course, affect any changes made in future surveys.

The NPTS is sponsored by four U.S. Department of Transportation (U.S. DOT) agencies: Office of the Secretary of Transportation, National Highway Traffic Safety Administration, Urban Mass Transportation Administration, and the Federal Highway Administration. The U.S. DOT conducts the survey to provide fundamental data on the amount and nature of household travel. The survey provides a benchmark of travel activity and a measure of the impact of selected demographic factors on travel patterns. The data is used within the U.S. DOT

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primarily for policy development, planning, and program review and evaluation. In addition, a wide variety of other users rely on NPTS for basic research needs. It is the only source of national information that provides a complete and current measure of travel by all modes of transportation, regardless of trip purpose or trip length. The capability to link travel information to the characteristics of the traveler, vehicle used, or both further enhances the utility of the survey data.

The NPTS has been conducted three times to date: 1969, 1977, and 1983. All three surveys in the series have been fairly similar in content, procedure, and methodology. All three were conducted by the U.S. Census Bureau, and all three were home-interview surveys with some telephone follow up.

EXPERIENCES TO DATE

The home-interview method was originally selected primarily because of survey procedures and content. One of the survey objectives was to obtain a comprehensive record of all household travel. Therefore, the decision was made to interview each household member aged 5 years and over, in order to ensure that all trips made by all household members were reported. The rationale for this approach is that no one could really know all the trips made by any other household member on a given day. The operational rule to interview each household member was coupled with a fairly significant amount of information to be gathered. Both of these pointed to the use of the home interview as the most appropriate methodology.

The choice was further reinforced by the use of the U.S. Census Bureau as the data collection agent. The U.S. Census Bureau has an existing staff of geographically dispersed part-time employees who conduct interviews for a number of nationwide surveys sponsored by various federal agencies. The availability of this interviewer staff provided the flexibility to select a truly nationwide sample, including rural areas.

An additional reason for using the home interview was the timing of the original NPTS. In 1969, the home interview survey and the mail-back survey predominated noncommercial survey operations. At that time few, if any, agencies were using telephone interviews for travel surveys. Given the choice between home interview and the mail-back survey, the detailed content of NPTS and the requirement to interview each person 5 years or older weighed heavily in favor of home interviews.

Because the home interview had been successful for the initial NPTS, it was continued for the surveys conducted in 1977 and 1983. This choice, combined with other decisions about the survey, allowed for a high degree of comparability among all three surveys in the series. Comparability is particularly important for the NPTS because it is the only source of national estimates for certain fundamental travel indicators.

Some of the other advantages obtained by using the home interview are the generally good quality of the data and the high response rates. For example, in the 1983 NPTS, 94 percent of all occupied households in the sample were interviewed. This impressive response rate may be the result of the home interview method, the credibility of the U.S. Census Bureau, or both.

These very substantial advantages are balanced by equally significant disadvantages. First, the home interview is generally the most expensive survey method. In the case of the NPTS, survey costs rose dramatically, even in the period between the 1977 and 1983 surveys. The same amount of funding was allocated to NPTS in 1977 and 1983. This fixed amount supported a survey of 18,000 households in 1977, but only 6,500 households in 1983.

Another problem area is the geographic scope of the survey. Conducting a nationwide home-interview survey requires interviewers located throughout the United States. Although the U.S. Census Bureau is staffed to meet this requirement, there is a lack of efficiency and effectiveness in conducting a relatively small survey that is so geographically disbursed. In smaller areas, the interviewers are assigned to complete only one or two NPTS household interviews in a month. Generally, the problem is that the interviewers conduct so few NPTS interviews that they are unable to build up expertise with the survey form. Given the costs and other problems associated with the home interview, it is likely that another methodology will be chosen for the next NPTS.

PLANS FOR THE FUTURE

The next NPTS is tentatively scheduled for 1987–1988. Although planning is progressing for the next survey, there are no guarantees that it will actually be conducted until funding and design issues are resolved.

In order to reduce the cost per interview and adjust the survey content to better meet the sponsors' needs, a redesign effort was initiated to propose alternative survey plans for the conduct of the next NPTS. A wide variety of options are being considered, with the existing survey as one of the options. Alternatives are being considered for all elements of the survey (e.g., content, method, timing, scope, contractor, and data editing).

Although the redesign work is not concluded, there are certain alternatives that appear more promising than others. In the area of survey methodology, it is highly likely that a telephone survey will be used. Some of the factors pointing to the use of a telephone survey are as follows:

- Decreased cost per interview—All indications are that a telephone survey could be accomplished for a considerably lower cost per household than home interview.
- Expanded sample size—This correlates to decreased cost per interview. For the same funding level, the sample size could be increased significantly. Sample sizes being considered are a minimum of 10,000 households and a maximum of 25,000.
- Centralized interviewing—The feature of centralized interviewing has many benefits. First, the interviewers can gain experience and proficiency with the survey form. Second, greater consistency and quality control can be achieved in a centralized setting. And third, adjustments to survey content and procedures can be made as the survey progresses, if necessary.
- Capability of on-line editing—For NPTS, on-line editing represents a significant advantage of a telephone survey. The heart of the NPTS dataset is the daily travel section. This is also the most fragile data for recall purposes. In previous surveys, by the time this data was edited it was impossible to ask the

respondent to add or clarify information. But, with computer-assisted telephone interviewing, a certain amount of editing of this critical data can be accomplished on a real-time basis.

Telephone interviewing would require a reduction of survey content from the amount currently collected. However, there are a number of items that have been of limited use in the past and probably could be deleted. These reductions would probably result in a survey of an appropriate length for telephone use.

There are some areas of concern associated with a telephone survey. First, there is the issue of whether to individually interview each household member. This was the procedure used in the NPTS surveys done to date, but those had the advantage of face-to-face contact. Each person at home was interviewed, and the remaining household members were usually contacted by telephone within 1 or 2 days. If the entire survey is accomplished by telephone, it may be unreasonable to expect that telephone contact can be made with each household member. However, this concern is somewhat alleviated by the fact that today the majority of U.S. households are comprised of one or two persons.

Possible biases in telephone surveys are another area of concern. Specifically, the issue is how to sample households with unlisted telephone numbers, those with frequent travel, and those without telephones. Unlisted telephone numbers may not be a problem if random digit dialing is used. Those households with members who travel frequently are difficult to contact no matter what survey method is used; however, a telephone survey may exacerbate the problem. The most significant bias issue is the household without a telephone. This issue will require much more thought and planning if the NPTS is to remain a representative sample of travel by all U.S. households. Despite the concerns expressed, it appears that a telephone survey is the most promising of the potential methods.

Other methods are being considered for the next NPTS, but these each have significant potential problems. A mail-back survey has the primary advantage of being the lowest-cost method. However, mail surveys have generally had low response rates and there is a bias in those who respond. The concern is that responses are obtained only from that portion of the population that does not mind responding to mail surveys. This hardly constitutes a representative sample. The final problem in the use of a mail survey is that the NPTS content is probably too long and too detailed to be collected effectively in a mail-survey format. This is true of even a streamlined NPTS.

Although a mail-back survey used alone has severe problems, mail may be effective as a subcomponent of a larger telephone survey. It is likely that either the daily travel log or vehicle odometer readings could be obtained as a mail-back component of a survey conducted primarily via telephone.

Consideration was also given to continued use of the home-interview technique. Cost is the main constraint in continuing a home-interview survey. The main advantage would be in maintaining a greater comparability with the previous surveys.

CONCLUSION

The telephone survey appears to be the predominant method of conducting travel surveys at the present. This probably reflects the fact that telephone surveys provide acceptable response rates at a low unit cost, while having the benefit of personal contact with the household. Based on these advantages, it appears likely that a telephone survey will be the methodology selected for the next NPTS.