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Travel Survey Manual

TMIP

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Travel Survey Manual

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Prepared by

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Preface

This manual was prepared by Cambridge Systematics, Inc. and Barton-Aschman Associates, Inc. under contract to the Federal Highway Administration (FHWA) as part of the Travel Model Improvement Program (TMIP). the TMIP is a cooperative effort of the U.S. Department of Transportation (including FHWA, the Federal Transit Administration (FTA), and the Office of the Secretary of Transportation (OST), the Environmental Protection Agency, and the Department of Energy. Christopher Fleet of FHWA managed the development of the manual. Other participants at the U.S. Department of Transportation included Elaine Murakami, Fred Ducca, and Jerry Everett of FHWA, Ed Weiner of OST, and Ron Fisher of FTA, who is the overall technical manager for the Cambridge Systematics TMIP contract.

Kevin Tierney of Cambridge Systematics was the primary author and editor of this manual. Contributing authors included Steve Decker, Kimon Proussaloglou, Thomas Rossi, and Earl Ruiter of Cambridge Systematics and Nancy McGuckin of Barton-Aschman. Other participants in the development of the manual included Thomas Buffkin, Molly Markert, Erin Vaca, and Moshe Ben-Akiva of Cambridge Systematics and David Kurth, Bill Martin, and John Hamburg of Barton-Aschman.

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Any oversights and omissions remain the sole responsibility of the authors.

1.0 Introduction

The increasingly sophisticated demands placed on transportation planning models in recent years have led to the need for re-examination of input travel survey data. The travel demand modeling field was developed primarily in response to the need to analyze potential changes in transportation infrastructure, such as major highway and transit capital projects, but the 1990 Clean Air Act Amendments (CAAA), the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), and to a lesser extent some earlier legislation, have redefined the role of travel demand models in the planning process to include:

- The provision of detailed input information for air quality analysis;
- The evaluation of the effectiveness of different transportation investments, not limited to highways;
- Support for the development of integrated regional and statewide transportation improvement efforts; and
- The enhancement of ISTEA management systems.

The development of the Travel Model Improvement Program (TMIP) is a recognition of the fact that transportation planning models are being asked to perform newer and more complicated analyses, and that in many cases the models are inadequate. The TMIP is designed to implement enhancements to current travel demand models and to develop new modeling procedures that accurately and reliably forecast travel for a broad range of modes, policy actions, and operational conditions. The TMIP consists of four tracks designed to provide practitioners with access to and understanding of the best transportation planning methods available.

A recent TMIP publication concludes that:

> "Transportation planning models lack the spatial and temporal detail, the behavioral sensitivity, and sensitivity to alternative modes of trip making needed to provide the forecasts required by the current regulations."[1]

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[1] Karla Karash and Carol Schweiger, *Identification of Transportation Planning Data Requirements in Federal Legislation,* prepared for the U.S. Department of Transportation's John A. Volpe National Transportation Systems Center, July 1994, p. 14.

This Travel Survey Manual examines one of the most important aspects of transportation planning models, the input travel survey data. Current transportation planning models rely to a great extent on the disaggregate behavioral travel data obtained from travel surveys for establishing the trip generation, trip distribution, and mode split modeling relationships. In addition, although they are still being planned, the next generation of travel models (as envisioned by the TMIP) will rely on very detailed household level analyses.[2] Given their nature, it is extremely likely that the new generation travel models will require as much or more disaggregate survey data collection than existing model systems.

Researchers spend a great deal of time and effort on improving the analytical methods used in transportation planning models. However, it is important to remember that the quality of the input data (primarily travel survey data) dictates the value of the resulting models, regardless of the approaches that are employed.

■ 1.1 Purpose of this Manual

This survey manual provides transportation planners with guidance for developing and implementing the most common types of travel surveys, including:

- **Household Travel and Activity Surveys** - Surveys that are used to track the travel behavior of households within the study area, generally employing diary methods.

- **Vehicle Intercept and External Station Surveys** - Surveys of auto travelers entering or leaving the study area, or crossing key screenlines within a study area.

- **Transit Onboard Surveys** - Surveys of transit passengers conducted as they travel.

- **Commercial Vehicle Surveys** - Surveys of taxi and truck owners, operators, or dispatchers designed to track commercial vehicle travel within the study area.

- **Workplace and Establishment Surveys** - Surveys taken at places of employment to develop trip attraction measures.

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[2]Gordon A. Shunk, *TRANSIMS Project Description*, prepared for the Travel Model Improvement Program, August 1994.

- **Special Generator, Hotel, and Visitor Surveys** – Specialized surveys designed to describe travel by visitors, and travel to and from special trip generators such as airports.
- **Parking Surveys** – Surveys of auto travelers parking in specific locations or parking lots within the study area.

The first set of travel survey guidelines was published by the Bureau of Public Roads in the 1940s.[3] The guide was updated in the mid-1950s and again in 1973.[4,5] Because there have been radical changes in the transportation planning environment over the last 20 years, and as the field of commercial marketing research (and its application to transportation issues) has rapidly improved in the last decades, many of the specific data collection techniques described in the 1973 guide have been sup-planted by more efficient and cost-effective procedures.

In this Travel Survey Manual, we assume that the user of this manual has recognized the need for newer or different disaggregate modeling data, and that the need for survey research of some kind has been defined. We also assume that the user of this manual has developed a detailed modeling plan and has a strong understanding of the data requirements for the anticipated models. This manual does not address transportation modeling explicitly.

■ 1.2 Emerging Issues for Travel Surveys

The newest generation of travel surveys is especially challenging for planners because the surveys need to obtain more and better data for modeling purposes in a time when survey research is becoming increasingly difficult to conduct. Typically, agencies are hard-pressed to assemble the required levels of resources (funding and manpower) necessary for implementing new survey data collection efforts because of competing transportation planning requirements. However, the need for the data continues to grow. Agency transportation planners now need to accurately measure the impacts of:

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[3] Highway Research Board, *Proceedings of the Twenty-fourth Annual Meeting of the Highway Research Board,* Washington, D.C., 1944.

[4] U.S. Department of Commerce, Bureau of Public Roads, *Manual of Procedures for Home Interview Traffic Studies* – revised edition, Washington D.C., October 1954.

[5] U.S. Department of Transportation, Federal Highway Administration, *Urban Origin-Destination Surveys,* Washington D.C., 1973 (reprinted 1975).

- Non-motorized travel;
- Intelligent transportation systems (ITS);
- Goods and person movement transportation system performance;
- Air emissions analysis related to vehicle operating modes, such as hot/cold starts and hot soaks; and
- Transportation demand management (TDM), transportation systems management (TSM), and transportation control measure (TCM) strategies.

Increased Modeling Data Requirements

Because of these additional analysis needs, new travel surveys must provide more detailed data on a number of subjects that previous surveys did not cover. The original travel surveys collected data on how people traveled, including number of trips, choice of destination, and choice of mode. The new modeling requirements dictate that travel surveys not only provide more detail on how people travel, but also yield behavioral information on peoples' choices of whether, when, and how they would travel under certain conditions. The new modeling requirements have led recent surveyors to collect:

- **Vehicle Characteristics and Usage Data** – In recent surveys, respondents have been asked detailed questions about the vehicles that are available to them and about vehicle usage for each trip. This information is being used for many purposes, including analysis of the cold start/hot start phenomena in air quality analysis.
- **Non-Motorized Travel** – Unlike many of the earlier travel surveys, new travel surveys are asking respondents to provide information on walking and bicycling trips. ISTEA requires that these modes be considered in mode choice models.
- **Activity-based Travel Diaries** – Some recent travel surveys have collected diary information on activities requiring and not requiring travel. These data will be used to develop activity-based models and to evaluate how people choose between activities requiring travel and other activities.
- **Time-of-day of Travel** – In response to the need for peak and off-peak travel modeling, newer travel surveys are asking more detailed questions about people's choices of travel times.
- **Stated Response (Stated Preference) Exercises** – Historically, travel surveys have recorded actual respondent behavior, or respondents' "revealed preferences." Some recent travel survey efforts have also

sought to predict the effects of new policies and travel options for which little revealed preference data are available. These efforts usually rely on exercises that ask respondents to make hypothetical decisions involving multiple attributes or parameters.

Survey Trends

In addition to the changing transportation planning requirements, travel surveys are also being greatly affected by changes in the market research and survey field. Travel surveys exist in the wider world of marketing research, and to properly design a travel survey effort, analysts must consider both the transportation planning outputs of the survey and the practical survey-related issues involved.

In his recent review of data collection methods in the U.S., Lysaker noted a number of recent trends in the commercial surveying field.[6] Although this review did not focus specifically on travel surveys, the general marketing research trends are applicable to the travel surveying practice. The key trends in travel surveying over the past several years in the U.S. include:

- Declining respondent cooperation rates;
- Increasing analytical demands on the survey data; and
- The use of new survey technologies, such as computer assisted interviewing and geographic information systems (GISs), to improve survey efficiency.

The net effect of these trends is that travel survey efforts have become substantially more complex than in the past.

Declining Cooperation Rates

In the past several years, the percentage of potential respondents refusing to participate in surveys has increased. Researchers attribute this trend to a number of factors. First, the proliferation of survey efforts has caused a general feeling of antipathy towards these efforts in a number of people. Almost all potential survey respondents are likely to have had some first hand experience with being asked to respond to surveys on some subject. If the experiences were unpleasant for any reason, the potential respondents are likely to balk when asked to consent to another effort, regardless of the subject matter or the survey sponsor, public or private.

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[6] Richard L. Lysaker, *Data Collection Methods in the U.S.*, Journal of the Market Research Society, 1989, Volume 31, Number 4, pp. 477-488.

In addition to being asked to participate in surveys, potential respondents are also bombarded with the results of various surveys from the media. Many of the results that are reported are contrary to the preconceived notions of potential respondents or turn out to be invalid. For instance, some political polls taken shortly before an election predict the wrong outcome. Many respondents conclude from these events that the inconsistency is the fault of the survey, and they generalize this finding to surveys, in general. Therefore, when these people are asked to participate in surveys, they do not see any reason to do so.

Another important reason for declining cooperation rates is that most of the survey techniques in use today are also used to sell products and services, and to solicit contributions. Practically everyone in the U.S. with a phone has been called (often at an inconvenient time) and asked to purchase something. Similarly, many households could measure their direct solicitation mail, or "junk mail," by the pound. When interviewers call homes, they are often met with refusals even before they can explain the nature of the call. A significant number of mail surveys are thrown away without ever being opened. Sales efforts disguised as surveys compound this problem.

In addition, the level of distrust in government activities has increased dramatically over the past 20 to 30 years. Many respondents are unwilling to share information with government agencies (such as MPOs and state DOTs) unless required to do so by law. Americans attach an extremely high value to their privacy rights, so they will often refuse to cooperate with voluntary government data collection efforts. Survey cooperation rates are higher in other countries where survey respondents are more accustomed to government inquiries.

Increasing Analytical Demands

As decision makers and the public at large are becoming more familiar with (and to some extent, more skeptical of) surveys, survey researchers are being asked to answer ever more complicated questions. Surveyors are being asked to evaluate differences between very specific market segments to help identify market niches for products and services. Such analyses require more detailed survey instruments, and greater reliance on questionnaires customized to specific respondent groups.

In addition, analysts are conducting more robust statistical analyses on the survey results to provide more usable information to decision makers. Twenty years ago, the use of complex statistical modeling procedures on survey data was limited to a few specific fields like travel demand forecasting. Today, most survey analysis efforts employ reasonably complex statistical analyses, taking advantage of advancements in the analytical capabilities of desktop computers. The increased demand for more complex analyses is requiring surveyors to increase the efficiency and quality of surveys.

Technology Advancements for Surveys

Over the past several years, most travel survey efforts have utilized computer technology advancements. Telephone interviewing is now dominated by centralized interviewing facilities and by Computer Assisted Telephone Interviewing (CATI) systems. In addition, the use of computer assisted personal interviewing (CAPI) techniques is becoming common in intercept surveys. These technologies increase the efficiency of survey efforts by allowing for on-line error checking during interviews and by obviating the need for most coding and keypunching tasks.

The rapid growth in the availability of GISs to transportation planners has also affected the way travel surveys are conducted and analyzed. GISs are commonly used in geocoding travel survey data once it has been collected. In addition, some recent survey efforts have relied on GISs to geocode origins and destinations in real-time during interviews. In these efforts, interviewers are able to determine whether the geographic information obtained is sufficient for analysis purposes or whether additional details need to be sought. This technique addresses one of the most difficult challenges of travel surveys, the need for reliable geocoding of locations.

■ 1.3 Using this Manual

Nowhere is it more true than in developing travel surveys that the "devil is in the details." This manual focuses on many very detailed aspects of travel surveys, because we as a profession have learned hard lessons about the importance of seemingly mundane surveying details. This manual is intended to help individuals responsible for implementing travel surveys avoid some of the most common pitfalls.

However, this manual cannot be used as a "cookbook." Every survey effort and every region has specific qualities that must be addressed in the design and implementation of travel surveys. Analysts need to consider their specific data needs and survey constraints before embarking on a survey effort.

■ 1.4 The Content of this Manual

Chapter 2.0 of this manual presents a step-by-step survey implementation process, which is then used to organize the later chapters that discuss specific types of travel surveys. The chapter provides a general overview of the survey research process without discussing specific types of surveys or specific surveying techniques.

Chapter 3.0 describes the range of travel survey options that can be used for collecting travel demand data. We describe several types of travel surveys, the survey methods typically used to field the surveys, and the types of data collected. This chapter is probably most useful for readers who are contemplating a data collection effort, but who have not yet determined the survey approach or approaches that they will use.

Chapter 4.0 discusses some survey issues that are common to all types of travel surveys. Specifically, issues related to survey management and coordination are outlined. We believe it will be useful to review this chapter prior to embarking on any travel surveys.

Chapter 5.0 provides a basic discussion of survey sampling and bias. The technical issues outlined in this chapter are relevant to each type of travel survey.

Chapters 6.0 through 12.0 provide detailed descriptions of the survey types addressed in this manual. For each survey type, we describe the decisions and issues related to each step of the survey process. The chapters are arranged as follows:

Chapter 6.0 - Household Travel and Activity Surveys;

Chapter 7.0 - Vehicle Intercept/External Station Surveys;

Chapter 8.0 - Transit Onboard Surveys;

Chapter 9.0 - Commercial Vehicle Surveys;

Chapter 10.0 - Workplace/Establishment and Special Generator Surveys;

Chapter 11.0 - Hotel and Visitor Surveys; and

Chapter 12.0 - Parking Surveys.

The information in Chapters 6.0 through 12.0 is purposely redundant in places to allow users interested in specific surveys to read only the individual chapter of interest, without referring to the others.

Chapter 13.0 discusses two emerging travel survey data collection methods, longitudinal data collection, such as panel surveys, and stated preference survey techniques. These types of survey data have a number of advantages in travel demand modeling applications, and analysts have begun to collect these data in a number of regions.

Chapter 14.0 discusses geocoding, one of the most difficult and time-consuming aspects of travel surveys. In recent years, our ability to geocode places described in travel surveys has improved dramatically, so we have provided an entire chapter on the subject.

2.0 The Generic Travel Survey Process

■ 2.1 The Survey Implementation Process

Most travel surveys (and other types of surveys, as well) follow a common implementation procedure. Backstrom and Hursh-Cesar divide the generic survey implementation process into the 20 steps listed in Table 2.1.[1] These 20 steps can be classified into the five general stages shown in the figure:

- Survey planning;
- Survey design;
- Field implementation;
- Data preparation; and
- Data analysis.

This manual concentrates on the three middle stages: survey design, field implementation, and the data preparation. The survey planning and data analysis stages are related to decisions about the scopes and the forms of the travel models and other analyses that are to be developed using survey data. For this manual, it is assumed that the agency has either developed a detailed plan for the formation or revision of an existing modeling system or has identified a particular set of survey data needs.

Figure 2.1 shows the many functional interrelationships between the steps in the implementation of a generic travel survey. Decisions made at each point of the process will affect many other elements of the survey effort. Once the need for a new travel survey has been identified, an agency needs to proceed with three tasks: compiling useful background information for the survey effort, designing the overall survey effort based on the recognized data needs and available data sources, and organizing the survey

[1] Charles Backstrom and Gerald Hursh-Cesar, *Survey Research,* 2nd edition, John Wiley & Sons, 1981, pp. 23-24.

Table 2.1 Backstrom and Hursh-Cesar's Survey Implementation Process

Survey Planning Stage

1. Definition – deciding the problem to be studied.
2. Hypothesis – specifying the relationships to be studied.

Survey Design Stage

3. Background Information – checking existing information on the problem.
4. Design – establishing study principles and procedures.
5. Organization – marshaling staff, funds, and materials.
6. Sampling – choosing the people to be interviewed.
7. Drafting – framing the questions for use in the field.
8. Constructing – shaping the format of the questionnaire.

Field Implementation Stage

9. Pretesting – discovering whether study methods elicit the desired data.
10. Training – teaching fieldworkers the proper data-gathering techniques.
11. Briefing – showing fieldworkers how to conduct the survey.
12. Interviewing and Data Collection – securing data from respondents.

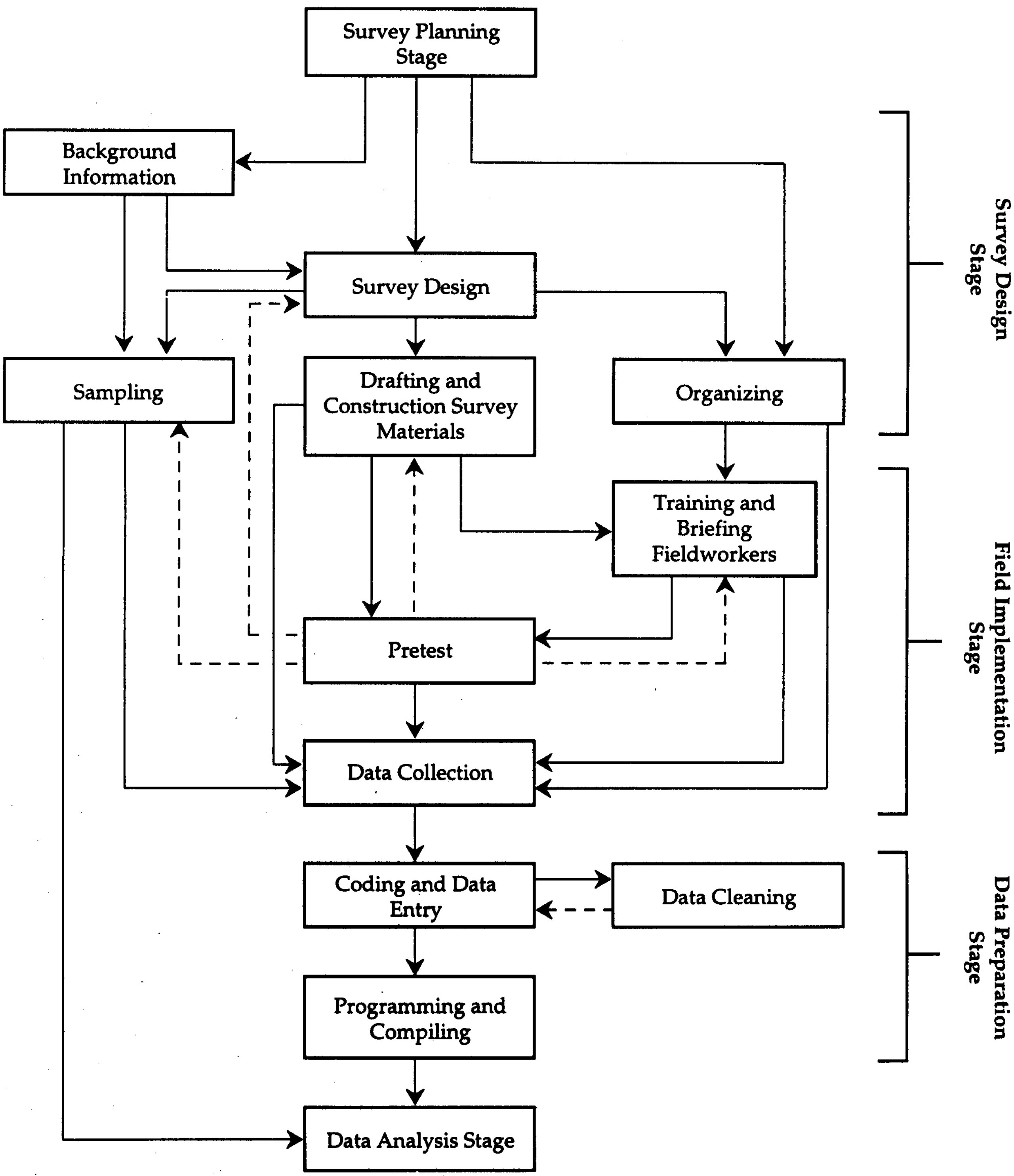
Data Preparation Stage

13. Coding and Data Entry – assigning numerical values to responses, and entering results.
14. Cleaning – assuring that all data are usable.
15. Programming – instructing the computer how data are to be manipulated.
16. Compilation – organizing the data into formats that are useful for analysis.

Data Analysis Stage

17. Analysis – relating the responses on two or more variables.
18. Testing – applying measures of statistical significance and goodness-of-fit.
19. Reporting – presenting the findings and conclusions of the study.
20. Using – applying the findings to the problems at hand.

Figure 2.1 The Travel Survey Process



team and survey resources. Decisions made during the survey design process allow the survey team to develop a sampling plan and to develop the preliminary survey instruments.

The field implementation stage of the travel survey involves the training of fieldworkers, conducting a survey pretest, and the actual survey data collection. The survey pretest allows the survey team to rethink survey design issues, including the overall design of the survey, the survey sampling procedures, and the survey instruments. In addition, the pretest can identify areas where additional fieldworker training would be helpful.

The results of the data collection effort are then fed into the data preparation stage. The survey results are coded, entered, and cleaned. Then the survey results are manipulated into useful formats for data analysis.

Chapters 6.0 through 12.0 apply the generic organization of survey steps to discuss specific types of travel surveys. In the remainder of this chapter, we briefly elaborate on each of the survey implementation steps.

■ 2.2 The Survey Design Stage

Assembling Background Information

Prior to embarking on any survey data collection effort, an agency should carefully review existing data sources. Available travel data can be used in a number of ways, including:

- **In Lieu of New Survey Work** - Travel surveys are often expensive and time-consuming. If appropriate, existing data sources can be used instead of the survey data. Of course, the quality and timeliness of existing data sources should be examined to determine whether new survey data collection may be avoided.

- **For Developing Survey Samples** - Existing information about the survey population can be used to develop more efficient samples so survey costs can be reduced and/or accuracy can be enhanced.

- **For Validating Survey Results** - One of the best ways to assess the validity of new survey results and detect potential biases in the data is to compare the survey results with other available information. This process can be accomplished with formal statistical analyses or with non-formal comparisons. Many statistical validation routines are commonly performed during the development of new travel models.

Background data sources for each type of travel survey are described in Chapters 6.0 through 12.0 of this manual, but generally, the most common sources of background information for travel surveys include:

- U.S. Census Population and Housing Summary Tape Files (STF1, STF2, STF3, STF4);
- U.S. Census Transportation Planning Package (CTPP);
- U.S. Census Public Use Microdata Sample (PUMS);
- Nationwide Personal Transportation Survey (NPTS);
- Previous local survey efforts; and
- Traffic counts and transit passenger counts.

Survey Design

In the survey design portion of the travel survey implementation process, the survey team needs to determine the best overall survey approach to obtain the particular data items required for the expected analyses. The survey designers need to accomplish two general tasks during the survey design effort:

- Selection of the general survey methods; and
- Establishment of budget and time constraints for the survey effort.

Ideally, the appropriate survey methods would be determined first, and then the budget and time constraints would be defined based on the selected approach. Usually, however, the survey method is selected with advance knowledge of the likely budget and schedule limitations. Thus, the challenge is to design the survey method or methods that will yield the most cost-effective data collection effort.

Regardless of whether the survey team is constrained by available resources, the selected survey methods should be based on anticipated data analysis needs. The decisions to be made in this regard include:

- **Which survey methods are appropriate, and which are likely to be the most effective at obtaining the needed modeling data?** As this manual will demonstrate, there are several different methods for completing each type of travel survey. The key design issue facing the survey team is which survey method is the most effective for obtaining the needed survey data. The strengths and weaknesses of different survey methods are discussed in Chapter 3.0. Later chapters discuss the choice of survey methods for specific types of surveys.

- **Which individuals or establishments should be included in the sample population?** The respondent population for travel survey efforts will depend on the particular survey data needs of an agency. For instance, if a survey is to be conducted as part of an effort to predict the effects of a potential transit fare increase, the best survey population is likely to be current transit riders. If the survey is being used to predict the effects of transit improvements, the best survey population would include both current transit riders and potential users.

- **What sampling frame or frames are available for sampling the relevant survey population? Do these sampling frames imply the use of any particular survey method, or exclude the use of any?** To conduct a survey, one needs to somehow enumerate (or list) the sample population so that a sample can be drawn. It is rare to find a perfect sampling frame, so the survey team needs to find or develop the best possible frame given available resources. Many lists are related to a particular survey method. For instance, some transit agencies maintain lists of riders and their telephone numbers that have been obtained from previous surveys. If such a list is to be used as a sampling frame, then the survey would have to employ a telephone method.

- **Should special measures be employed to enhance the likely respondent cooperation rate?** Travel surveyors have employed many mechanisms to increase survey response rates, including monetary incentives, letters of encouragement, and the personalization of survey materials for individual respondents. Since these mechanisms generally increase the cost of surveys, survey teams need to determine which of these to employ in a particular survey.

- **What procedures are needed to ensure that groups that are difficult to survey are included in the survey effort? What needs to be done to assure that respondents' language and literacy limitations do not significantly bias survey results?** Travel survey populations often include a number of subpopulations that are particularly difficult to survey. Travel survey designers need to take steps to encourage members of these groups to participate to the maximum extent possible.

- **What techniques are available (and which should be used) for obtaining the survey response data given a particular survey method?** Travel surveyors have conducted travel surveys using a number of data retrieval techniques. Mail surveys (and other self-administered surveys) have been conducted using standard questionnaires, bubble forms (similar to the forms used to record answers on standardized tests, like the SAT), and scratch-off forms, in which respondents can complete without a pen or pencil. Personal interview and telephone survey results can be recorded using pencil-and-paper techniques or by using a computer-assisted approach (CAPI or CATI).

Organization

In the organizational stage of the survey implementation process, the survey team defines the logistical requirements of the survey effort, and determines how the available survey resources are to be allocated. The organization task includes determining the following:

- Staff needs (including numbers and required special skills);
- The need for consultant contract help;
- The level of expertise required of interviewers and other fieldworkers;
- Field supervision needs;
- The need for special facilities;
- Equipment needs;
- Coordination needs (local agencies, police, etc.); and
- Citizens' participation and publicity needs.

Sampling

Almost all travel surveys rely upon sampling techniques in which a part of a total population is queried to make inferences about the population as a whole. Sampling a population, rather than conducting a full population census, has the following advantages:[2]

- Economy;
- Speed and timeliness;
- Feasibility; and
- Quality and accuracy (data collection for a census may be so difficult that the quality of data would be poorer than sample data).

The challenge facing the survey team is to select a sampling approach and sample sizes that will enable the development of reliable, accurate transportation demand models without overspending on an expensive data collection effort.

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[2] Leslie Kish, *Survey Sampling*, John Wiley & Sons, Inc., 1965, p. 18.

In theory, developing a statistically reliable survey sample involves the following steps:

- Identification of the survey population (or universe);
- Identification of sampling frame and selection of sampling procedures;
- Determination of necessary precision (sampling error) for one or more specific data items being collected;
- Calculation of sample size; and
- Estimation of necessary resources.

In practice, the survey design process will likely be constrained by the available resources from the beginning. While an agency might be able to reduce costs by reducing the amount of data collected for each unit or adopting procedures from elsewhere, the steps would still likely have to be modified to more closely resemble the following:

- Determination of available resources;
- Identification of survey population;
- Identification of sampling frame and selection of sampling procedures;
- Determination of maximum sample size based on procedures and resources;
- Determination of survey precision for one or more data items being collected; and
- Assessment of the adequacy of precision levels.

The Sample Design Workshop of the Second International Conference on New Survey Methods in Transport found that:

> "Little formal effort is usually given to the analyses of sample size requirements, primarily because budgets were almost invariably set prior to the technical involvement of the transportation analyst. These budgets reflect the expectations of administrators as to the cost of particular items of information, rather than any explicit considerations of required accuracy."[3]

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[3] Pete Fielding and Hugh Gunn. *Sample Design Workshop Summary* in Ampt, E.S., Richardson, A.J. and Brög, W. (1985). *New Survey Methods in Transport,* VNU Science Press: Utrecht, The Netherlands, p. 25.

The Workshop also identified the difficulty of determining necessary precision levels as a reason for first identifying the resource constraints, and then determining the resulting survey parameters:

> "The idea that there might be a single optimal allocation of resources was seen as an oversimplification, in that the end use of the data is generally an input to a large number of very different, but interdependent analyses. No single, most important output could be defined, so no natural criterion for optimality could exist."[4]

The basic principles of sampling for travel surveys are outlined in Chapter 5.0 of the manual. Later sections identify the most commonly used survey populations, sampling frames and sampling procedures for each type of travel survey. These sampling approaches are all variations and combinations of the most common sampling procedures:

- **Simple Random Sampling** - With this approach, sampling units are drawn randomly from the sample frame.

- **Systematic Sampling** - With this approach, rather than randomly selecting from the sampling frame, the analyst selects sampling units in sequences separated by a preset interval. Provided that the sampling frame order is relatively unbiased, this approach is essentially equivalent to the simple random sample. Often, in personal intercept surveys, fieldworkers are instructed to approach every `nth' person passing a certain point. Similarly, random-digit-dialing (RDD) telephone surveys are often conducted by calling every `nth' telephone number within a prespecified set of telephone exchanges.

- **Stratified Sampling** - If data are available to segment the survey population into subpopulations (or strata) prior to the sample selection, then this sampling approach may help to reduce sampling error or to reduce the amount of data collection needed. Household travel surveys commonly use stratified samples, based on measures such as household size and automobile availability.

- **Cluster Sampling** - With this approach, the sampling units are actually groups (clusters) of the survey elements rather than individual elements. All of the units within a selected cluster may be included in the sample, or a second stage subsample may be drawn from the chosen cluster. Workplace/establishment surveys are examples of cluster surveys. Some small number of establishments are first selected from the

[4] Pete Fielding and Hugh Gunn. *Sample Design Workshop Summary* in Ampt, E.S., Richardson, A.J. and Brög, W. (1985). *New Survey Methods in Transport,* VNU Science Press: Utrecht, The Netherlands, p. 25.

population of all establishments within a study area. Employees and visitors are then sampled within the selected establishments.

- **Choice-based Sampling** - When the data analyses require significant representation of a group or groups which are difficult to locate in the population at large, a sample may be drawn on the basis of the outcome of one of the choice processes under study. A common example of choice-based sampling is the collection of data from transit users on board transit vehicles for use in the development of mode choice models.

A number of textbooks deal with the details of survey sampling.[5,6,7]

Drafting and Constructing

The earlier steps of the survey implementation process dictate the types of survey forms that will be needed and the respondent information that will be required from the survey. Of particular importance will be the survey administration methodology; specifically, whether responses to survey questions will be completed by respondents or by trained interviewers. In the questionnaire drafting and construction step, the survey team develops the data collection instruments. The following tasks are needed for developing the actual survey instruments:

- Identification of the required survey instruments and related forms;
- Selection of the types and forms of the questions that will best address the data needs;
- Formulation of wording for the survey questions;
- Determination of the best sequencing for the questions;
- Refinement of the questionnaire to ensure that all questions are effective and necessary; and
- Design of the layout of the survey instruments.

[5] Peter Stopher and Arnim Meyburg, *Survey Sampling and Multivariate Analysis for Social Scientists and Engineers*, D.C. Heath and Company, 1979.

[6] Leslie Kish, *Survey Sampling*, New York: John Wiley & Sons, 1965.

[7] William Cochran, *Sampling Techniques*, 2nd edition, New York: John Wiley & Sons, 1966.

■ 2.3 The Field Implementation Stage

Pretesting

All travel surveys should be tested extensively before they are actually undertaken. Nearly all survey researchers stress the necessity and importance of pretesting questionnaires, but this is the stage of the survey implementation process which is most likely to be squeezed out due to time and cost pressures.[8] If the pretest is conducted appropriately, the surveyor will be able to improve the survey effort on a number of different fronts, including:

- Refining fieldworker and interviewer procedures and logistics;
- Testing and revising question wording, sequencing, and formatting;
- Comparing alternative approaches to gathering certain data items;
- Identifying unexpected responses and respondent behavior;
- Estimating the survey completion time; and
- Developing preliminary estimates of the variance in key variables to help establish final sample sizes.

If possible, travel survey pretests should be conducted in three steps: the office pretest, the questionnaire pretest, and the survey dry-run.

Office Pretest

The office pretest, whether conducted formally or informally, is likely to be the best mechanism for identifying problems with the questionnaire and with specific questions. Many researchers feel that the best way to discover potential survey problems before they occur is to have colleagues or other experts not involved directly in the survey design review the questionnaire and proposed procedures.[9] Two recent studies of pretest error detection rates support this thesis. These empirical studies found

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[8]Shelby D. Hunt, Richard D. Sparkman Jr., and James B. Wilcox, *The Pretest in Survey Research: Issues and Preliminary Findings,* Journal of Marketing Research, Volume 19, May 1982, pp. 269-273.

[9]See Paul E. Green, Donald S. Tull, and Gerald Albaum, *Research for Marketing Decisions,* 5th edition, Prentice Hall (Princeton NJ),1988.

that pretests that rely solely on samples drawn from the ultimate target population have fairly low error detection rates.[10,11]

Questionnaire Pretest

Although it is an important element of testing the questionnaire, the office pretest will be insufficient in most cases. Travel survey questionnaires should be tested on non-experts because they are often confusing to people without knowledge of transportation planning, and because the surveys often rely upon respondents' understanding of technical (and sometimes ambiguous) terms and expressions. For instance, a common challenge in travel surveys of all types is to get respondents to use a consistent definition for the term, "trip." The questionnaire pretest is the stage of the survey implementation process that ensures that respondents are answering in a consistent manner.

During the questionnaire pretest, respondents are administered the survey, and are asked to describe any problems or areas of confusion that they encounter. Often, these pretests are personally administered even when the ultimate survey will not be. It is becoming increasingly popular to conduct this portion of the pretest as part of a formal or informal focus group. This allows the analyst to observe first-hand how respondents react to the survey.

There are two procedures used to determine the respondents' reactions to the questionnaire. In the "protocol" method, the respondent is asked to think out loud as the questionnaire is being completed. In the "debriefing" method, the respondent completes the questionnaire and then talks about the questionnaire afterwards.[12] The protocol method is generally the better approach for identifying problems with specific questions; the debriefing approach is the better approach for identifying question sequencing and respondent tiring. Some surveyors have split the pretest so that some respondents use the protocol approach while others are debriefed.

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[10]Shelby D. Hunt, Richard D. Sparkman Jr., and James B. Wilcox, *The Pretest in Survey Research: Issues and Preliminary Findings*, Journal of Marketing Research, Volume 19, May 1982, pp. 269-273.

[11]Adamantios Diamantopoulos, Nina Reynolds, and Bodo Schlegelmilch, *Pretesting in Questionnaire Design: The Impact of Respondent Characteristics on Error Detection*, Journal of the Market Research Society 1994, Volume 36, Number 4, pp. 295-313.

[12]Nina Reynolds, Adamantios Diamantopolous, and Bodo Schlegelmilch, *Pretesting in Questionnaire Design: A Review of the Literature and Suggestions for Further Research*, Journal of the Market Research Society, 1993 Volume 35, Number 2, pp. 171-181.

The Survey Dry-Run

The final step of the pretesting task is to complete the survey on a small number of respondents in an identical manner to the full survey effort. Ideally, the pretest would encompass the whole range of survey tasks from sample selection to data analysis. This will ensure that all aspects of the survey effort are in place, and are operating as expected prior to the beginning of any data collection.

Sometimes, when the survey dry-run goes well, and the pretest timing and sample design are consistent with the larger effort, the data can be used in the general survey effort. However, surveyors need to allocate their time and money resources so that they are prepared to make changes in the questionnaire and procedures based on the outcome of the survey dry-run. If problems are found, the questionnaire(s) and/or survey procedures should be modified and re-tested if necessary. Ideally, this means that pretests would be completed well in advance (often a month or more) of the actual survey.

Training and Briefing

The quality of the fieldworkers, and interviewers in particular, will have a major effect on the success of the survey effort. Assembling a group of well-trained and consistent fieldworkers is not an easy task because of the nature of the work. Survey fieldwork is low-paying, generally part-time, intermittent work requiring the individual to have schedule flexibility, often during the evenings. The job requires excellent communication skills and reasonably good reading and writing skills. In addition, some travel surveys require fieldworkers to have a high level of mobility.

In many cases, direct supervision of fieldworkers is minimal, so they must be carefully trained and briefed on the travel survey effort. Training involves teaching or re-teaching the basic fieldwork skills necessary for a survey of the type being conducted. Training should include the following topics:[13,14]

1. Use of survey quota sheets, maps, building layouts, etc. (for field surveys).

2. Procedures for observing or counting individuals and for recording the information (field surveys).

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13 Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, p. 115.

14 Charles Backstrom and Gerald Hursh-Cesar, *Survey Research*, 2nd edition, John Wiley & Sons,

3. Procedures for contacting potential respondents and presenting the study to them (or reminding them of the study).

4. Procedures for screening potential respondents based on survey quotas or other criteria to determine whether to ask a particular person to participate.

5. The conventions used in the design of the questionnaire with respect to wording and skip instructions so that interviewers can ask the questions in a consistent and standardized way.

6. Procedures for using computer-assisted questionnaires (CAPI and CATI surveys).

7. Procedures for probing inadequate answers in a non-directive way.

8. Procedures for recording answers to open-ended and closed questions.

9. Rules and guidelines for handling the interpersonal aspects of the interview in a non-biasing way.

The fieldworker briefing provides the fieldworkers with specific information regarding the particular study. Generally, it is extremely helpful for the sponsoring agency to be directly involved in the briefing of fieldworkers, because agency personnel will best be able to describe the importance of the survey effort to their future efforts. Briefing issues include the following:[15,16]

1. Specific purposes of the project, including the sponsorship, the general analysis goals, and anticipated uses of the research. Fieldworkers need this information because they will need to provide respondents and others with appropriate answers to questions and because this information will help fieldworkers enlist cooperation.

2. Description of everything in the fieldworker kit (for field surveys).

3. Description of how the forms are to be completed (pencil-and-paper approach) or how responses are to be recorded on the computer (CAPI and CATI).

4. The specific approach that was used for sampling, again to provide a basis for answering respondent questions. In addition, there may be some training required in how to implement the basic sample design.

5. Details regarding the purposes of specific questions.

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[15] Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, p. 115.

[16] Charles Backstrom and Gerald Hursh-Cesar, *Survey Research*, 2nd edition, John Wiley & Sc

6. The specific steps that will be taken with respect to confidentiality, and the kinds of assurances that are appropriate to give to respondents.

7. Detailed description of procedures to follow if problems are encountered.

8. Procedures for contacting field supervisors (field surveys) or central location supervisors (telephone surveys).

In addition to providing fieldworkers with an understanding of the procedures to be employed in the study, the training and briefing sessions should motivate fieldworkers to believe that the survey work and their efforts are important, and that the highest quality data are needed. The participation of personnel from the sponsoring agency in the training/ briefing sessions may help fieldworkers understand the importance of their work.

Under ideal circumstances, the training and briefing sessions should impart the following attitudes to the fieldworkers:[17]

- **This Job is Important** - Stress the importance of this particular study: how it is intended to contribute to the public good, solve problems, and improve the community.

- **I Must Follow Instructions** - Teach the importance of following instructions, the necessity of proper field procedures, and the importance of consistency.

- **Biases can Cripple Data** - Teach fieldworkers about the destructive role of the biases that they can bring into the research effort.

- **Research is Important** - Communicate the value of research: how research information improves our ability to make decisions, to solve problems, to contribute to the common goals of society, and to save money and resources.

- **Surveys Work** - Stress that surveys can be valid, reliable measures of people's information, attitudes, preferences, and behavior.

- **People Like to Participate in Surveys** - Help fieldworkers understand that they are not snoops or irritants: many people like to express their opinions, they know about polls, they are usually flattered to be chosen, and they are curious about how it all works.

- **I Am a Professional** - Each fieldworker should believe: "I have a job to do; I am a professional being paid for services rendered."

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[17]Charles Backstrom and Gerald Hursh-Cesar, *Survey Research,* 2nd edition, John Wiley & Sons, 1981, p. 248.

- **Randomness Works** - Each fieldworker should believe: "no matter what I think about who should be part of the sample, we are likely to get a better (more fairly representative) sample by relying on chance and the survey selection procedures, rather than personal decisions about whom to interview."

- **The Respondent is Entitled to Courtesy** - Each fieldworker should understand that "I must respect the people whose time I am using, and I must treat all respondents with equal courtesy."

- **The Respondent is Entitled to Privacy** - Warn that respondents usually are more comfortable expressing themselves privately on some issues, so fieldworkers must help to ensure that privacy.

Interviewing and Questionnaire Distribution

The data collection fieldwork tasks of the survey implementation process are where the considerable planning efforts of the survey designer are actually put to the test. Unfortunately, these data collection tasks are usually those over which the designer has the least control. They are also the tasks where the greatest amount of uncorrectable bias can enter the process. Major interviewer and fieldworker errors are very costly because they may require redoing part or all of the fieldwork, but small errors by interviewers and fieldworkers may be as bad. These smaller errors are often undetectable, and may greatly increase the level of bias in the survey results, unbeknownst to those analyzing the data.

To ensure that fieldworkers are performing the necessary survey functions in the non-biasing and consistent manner for which they have been trained, adequate supervision is essential. For some types of surveys, such as telephone surveys, supervision techniques have been developed that help to identify problems and help interviewers to correct them immediately. For instance, central site telephone survey supervisors can maintain up-to-the-moment statistics on interviewer completion rates, average completion times, and item non-response levels. Telephone survey supervisors can usually monitor individual interviews if problems with particular interviewers are detected. However, the cost and logistics of supervision for some types of surveys, such as in-home personal interviews, can be prohibitive.

Some key issues for fieldwork supervisors in evaluating the fieldwork as it occurs are the following:

- Are the survey response rates and cooperation rates different than expected prior to the survey fieldwork?

- Are the costs per completed interview different than expected prior to the survey?

- Is the quality of the completed questionnaires and interviews - response rates, validity of responses, legibility - as expected?

- Are survey fieldwork procedures working adequately? Are staff being utilized efficiently?

- Are fieldworkers completing their tasks consistently?

- Are survey response rates and cooperation rates significantly lower or higher than the average for a specific fieldworker (a low response rate will affect survey cost while a high response rate might suggest improper survey techniques)?

If problems are detected during the fieldwork process, the survey team should be ready to modify the procedures or retrain (or replace) field-workers, as necessary. Such modifications are generally very challenging since the available information on which to make decisions is limited, and the underlying reasons for the detected problem(s) are usually not obvious.

■ 2.4 The Data Preparation Stage

Coding and Data Entry

During the coding step of the survey process, the raw survey data are translated into codes usable for model development and presentation of results. The objective of the survey team in this step is to "unambiguously assign each survey answer to one and only one analytically meaningful code."[18]

Most travel surveys rely on a three-step process for converting responses to usable data:

1. The respondent or fieldworker records a response;

2. The coder translates the response into a pre-specified code; and

3. The data entry specialist keys the response into a database.

Many survey instruments can be designed to be "self-coding" without damaging the clarity of the questions. These surveys greatly reduce or eliminate the work of the coder. In addition, the interactive processing

[18]Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, p. 130.

available with computer assisted telephone interview (CATI) and computer assisted personal interview (CAPI) surveys reduce these steps to a single automated step. Computer assisted survey techniques also allow interviewers to check for the reasonableness of responses vis-à-vis other responses in the interview, and to correct problems prior to losing contact with the respondent.

Of particular interest are recent improvements in technologies to perform geocoding, the translation of locational survey data into a usable format. Chapter 14.0 discusses geocoding issues in some detail.

Editing and Cleaning

Once the survey data have been entered, the survey team should systematically analyze the results to identify data problems. Three editing and cleaning tasks can be conducted:

1. Simple data cleaning to correct coding and data entry problems;

2. Validation of survey responses; and

3. Application of analytical techniques to reduce non-response.

The first step is to verify the completeness of each record. Next, each data field should be checked to make sure only legal codes are entered. Then, the analyst should evaluate the internal consistency of the responses to related questions.

Manual checking of the survey data by surveyors or editors is essential, but writing specialized programs to perform automated checking of data files is usually also worthwhile. Such programs can consistently perform intra- and inter-record data checks that would be impossible to perform manually. For example, a survey record might include the beginning and ending time of an activity or trip with associated "am" or "pm" codes. If one of the codes is mis-keyed, the resulting data could imply that the activity or trip ended before it began, even though all data passed specified range checks.

Likewise, a household included in a home interview survey might have five members. If data for one of the household members was skipped in data entry, the error would never be caught via simple range checks of specific data items. Survey data that are "clean" in terms of range checks for specific data items often contain illogical data. Such errors can affect resulting data summaries and travel models.

If problems are identified with a particular response, the analyst should refer to the original sources, the completed interview sheets or the returned questionnaires. The error(s) in the database should be corrected if possible, but if the error involves more than coding and entry errors, the record will need to be marked unusable and dropped from the analysis database. As one would expect, tracking down and correcting errors in large survey databases is a long, slow, and inefficient process. It is generally much more cost-effective to spend extra time on the coding and data entry tasks to avoid large editing tasks.

CATI and CAPI surveys offer the opportunity to perform data cleaning and consistency checks on-line, while respondents are still accessible, but one of the drawbacks of computer-assisted interview surveys is that there is no source which to refer to when incorrect or inconsistent data are found in the database after the survey. Therefore, it is essential that editing, cleaning, and consistency checks be built into the programs. If operators enter invalid information during an interview, the computer should prompt them to try again.

The second editing/cleaning task that is sometimes performed is to validate a small sample of the survey responses by recontacting respondents and reviewing their responses. This process can be conducted on a random sample basis to ensure that each fieldworker completed the work he or she was supposed to complete, and to ensure that responses were completed consistently. The validation process can also be used selectively if there is some question about the work of certain fieldworkers. Finally, validation can be used for responses with identified problems to limit the number of non-usable responses.

The final editing task available to analysts is to apply statistical procedures to impute the values of missing or incorrect data elements. In almost every survey, some respondents will be unwilling or unable to answer all the questions posed to them. In addition, many respondents will knowingly or unknowingly respond to questions inaccurately. Some question types are more susceptible to item non-response and inaccuracy than others, with questions about income generally being the most problematic. Some analysts have statistically related the variable in question to other survey variables or other data sources, such as Census data, to be able to use the response more effectively in subsequent analyses.

This approach is still much debated, however, since bias could be increased in some cases, and because many analysts believe that imputing values implies that the answer to the question is already known. The survey team has other options, including:

- Ignoring the non-response (if the sample size is sufficient without them); and

- Using a modeling variable to describe the non-response.

These and other mechanisms for reducing non-response are discussed in later chapters.

Programming and Compiling

The final steps of the survey process covered in this manual relate to preparing the survey data for modeling and other analyses. Fortunately, the task of compiling survey datasets has been greatly simplified since the days of the previous Travel Survey Manual, when piles of perforated computer cards awaited the analyst. Today, survey data are generally entered in ASCII data files which are easily read into any of the available statistical analysis software packages. Thus, the compilation task is quite straightforward.

However, there are three key programming and compiling tasks that are of special interest to the modeling analyst:

- The determination of data storage needs;

- The development of one or more survey response weighting schemes; and

- The tabulation of survey results.

Large survey efforts require a great deal of data storage. Often, the survey database from a travel survey will use in excess of 60 megabytes, excluding any constructed variables or analysis results (which could easily double the size of the file). The survey team should make rough calculations of the data storage requirements once the survey coding requirements are known, and should plan to invest in expanded storage if necessary.

The determination of survey weights is a key element of the survey analysis. Depending on the modeling analysis needs, results obtained from surveys that are designed to (or accidentally) oversample or undersample some groups of the population usually need to be weighted so that members of the subgroups are proportionally represented in the population as a whole. Some analyses will require the use of the weighted data while others will not. Often, different weighting schemes are used depending on the analysis that is being applied.

Tables 2.2 and 2.3 illustrate two weighting exercises. Table 2.2 shows the calculation of work trip mode weights for a recent household travel survey. The first columns of the table shows the modal distribution of work trips obtained from a survey of 8,346 work trips. The following columns show the actual modal distribution for the study area based on best available information, including the Census Journey-to-Work data. To make conclusions about the work trip mode split from the survey data, it is

Table 2.2 An Example of Travel Survey Weighting: Work Trip Mode Choice

Mode	Survey Returns	Percent of Returns	Estimated Modal Usage	Estimated Shares	Survey Weight
Walk	33	0.4%	191,614	2.8%	6.992
Drive Alone	4,721	56.7	5,157,659	74.4	1.315
Drive HOV2	240	2.9	256,376	3.7	1.286
Drive HOV3+	78	0.9	106,896	1.5	1.650
Auto Passenger	564	6.8	737,868	10.6	1.575
Local Bus – Walk Access	2,314	27.7	362,661	5.2	0.189
Local Bus – Park & Ride	39	0.5	4,755	0.1	0.147
Local Bus – Kiss & Ride	59	0.7	4,417	0.1	0.090
Express Bus – Walk Access	130	1.6	23,046	0.3	0.213
Express Bus – Park & Ride	76	0.9	7,508	0.1	0.119
Express Bus – Kiss & Ride	29	0.3	2,310	0.0	0.096
Bicycle	63	0.8	76,127	1.1	1.455
Total	**8,346**	**100.0%**	**6,931,237**	**100.0%**	

Table 2.3 An Example of Survey Weighting: Choice of Transit Ticket Type

Ticket Type	Survey Returns	Percent of Rides	Mean Trips Per Rider Per Month	Percent of Riders
Cash Fare	203	34%	35.9	47%
Monthly Bus Pass	301	50	64.6	39
Cash Fare and Transfer	44	7	34.7	11
One Way Ticket	8	1	46.2	1
Student Fare	1	0	40.0	0
Senior Citizen Fare	42	7	31.5	11
Total	**599**	**100%**	**50.1**	**100%**

necessary to weight each survey response by the ratio of the actual share divided by the survey share. For instance, the survey work trips that were made by walking need to be weighted by (191,614/6,931,237)/(33/8,346) = 6.99.

Table 2.3 illustrates another common weighting exercise. As discussed below, transit onboard surveys generally sample transit trips. To make conclusions about transit riders, one needs to weight the survey results by individuals' frequency of transit usage. The example shows survey results for a question about the respondents' choices of fare types. Monthly pass trips accounted for 50 percent of the surveyed trips, but because monthly pass users use transit more frequently (based on another survey question) they represent only 39 percent of transit users. Users of the data would want to use the weighted percentages to make conclusions about riders, and the unweighted percentages to make conclusions about transit trips.

The final programming task is the tabulation and cross-tabulation of the raw and weighted survey results. Because the survey team will usually soon be immersed in detailed and time-consuming model estimation efforts, a useful final step for the survey work is to produce a complete set of cross-tabulations of the survey results. The tabulations will be a useful reference source for the analyst while he or she develops the travel models, and they will provide interested, less technical parties with a great deal of information on the survey population under study. For most agencies, it is advantageous to produce travel survey results reports as quickly as possible. These reports will provide funding agencies and other interested groups and individuals with evidence that the travel survey effort was more than a purely academic effort used to develop obscure modeling parameters.

The preparation of clear, concise data documentation is an important task. Too often, final datasets are documented by a list of variables and a copy of the survey instruments. A data dictionary that clearly delineates the file format(s) and the data contained in each field should be prepared, including allowable codes and meanings. This is especially true if derived variables (such as zone numbers) or independently estimated information (such as weighting factors) have been added to the dataset.

Finally, care must be taken to ensure confidentiality of the data. Many surveys collect personal information - number of household members, ages of household members, household income, typical daily travel patterns, and household addresses. Such a database could be a valuable tool to a "high-tech" thief. Care should be taken to ensure that data files containing personal information are never distributed with detailed address or locational data (e.g., latitude and longitude).

3.0 Options for Travel Surveys

This chapter describes the different types of travel surveys, the general types of survey data typically sought in each type of travel survey, and the available survey methods currently being used for each type of travel survey.

■ 3.1 The Types of Travel Surveys

This manual discusses the seven most common types of travel surveys used to learn more about (and to model) the behavior of users of highway and transit facilities. Each of the survey types provides a unique perspective for input into travel demand models, so the selection of the appropriate travel survey type should be based on the development or revision plans for the models themselves.

Household Travel/Activity Surveys

Traditionally, the most important building block for urban and regional travel demand models has been the household travel survey. In a household travel survey, respondents are contacted in their homes and are queried about their household characteristics, the personal characteristics of members of the household, and about recent travel experiences of some or all household members.

Household travel surveys have been conducted in the United States for more than 40 years, but because of the extensive effort required, most regions have conducted only one or two of these surveys. The first generation of household travel surveys are characterized by those that were conducted in the 1960s to address the requirements of the FHWA's 3-C planning process. These surveys were conducted by sampling households in the region and sending survey staff to the households to solicit cooperation and to conduct interviews. In some cases, the survey workers left survey materials, including travel diaries for each household member for an upcoming period of time and then returned to collect the travel information, but usually the surveys asked respondents about recent past travel.

Usually, the primary focus of the household survey was to assemble origin-destination data based on fairly coarse zone systems. The U.S. Department of Transportation's sample size recommendations for household surveys ranged from one dwelling unit out of 25 for study area populations over one million people, to one dwelling unit out of five for study area populations under 50,000 people. The same guidelines set the range of "minimum sample sizes" to between one out of 100 dwelling units for the largest areas, to one out of 10 dwelling units for the smallest areas.

Most planning agencies developed their four-step transportation demand models primarily from the data that they gathered in their 1960s household surveys. In many cases, these models continued to rely on the 1960s household survey data for the next 20 to 30 years.

The first generation in-home survey method was considered to be the acceptable procedure for household travel surveys throughout the 1970s and the first part of the 1980s, though significantly fewer major household survey efforts occurred in this period than the preceding period.

During the 1980s, planners began to recognize the need for updated household travel data. However, the new household survey methods that survey designers employed were significantly different than the earlier efforts. In the past several years, most household travel surveys have been conducted by using telephone or mail surveys or some combination of the two. In addition, typical sample sizes measured as a percentage of the survey universe have been reduced to one-quarter to one percent of study area dwelling units. This decrease in sample size has lead to very little decrease in the overall accuracy of the survey results because the newer surveys rely on more efficient stratified sampling techniques and because modelers generally apply disaggregate modeling techniques to develop origin-destination data, rather than rely solely on the survey data. Collecting travel data through diaries instead of through recall techniques is now common practice, and many recent surveys have redefined the diary unit from the simple trip to more detailed elements of the trip, or to activities that can be related to trip making.

Several factors contributed to the development of the second generation of household travel surveys in the U.S. The most important factor was the need to reduce the high costs-per-interview and logistical difficulties of the in-home interview. Advances in commercial market research allowed transportation planners to develop alternative approaches. At the same time, developments in travel model research and inadequacies in traditional travel models have lead planners to consider issues such as trip-chaining, activity-based modeling, and time-of-day modeling.

Despite the changes, the household travel or activity survey remains the best source of regional trip generation and distribution data for most regions. It is highly likely that household travel and activity surveys will be central to the development of microsimulation-based modeling systems, like TRANSIMS.

In addition to being used for developing, revising, and updating regional modeling efforts, household travel surveys are being used in the following ways:

- Some transit agencies use household travel surveys to conduct surveys of transit users and non-users in their regions. The surveys are used to estimate transit market share and to assess differences between actual transit users and potential users.
- Agencies have performed household travel surveys in advance of major infrastructure projects to help assess the potential demand and to determine the level of public support.
- Agencies sometimes perform household travel surveys simply to increase their understanding of travel in their regions, and to be able to address specific questions that policymakers may raise.

A renewed research interest in the household travel and activity survey is demonstrated by the recent Transportation Research Board Conference on Household Travel Surveys: New Concepts and Research Needs. In recent years, research on household travel and activity surveys conducted in Europe and Australia has been particularly interesting because many planners in those countries are trying to develop advanced modeling techniques, but with much better survey climates than in North America. Recent publications by Richardson, Ampt, and Meyburg and by Axhausen provide some information on these international survey efforts.[1,2] Chapter 6.0 describes the typical procedures used to conduct household travel surveys.

Vehicle Intercept and External Surveys

Vehicle intercept survey data are used by travel demand modelers for three purposes:

- To provide origin-destination data and other data on trips that come into or go out of the model study area for modeling internal-external and external-external trips (external survey);
- To provide origin-destination data and other data for auto travelers in a particular corridor for sub-area and small area models; and

[1] K.W. Axhausen, *Travel Diaries: An Annotated Catalogue,* University of London Centre for Transport Studies Working Paper, November 1994.

[2] Anthony Richardson, Arnim Meyburg, and Elizabeth Ampt, *Survey Methods for Transport Planning,* Eucalyptus Press, Melbourne, 1995.

- To provide origin-destination data and other data for auto travelers crossing important internal cordons, screenlines, and cutlines that can be used for travel model validation.

Unlike the household surveys, these surveys rely on intercepting or observing people in the course of travel. These surveys are conducted by stopping vehicles and then interviewing drivers or distributing mailback questionnaires to them, or by observing vehicle license plates and then recontacting the owners of the vehicles. Traditionally, these surveys have focused on gathering information on the particular trip being made at the time of the intercept with little emphasis on other information. Chapter 7.0 describes the typical procedures used in the collection of vehicle intercept and external surveys.

Transit Onboard Surveys

Transit onboard surveys are similar to the vehicle surveys in that they are intercept surveys and use a choice-based sample population (to be eligible for the survey, the respondent has both decided to travel and to use the particular mode of interest). Transit onboard surveys are generally conducted for two reasons:

- To provide modelers with transit trip origin-destination data and transit rider characteristics, which in many regions is very difficult to obtain from the household survey because transit trips may make up a very small proportion of total trips; and

- To provide transit planners with ridership data that will allow them to analyze changes in service.

Generally, transit onboard surveys collect trip-specific travel data and some limited respondent information. Often, planners are interested in surveying both users and non-users (or infrequent users) of transit services. This is generally accomplished by using a combination of transit onboard surveys and either household travel survey techniques or vehicle intercept survey techniques. Chapter 8.0 describes the issues related to transit onboard surveys.

Commercial Vehicle Surveys

Travel demand modeling for commercial vehicles is somewhat primitive compared to passenger travel modeling. However, ISTEA's intermodal planning requirements have added to the importance of commercial vehicle data collection. Some information on commercial vehicle travel can be obtained through household surveys and vehicle intercept surveys, but the only way to accurately analyze the universe of commercial vehicle trips is through a commercial vehicle survey.

Commercial vehicle surveys are used primarily to obtain origin and destination data for trucks, taxis and other commercial vehicles. Recent efforts have also begun to obtain more detailed trip purpose and truck contents information. This information can be used in the development of disaggregate urban commodity flow models. Chapter 9.0 discusses commercial vehicle surveys.

Workplace and Establishment Surveys

Establishment surveys are used to collect travel information about trip attraction sites. These surveys generally collect traveler characteristics and trip origin and destination data. Typically, workplace surveys are designed as intercept surveys where respondents are surveyed as they enter or leave their workplace or another establishment. In some cases, workplace surveys are centrally distributed to employees by employers or employer transportation management agencies. In these cases, the survey method is more of a general population survey, like the household survey.

A special application of the workplace/establishment survey is the special generator survey. Special generator land uses are unique to a region (such as an airport, university, or large shopping mall), or they attract and produce significantly more trips than would be indicated by their employment, square footage, or land area. Since trip rates to and from these sites might be significantly different, surveys of trips to and from these locations can be especially useful. Chapter 10.0 presents descriptions of workplace, establishment, and special generator surveys.

Hotel/Visitor Surveys

In many parts of the country, a large percentage of the daily regional travel is conducted by visitors or tourists to the region. In some of these areas, planners have sought, or are seeking, to develop visitor travel demand models. The household travel or activity survey could be used to account for some of this travel if data are collected from visitors staying in local residents' homes. However, visitors staying in hotels, motels, or other lodging would elude the household survey, and there are likely to be significant differences between the travel patterns of those visitors staying with residents and those who pay for their accommodations.

Visitor travel could theoretically be surveyed by one of the intercept methods discussed in Chapters 7.0 and 8.0 (transit onboard or vehicle intercept), but collecting the needed trip generation information with these survey methods would be practically impossible. To obtain the necessary visitor data, some metropolitan areas have conducted hotel visitor surveys. A description of this survey method is presented in Chapter 11.0.

Parking Surveys

The latest generations of travel demand models have recognized the importance of parking supply, costs, and subsidies on travel decisions. When detailed parking information is needed, parking surveys are sometimes used. During a parking survey, fieldworkers conduct interviews with, or distribute questionnaires to people as they enter or leave parking facilities, or leave questionnaires on the windshields of parked cars.

Parking surveys are similar to workplace/establishment surveys in that travelers are usually surveyed at the attraction end of their trips, but parking surveys generally seek to collect more detailed information about parking and access issues. Parking survey procedures are presented in Chapter 12.0.

■ 3.2 Selecting the Proper Types of Travel Surveys

The selection of the proper types of surveys to use in developing or enhancing travel models should be based on the type of data required for the models, each survey type's survey population, the data available from each type of survey, and the cost and complexity of fielding the survey. The cost and complexity of the survey type is related to the actual marketing research techniques needed to complete the survey effort.

The Modeling Uses of Survey Data and The Survey Populations

Table 3.1 shows the most common survey population or populations and the most common data uses for each type of travel survey considered in this Manual. In selecting the most important and cost-effective travel surveys for modeling purposes, the analyst needs to determine whether the survey type will truly reach the most appropriate population or universe. For instance, it is important to note that the survey populations for the intercept surveys are not the travelers, but instead are the trips themselves. Conversely, the general population surveys, such as the household survey, have populations which are based on the trip-making unit, not the trip. These distinctions can have important implications on the models that are developed with these survey data, particularly when the two types of data are combined.

Table 3.1 Common Survey Populations and Modeling Uses of Different Travel

Survey Type	Common Survey Populations	Common Modeling Uses of Data
Household Travel or Activity Surveys	Households within a pre-specified study area **OR** People within a pre-specified study area.	Trip generation, trip distribution, mode choice, time-of-day of travel, traveler behavior
Transit On-board Surveys	Transit passenger trips on a pre-specified set of transit services.	Mode choice
Vehicle Intercept or External Station Surveys	Vehicle-trips on one or more highway segments, perhaps by direction **OR** Person-trips by vehicle on those highway segments.	Trip distribution, model validation
Commercial Vehicle Surveys	Commercial vehicles garaged within a pre-specified study area **OR** Commercial vehicle trips made by those vehicles.	Commercial vehicle travel (generation, distribution, time-of-day)
Workplace, Establishment and Special Generator Surveys	Employees of pre-specified establishments **OR** All trips to and/or from the establishment.	Trip attraction models, parking and transit cost/subsidy
Hotel and Visitor Surveys	Hotel guests at pre-specified establishments **OR** All trips to and/or from the hotel.	Visitor models (generation, distribution, time-of-day)
Parking Surveys	All vehicles parked at pre-specified locations during a pre-specified time period **OR** All vehicle or person-trips to those parking locations.	Parking cost (for mode choice)

Usually expansion data can be collected in the survey (or along with the survey) that will allow the modeler to weight the survey results to a different survey universe, but the cost of obtaining these data need to be considered in deciding whether a particular survey type makes sense. For instance, the analysis of vehicle intercept surveys generally requires high quality vehicle count and classification data to expand the survey results.

The most appropriate type of travel survey depends on the data needs of the surveyor. Usually, travel modeling analysis requirements dictate the types of surveys that are needed. Household travel surveys are particularly relevant for current travel models. These surveys can provide information on the number and distribution of trips being made and the travel modes being selected by individuals within households, as well as the household and the individual's characteristics.

The other survey types can provide specific data that modelers want or need to develop or enhance travel models. The detailed model plan will determine the data needs, and therefore the survey types that are needed.

Of course, there are reasons other than travel model development/ enhancement for conducting travel surveys. For instance, transit onboard surveys are often conducted for developing new transit routes or modifying existing ones. Vehicle intercept surveys are commonly used in site impact planning. Surveys developed for different reasons can be, and often are, used in travel modeling efforts, so it is extremely helpful to design and coordinate these surveys with this in mind.

Travel Survey Data

Travel surveys can be used to collect several kinds of information from respondents, including:

- Factual information about themselves or their households or other affiliations (socioeconomic, demographic, employment data);
- Behavioral travel information about one or more trips or travel-related activities (revealed preference travel data);
- Test-of-knowledge information (data used to determine respondents' familiarity with a particular subject);
- Attitudinal information and perceptions (data from ratings, rankings, or comparisons of actual or hypothetical subjects);
- Opinion information (data gathered from open-ended responses);
- Stated response travel information (stated preference data compiled from tradeoff analyses and other hypothetical choice exercises); and

- Longitudinal information (data gathered from the same or similar respondents over a period of time).

Figures 3.1 through 3.6 show example portions of travel surveys seeking each of the first six of these data types. The seventh type of data, longitudinal information, can actually be any of the first six types, but tracked over a period of time through successive surveys.

Each type of survey is well-suited to obtain certain types of these data. Figure 3.7 summarizes the kinds of data that each type of survey has been or could be used to collect.

Traveler and household information is commonly obtained from all the survey types, except surveys of freight movement. The best types of surveys for collecting large volumes of these data are the household travel/activity survey and the workplace survey with centrally-distributed questionnaires. These survey types are based on samples of the individuals for which the socioeconomic/demographic data are being collected, rather than the trips that they are making, so frequency weighting can be averted. In addition, when a great amount of these data are needed, the intercept survey methods may be practically inadequate. The two most common survey methods for intercept travel surveys, short interviews of travelers in the course of their travel, and personally distributed mailback questionnaires, have limited lengths so it is difficult to include many socioeconomic or demographic questions in these surveys. Sometimes, the intercept survey types are used as an initial recruitment followed by a household travel/activity survey to obtain the more detailed data.

Revealed preference travel data can be obtained from any of the survey types, but the individual survey types are particularly well-suited for collecting certain types of travel behavior data. Household surveys are commonly used to obtain detailed travel and activity diary data. The ability to contact each household member and the ability to use more complicated questionnaires with this type of survey make it the best choice for collecting household diary data. Commercial vehicle surveys can also be used to obtain diary-type information, but generally the sampling units in these surveys are the vehicles, rather than people or households. Diary data are generally not collected using the other types of surveys because of the length and complexity of the questions, and because not all household members can be easily contacted through these methods.

The other types of surveys are usually used to collect information on the specific trips that respondents were making when they were intercepted or observed. The household and commercial vehicle surveys sometimes

Figure 3.1 Example Factual Information Questions

	PERSON NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
	YEAR OF BIRTH	19__	19__	19__	19__	19__	19__	19__	19__	19__	19__	19__	19__
RELATIONSHIP OF THIS PERSON TO YOU	Self	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Spouse	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Son/Daughter	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Father/Mother	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Brother/Sister	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Other Related	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Not Related	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SEX	Male	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Female	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
HAVE A VALID DRIVER'S LICENSE?	Yes	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	No	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
EMPLOYMENT STATUS	Employed Full Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Employed Part Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Self-Employed	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Unemployed	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
IF EMPLOYED TYPE OF INDUSTRY	Finance/Insurance/Real Estate	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Retail Trade	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Service	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Agriculture/Mining	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Construction	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Wholesale Trade	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Government	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Manufacturing	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Transportation/Communications /Utilities	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ENROLLED IN SCHOOL?	No	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Full Time Student	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Part Time Student	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Source: SCAG Household Travel Survey, 1991 (Part of a Mailed Survey Instrument).

Figure 3.2 Example Travel Behavior Questions

1995 NATIONWIDE PERSONAL TRANSPORTATION SURVEY TRAVEL DIARY

Complete one line below for each time you traveled from one place to another on your travel day.

- Remember to record each return trip to home or work.
- Be specific. Record each place you went on a separate line, even if you stopped several places on one journey.
- The first trip should be the first place you traveled to after 4 a.m.
- The last trip should be to your home, or wherever you ended the day.

SARAH (30)

Monday 03/13/95

	WHERE DID YOU GO? (home, bus stop, bank, restaurant, work, friend's house, etc.)	WHAT IS THE ADDRESS, OR NEAREST ROAD INTERSECTION?	WHAT TIME DID YOU BEGIN YOUR TRIP?	HOW FAR DID YOU TRAVEL TO GET THERE? (6 blocks, 3 miles, etc.)	WHAT MEANS OF TRANSPORTATION DID YOU USE? (car, bus, subway, walk, bike, etc.)	HOW LONG DID IT TAKE TO GET THERE?	WHO WAS WITH YOU? (friends, son, wife, coworker, no one, etc.)
1	Rosewood Elem. School	Ferndale Rd. & Murray Ave.	7:15 ☒ am ☐ pm	3 miles	car	10 minutes	son
2	Work	9001 E. Washington Ave.	7:25 ☒ am ☐ pm	22 miles	car, subway, walk	48 minutes	no one
3	Restaurant	Elm St. & 3rd St.	11:45 ☒ am ☐ pm	4 blocks	walk	10 minutes	2 coworkers
4	Drug Store	5th Ave & Smith St.	12:40 ☐ am ☒ pm	2 blocks	walk	5 minutes	2 coworkers
5	Work	9001 E. Washington Ave.	12:50 ☐ am ☒ pm	2 blocks	walk	8 minutes	2 coworkers
6	Day Care Center	603 Wilson Rd.	4:00 ☐ am ☒ pm	21 miles	walk, subway, car	53 minutes	no one
7	Library	N. Main St. & Rosewood Dr.	5:05 ☐ am ☒ pm	2 1/2 miles	car	7 minutes	son
8	Home	1621 Forrester Lane	5:15 ☐ am ☒ pm	2 miles	car	15 minutes	son
9	Playground	Lexington Rd. & S. Broad St.	6:30 ☐ am ☒ pm	1 mile	bike	10 minutes	son, husband
10	Home	1621 Forrester Lane	7:20 ☐ am ☒ pm	1 mile	bike	10 minutes	son husband
11			__:__ ☐ am ☐ pm				
12			__:__ ☐ am ☐ pm				
13			__:__ ☐ am ☐ pm				
14			__:__ ☐ am ☐ pm				
15			__:__ ☐ am ☐ pm				

OMB No.:2125-0545 Exp.:8/30/96

Source: Nationwide Personal Transportation Survey, 1995 (Part of a mailed survey instrument).

Figure 3.3 Example Test-of-Knowledge Question

Post-Implementation Survey

Programming Draft
April 9, 1993

C44. *Ask if Q.C42 = 1:*
Can you tell me in as much detail as possible what the advertisements said?

{preliminary precoding list.}

"Showcase" Print and Subway System Ads	
Improving the "A" line between 125th and 207th Streets. "Make the World a Better Place."	1
More frequent weekend service. "If only weekends came more often."	2
Other TA Print and Subway System Ads	
"Going your way."	3
New subway cars / overhauled cars.	4
Faster service. "Blue tights and red cape."	5
Undercover cops.	6
On-time performance better than 90%.	7
Station Managers.	8
Non-TA Print and Subway System Ads	
Fare Increase. "Maybe it's not just the train that's taking you for a ride."	9
Funeral. Funding for the Subway.	10
Radio Ads	
"Makeover." System improving. Better than before.	11
New subway cars.	12
500 new police officers.	13
Better platform lighting.	14
On-time performance.	15
Decline in crime.	16
Express trains.	17

Source: New York MTA Household Survey, 1993 (Part of a CATI Telephone Survey Instrument).

Figure 3.4 Example of an Attitude/Perception Question

22. This month, how do you rate BART in each area below:
(Excellent - 1, Very Good - 2, Good - 3, Fair - 4, Poor - 5)

1. On-time performance	______	(30)
2. Station cleanliness	______	
3. Train cleanliness	______	
4. BART personnel	______	
5. Parking	______	
6. Security	______	
7. Train announcements	______	
8. Station announcements	______	
9. Telephone transit information	______	(38)

Source: BART On-Board Survey, 1993 (Part of Personally Distributed Mailback Survey Instrument).

Figure 3.5 Example of an Opinion Question

21. What one thing could NJ TRANSIT do that would most improve your bus travel?

____

____

____

____

office use [ ]

Source: New Jersey Transit On-Board Survey, 1991 (Part of Personally Distributed Mailback Survey Instrument).

Figure 3.6 Examples of Stated Preference Questions

19. A new type of travel called maglev has been proposed. With this system, high speed trains would travel between cities along specialized elevated tracks, following the routes of major highways. The train interiors and the on-board services would be similar to existing airline service. The stations would offer the same services as small airports.

    Suppose these trains were available to you for the trip you were making when you were given this form. As you did in the last question, please rank the different travel options described below.

You travel by	Time on train to get to the city you were traveling to	One-way travel cost per person, including fares and the cost to get to and from stations	Total time to get to and from the train by car, taxi, or public transit	Train frequency	Rank
Maglev	3 hours	$60	20 minutes	Departs every 2 hours	
Maglev	2½ hours	$50	60 minutes	Departs every 1½ hours	
Maglev	2 hours	$100	50 minutes	Departs every hour	
Maglev	1½ hours	$75	30 minutes	Departs every 3 hours	

20. Now, please rank the services described below from 1 to 4 for the specific trip you were making when you were given this form.

You travel by	One-Way Travel Cost	Total Travel Time (door to door)	Frequency	Rank
Auto	Same times and costs as your current trip			
Maglev	$75	3 hours	Departs every 2 hours	
Maglev	$125	1½ hours	Departs every hour	
Maglev	$100	2½ hours	Departs every 2½ hours	

21. In ranking the options in the last question, what was the most important factor for choosing the order that you did?

- ☐ Mode of travel
- ☐ Travel cost
- ☐ Travel time
- ☐ Frequency of service
- ☐ A combination of the factors (*please list*) ______________________

____

Source: NYSDOT and Mass EOTC Vehicle Intercept Survey, 1993 (Part of Vehicle Intercept Mailback Survey Instrument).

Figure 3.7 Types of Survey Data Available from Different Travel Surveys

Survey Data	Surveys Before or After Travel			Surveys During the Course of Travel (Intercept Surveys)					
	Household Travel/ Activity	Commercial Vehicle (Fleet Manager Surveys)	Workplace/ Hotel/ Establishment (Centrally-distributed Surveys)	Transit Onboard	Vehicle Intercept/ External Station	Commercial Vehicle (Intercept Surveys)	Workplace/ Hotel/ Establishment (Intercept Surveys)	Special Generator	Parking
Socioeconomic/demographic data on travelers and/or their households	●	○	●	●	●	◒	●	●	●
Revealed preference travel data									
– travel diaries (multiple trips)	●	●	⊖	○	○	○	○	○	○
– activity diaries	●	◒	⊖	○	○	○	○	○	○
– on a specific trip	●	◒	●	●	●	●	●	●	●
Attitudinal/perception data (ratings, rankings, allocation of points)	●	●	●	●	●	●	●	●	●
Knowledge data	●	●	●	◒	◒	◒	◒	◒	◒
Opinion data/open-ended questions	●	●	●	◒	◒	◒	◒	◒	◒
Stated response travel data (stated preference tradeoff analysis)	◒	⊖	⊖	◒	◒	⊖	⊖	⊖	⊖
Longitudinal (panel) data	◒	⊖	⊖	○	○	○	○	○	○

Notes:

- ● Data are commonly collected with this type of travel survey
- ◒ Data are sometimes collected with this type of travel survey
- ⊖ Data could feasibly be collected with this type of survey, but generally are not
- ○ Data are not collected with this survey method

Source: Cambridge Systematics and Barton-Aschman Associates, 1995.

also request data on specific individual trips, such as work trips for households, or the last trip of a particular type for a commercial vehicle, but these data are generally obtained with diary-type questions.

Attitudinal/perception questions are commonly asked on all types of travel surveys. These questions are used to obtain quantitative data that support policy decisions, but the data are generally not used in formal demand models. Test-of-knowledge and opinion data provide less quantitative information to support policy decisions. These data are most easily obtained on longer surveys, since questions of these types often need to be preceded by fairly lengthy descriptions to which individuals are asked to respond. Open-ended opinion questions are sometimes asked at the end of transit onboard, vehicle intercept, and other intercept surveys. The questions are often used to simply allow interested respondents the opportunity to "sound-off." Some surveyors believe that this opportunity encourages individuals to respond to the entire survey. In many cases, these open-ended responses are not even entered or coded.

Increasingly, travel surveys are being used to obtain stated response data (usually stated preference data). These types of data are being obtained in household surveys and in transit onboard and vehicle intercept surveys, but any type of travel survey could be used to obtain them.

Finally, longitudinal data have been and are being obtained in household travel/activity surveys. These data may provide those analyzing it with unique travel behavior insights, including the measurement of how household travel patterns change over time and the determination of the relationship between travel and residential choice.

In the following chapters, specific data items commonly collected by each travel survey type are tabulated and discussed.

Available Survey Methods for Travel Surveys

The most common general methods used for surveying the public in the U.S. are:

- Personally administered interviews;
- Self-administered surveys distributed by intercept methods;
- Self-administered surveys distributed to groups;
- Telephone interviews; and
- Self-administered mail surveys.

Each method has its strengths and weaknesses, and each is the optimal choice for certain circumstances. Some survey methods are more reasonable than others for certain travel survey types. This section outlines the steps of the different survey methods and discusses the advantages and disadvantages of each one.

Personally Administered Interviews

The most traditional survey method is the face-to-face interview, in which trained interviewers approach potential survey respondents, request their participation, and ask them the survey questions. Personally administered travel interviews can take place in one of four ways:

- **In-home Interviews** – Respondents are contacted and interviewed about past and/or future travel they have conducted. Until the 1970s, this survey method was commonly employed for household travel surveys.

- **Personal Intercept Interviews** – Respondents are contacted and interviewed in the course of their travel. Transit onboard, vehicle intercept, and some establishment surveys employ this method.

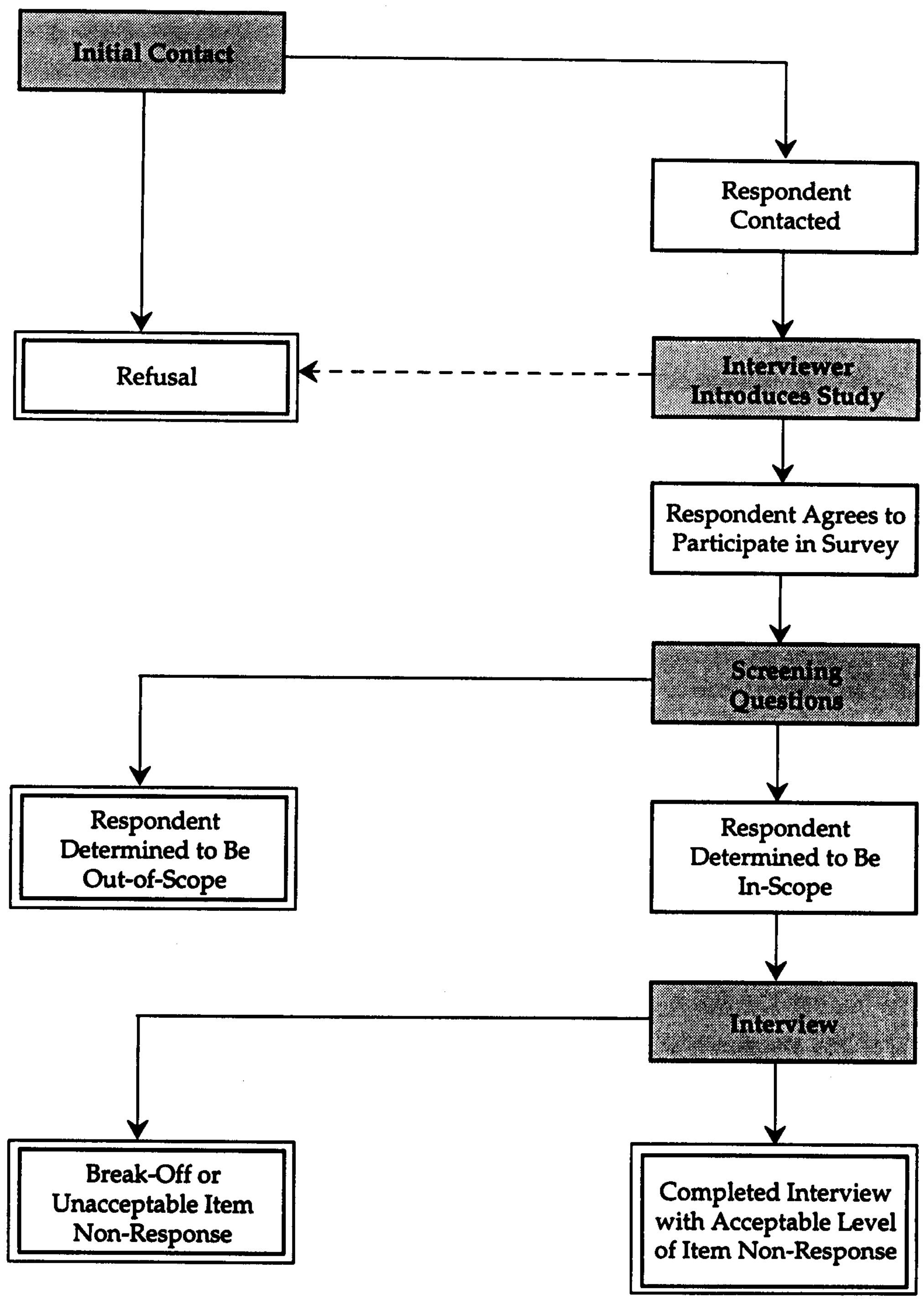
- **Workplace Interviews** – Respondents are contacted and interviewed at work. Some commercial vehicle and workplace surveys use this survey method.

- **Central Location Interviews** – Respondents are contacted and interviewed at public locations, including shopping malls that attract a representative sampling of a travel survey's population of interest. This method is not yet common for travel surveys, but its use is increasing in other surveying fields.

The survey fieldwork procedures for the different personally administered survey methods and for different travel survey types vary, but in all cases the process for interviewing each potential respondent is similar to that which is shown in Figure 3.8.

As Figure 3.8 shows, the first step in the personally administered survey field process is to contact the respondent. This might involve a fieldworker knocking on a person's door for in-home surveys, greeting a transit rider on a bus or at a station for onboard surveys, or stopping a vehicle at an interview station for vehicle intercept surveys. At this point, the potential respondent can immediately refuse to speak with the interviewer or else he or she could find out what the interviewer wants.

Figure 3.8 Process Diagram for an Example Personal Interview Survey



The interviewer introduces the study, and the respondent could agree or refuse to participate. For many studies, some respondents that agree to participate are not in the survey population of interest for one reason or another, so they need to be screened out. Screening questions can be as simple as: "Are you waiting for bus number 5?" or "Are you the head of the household?" or more complicated, such as a series of questions about the geography of a person's current or recent trips. Depending on the respondent's answer to the screening questions, the interviewer may terminate the interview. If the respondent is determined to be in the survey population of interest, then the interview would be conducted. At this point, the interview could be completed, or the respondent could break it off or refuse to answer the key questions that are needed for the responses to be usable.

Table 3.2 summarizes the most commonly cited positive and negative aspects of personally administered interviews when compared to other survey methods. The ways that these advantages and disadvantages affect particular travel surveys are discussed in later chapters.

Self-Administered Surveys Distributed by Intercept Methods

A common variant to personal interviews in travel surveys is the personal distribution of self-administered surveys to respondents. The respondents are asked to complete the survey and to return it in some way, usually by mail or by dropping it in a conveniently located collection bin. Figure 3.9 shows an example of a survey process for this method. The intercept, recruitment, and screening of respondents is essentially the same as for the personal interview method, but rather than interviewing the respondent, the fieldworker simply hands them a questionnaire to complete.

A number of outcomes are possible: the respondent could complete the questionnaire and return it as requested, she or he could simply never return the questionnaire, or she or he could return the questionnaire in unusable condition. If a returned questionnaire is unusable but provides respondent address or telephone information, it might be possible to recontact the respondent for additional information to make the response usable.

The advantages and disadvantages of this survey method with respect to other methods are summarized in Table 3.3.

Self-Administered Surveys Distributed to Groups

For some survey efforts, it is possible to assemble groups of respondents to complete self-administered surveys. This survey method seeks to combine the advantages of personal interview surveys, such as having the opportunity to explain the questionnaire and answer respondent questions, with

Table 3.2 Personal Interviews

Advantages	Disadvantages
Probably the most effective way of enlisting respondent cooperation.	Likely to cost more than the other alternatives.
Interviewer can answer respondent questions and probe, if necessary.	Likely to be the most labor-intensive method.
Interviewer can administer a reasonably complex instrument, with special sequencing; skip patterns, and difficult instructions; particularly if CAPI is used.	Requires a trained staff of interviewers that is geographically near the sample.
Visual cues or aids can be used.	Fieldwork is likely to take longer than with the telephone survey method.
Can easily combine a self-administered section of the survey.	Method is the most susceptible to disruptions and to crime problems.
The best method for developing a rapport with respondents and to build respondent confidence.	
When conducted in homes, long and very detailed interviews are possible.	

Figure 3.9 Process Diagram for an Example Intercept/ Self- Administered Survey

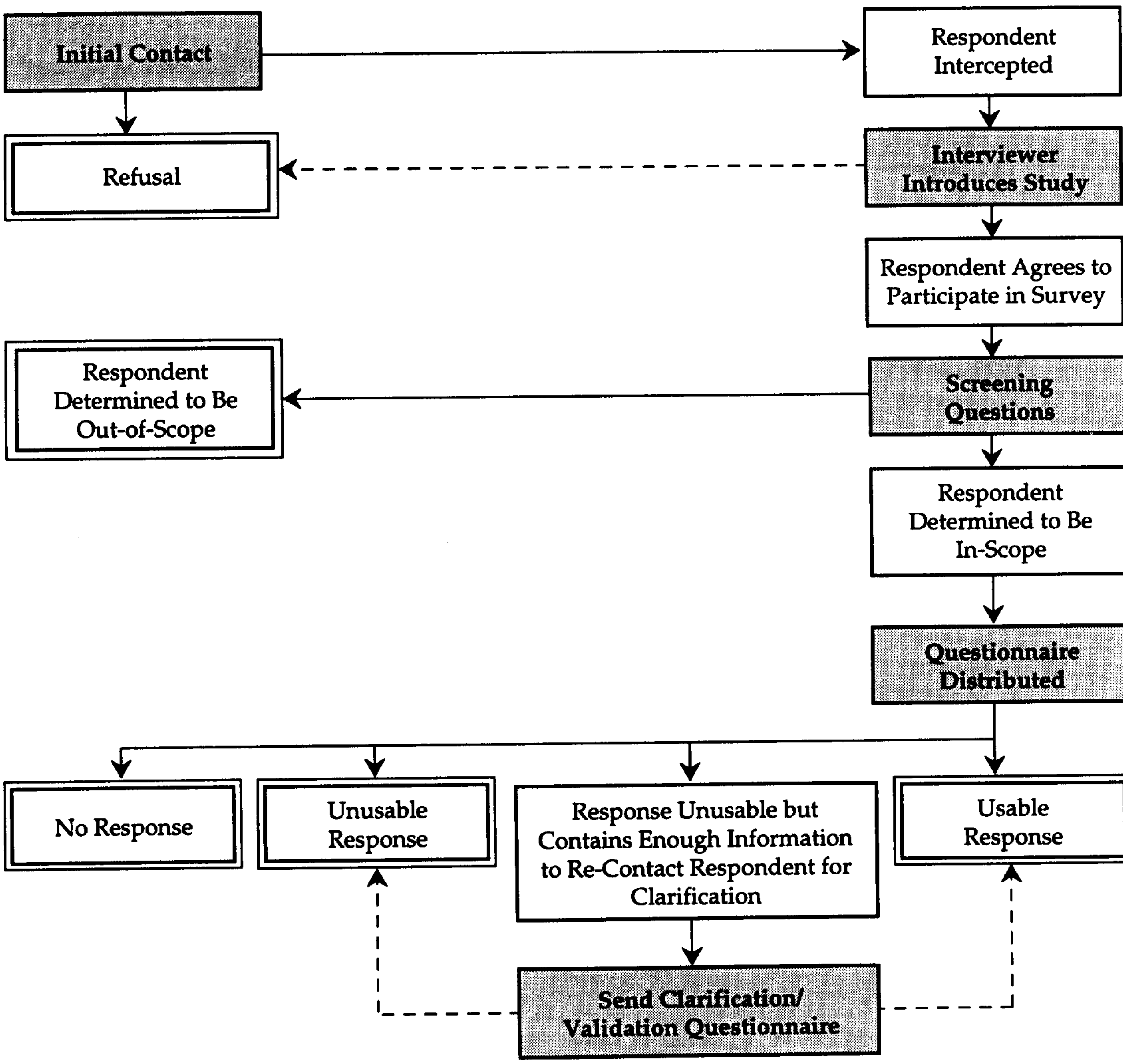


Table 3.3 Self-Administered Surveys Distributed By Intercept Methods

Advantages	Disadvantages
Lower cost than personal interviews; because of higher fieldworker productivity.	High nonresponse rates.
Easy to present questions requiring visual aids.	Excellent questionnaire design is required.
Good method for asking batteries of similar questions; and for asking questions with long or complex response categories.	Requires respondents to have good reading and writing skills.
Respondent feels more anonymous than with interview methods.	No opportunity to probe or clarify responses.
Very short contact time with respondents is good for surveying busy people; and increases the efficiency of fieldworkers.	Need trained fieldworkers and supervisors for questionnaire distribution.
Provides access to specific groups without causing excessive delays to respondents.	Data editing task could be substantial, especially if detailed address information is required.
Respondents can be asked to provide thoughtful and detailed responses.	

the advantages of personally distributed self-administered surveys, including the ability to ask questions with long sets of response categories or questions that require extra response time. This survey method is sometimes used to survey hard-to-survey groups, including ethnic groups and special-interest groups. Table 3.4 describes the advantages and disadvantages of group surveys.

Telephone Interviews

In the past 15 years, the telephone interview survey has become an extremely popular surveying tool, both for transportation surveys and for other types, as well. As the cost of survey fieldwork has risen, telephone surveys have become more cost-effective (though less flexible in terms of content) than traditional in-home interviews. Telephone interviewers can contact several households in the time it takes a field interviewer to travel to one particular home, and telephone interviewers can be supervised much more effectively than field interviewers.

Telephone surveys are limited in that only households with telephones can be contacted. Nationally, approximately 93 percent of households have telephones, but this percentage varies from city to city. Households without phones are more likely to be composed of ethnic minorities, be poorer, and have lower auto ownership rates than households with phones.[3] Since such households are likely to make fewer trips and are less likely to use an automobile for trips, telephone surveys may bias survey results to some degree.

There are ways to address the potential bias resulting from non-telephone households. If they can be identified, households without phones can be interviewed in person. Alternately, households which share demographic or other characteristics with non-telephone households can be oversampled. The U.S. Census Public Use Microdata Sample (PUMS) can be used to identify these characteristics.

There are two types of telephone surveys. In the first, a sample of telephone numbers is drawn from available telephone number lists (either published directories or lists from previous survey efforts). In the second type, the sample of numbers is drawn from a random list of numbers. This is known as a random-digit-dialing (RDD) survey.

Working off available telephone number lists or directories greatly enhances the likelihood that an attempted call will be to a working phone at a private residence, and in most cases allows the surveyor to know the

[3]Blair A. Cohen, A. Peter Lobe, Elaine Fielding, and Li-Shou Yong, *Analysis of Households Without Phones: Impact for the NPTS 1995*, Report to FHWA, December 10, 1993.

Table 3.4 Self-Administered Surveys Distributed To Groups

Advantages	Disadvantages
Lower cost than personal interviews.	Not possible to convene groups for many surveys.
Opportunity to explain the study and answer questions about the questionnaire.	Requires a facility for meeting with the groups.
Easy to present questions requiring visual aids.	Excellent questionnaire design is required.
Good method for asking batteries of similar questions; and for asking questions with long or complex response categories.	Requires respondents to have good reading and writing skills.
Respondent feels more anonymous than with interview methods.	
Respondents can be asked to provide thoughtful and detailed responses.	

address of the respondent before calling them (this is particularly useful for survey efforts with specific study areas or studies with geographic area quotas or targets). However, the rate of unlisted telephone numbers in the U.S. is high and increasing. Table 3.5 shows the percentage of households with telephones and the percentage of phone numbers that are unlisted for 100 metropolitan areas.

Many travel surveyors are willing to accept that a telephone survey will be unable to include five to 15 percent of the households in an area because the households have no phones, but most surveyors balk at the idea of excluding up to half the households in a region from a survey sampling frame. For this reason, RDD surveys are more commonly used in travel surveys than surveys with directories. Some travel surveyors have used a combination of the two approaches to maximize the efficiency of the listed approach, while compensating for the potential bias with RDD surveys.

Regardless of whether a listed approach or an RDD approach (or a combination of the two) is adopted, the process for conducting individual telephone surveys is similar to that shown in Figure 3.10. The process diagram assumes that the telephone survey was designed with the following parameters:

- Up to three attempts will be made to a single telephone number (typical telephone travel surveys allow for between five and 10 attempts);
- Interviewers hang up if there is no answer after 10 rings; and
- Interviewers do not leave messages on answering machines.

Table 3.6 discusses the key advantages and disadvantages of the telephone interview for travel surveys.

Mail Surveys

Mail surveys are commonly used for travel surveys because of their low cost and resource requirements; and because of their simplicity. A mail survey in its most simple form requires obtaining a complete address list from a source, such as a utilities customer database, sending self-administered surveys to the households, and then simply waiting for replies. Travel surveyors have found that response levels can be enhanced through the use of pre-notification letters and follow-up letters and questionnaires.

Figure 3.11 shows the process for an example mail survey. In this survey, a letter is sent to each potential respondent alerting them to the fact that they will be receiving a mail survey in a few days. Immediately following the letter, the surveying organization sends the mail survey to all the addresses, except those for which the prenotification letters were returned undeliverable. Once the survey materials have been sent, the surveyor simply waits for responses. After approximately seven days, households

Table 3.5 Unlisted Rates of the Top 100 MSA Markets for 1989

MSA	Percent w/Phones	Percent Unlisted
Akron	95.4	27.2
Albany-Schenectady-Troy	94.4	20.9
Albuquerque	92.2	37.1
Allentown-Bethlehem	96.4	28.3
Anaheim-Santa Ana	**96.6**	**53.9**
Atlanta	92.9	31.1
Austin	92.9	35.9
Bakersfield	**91.8**	**52.2**
Baltimore	95.3	31.6
Baton Rouge	91.4	25.0
Bergen-Passaic	96.0	38.3
Birmingham	91.8	28.2
Boston-Lawrence-Salem-Lowell-Brockton	95.6	21.2
Bridgeport-Stamford-Norwalk-Danbury	96.6	19.9
Buffalo	95.0	20.0
Charleston, SC	89.2	23.8
Charlotte-Gastonia-Rock Hill	91.4	31.5
Chicago	**94.1**	**44.4**
Cincinnati	94.9	28.0
Cleveland	95.6	28.7
Columbia, SC	91.0	30.3
Columbus, OH	93.8	27.4
Dallas	92.6	33.8
Dayton-Springfield	93.4	26.0
Denver	**95.1**	**45.5**
Detroit	**96.0**	**44.6**
El Paso	**87.6**	**40.4**
Fort Lauderdale-Hollywood-Pompano Beach	93.4	26.8
Fort Worth-Arlington	93.7	30.0
Fresno	**93.0**	**57.4**
Gary-Hammond	95.8	25.9
Grand Rapids	96.4	27.6
Greensboro-Winston-Salem-High Point	91.5	23.8
Greenville-Spartanburg	89.3	32.0
Harrisburg-Lebanon-Carlisle	95.8	25.9
Hartford-New Britain-Middletown-Bristol	96.1	22.2
Honolulu	95.4	33.5
Houston	91.7	41.4
Indianapolis	94.3	29.7
Jacksonville	88.5	28.0
Jersey City	**88.8**	**51.9**
Johnson City-Kingsport-Bristol	86.4	21.9

Bold Face Indicates the 25 MSAs with the Highest Incidence of Unlisted Phones

Table 3.5 Unlisted Rates of the Top 100 MSA Markets for 1989 (continued)

MSA	Percent w/Phones	Percent Unlisted
Kansas City	95.6	31.3
Knoxville	90.6	24.5
Lake County, IL	96.6	33.5
Las Vegas	**90.8**	**62.3**
Little Rock-North Little Rock	91.4	23.8
Los Angeles-Long Beach	**93.4**	**61.2**
Louisville	93.7	27.1
Memphis	92.2	26.9
Miami-Hialeah	**90.8**	**46.8**
Middlesex-Somerset-Hunterdon	97.3	31.9
Milwaukee	96.6	34.9
Minneapolis-St. Paul	97.3	24.1
Mobile	88.7	27.4
Monmouth-Ocean	97.0	22.4
Nashville	92.5	30.6
Nassau-Suffolk	97.0	18.4
New Bedford-Fall River-Attleboro	94.2	30.2
New Haven-Waterbury-Meriden	96.2	20.6
New Orleans	91.6	33.6
New York	89.7	36.8
Newark	**94.0**	**40.1**
Norfolk-Virginia Beach-Newport News	91.3	25.9
Oakland	**95.6**	**59.2**
Oklahoma City	94.2	32.5
Omaha	96.0	29.7
Orlando	89.6	37.8
Oxnard-Nentura	**95.8**	**49.5**
Philadelphia	95.6	37.5
Phoenix	**91.8**	**43.4**
Pittsburgh	96.7	28.1
Portland, OR	**94.5**	**39.8**
Providence-Pawtucket-Woonsocket	94.8	24.0
Raleigh-Durham	93.2	21.9
Richmond-Petersburg	93.0	19.0
Riverside-San Bernardino	**93.6**	**53.9**
Rochester, NY	95.1	22.9
Sacramento	**94.6**	**54.3**
Salt Lake City-Ogden	95.2	30.2
San Antonio	**92.2**	**39.7**
San Diego	**95.0**	**50.9**
San Francisco	**95.5**	**53.2**

Bold Face Indicates the 25 MSAs with the Highest Incidence of Unlisted Phones

Table 3.5 Unlisted Rates of the Top 100 MSA Markets for 1989 (continued)

MSA	Percent w/Phones	Percent Unlisted
San Jose	**97.0**	**55.5**
Scranton/Wilkes-Barre	96.0	21.6
Seattle	95.7	28.1
Springfield, MA	94.6	26.9
Saint Louis	96.0	29.6
Syracuse	94.1	20.4
Tacoma	**93.8**	**41.7**
Tampa-St. Petersburg-Clearwater	90.6	25.8
Toledo	94.0	32.4
Tucson	**91.2**	**46.5**
Tulsa	93.6	31.4
Washington, DC	95.9	26.8
West Palm Beach-Boca Raton-Delray Beach	92.6	20.9
Wichita	94.3	24.3
Wilmington, DE	95.0	36.7
Worcester-Fitchburg-Leominster	95.0	21.6
Youngstown-Warren	94.9	28.5

Bold Face Indicates the 25 MSA's with the Highest Incidence of Unlisted Phones

Source: Survey Sampling, Inc., 1990.

Figure 3.10 Process Diagram for an Example Telephone Survey

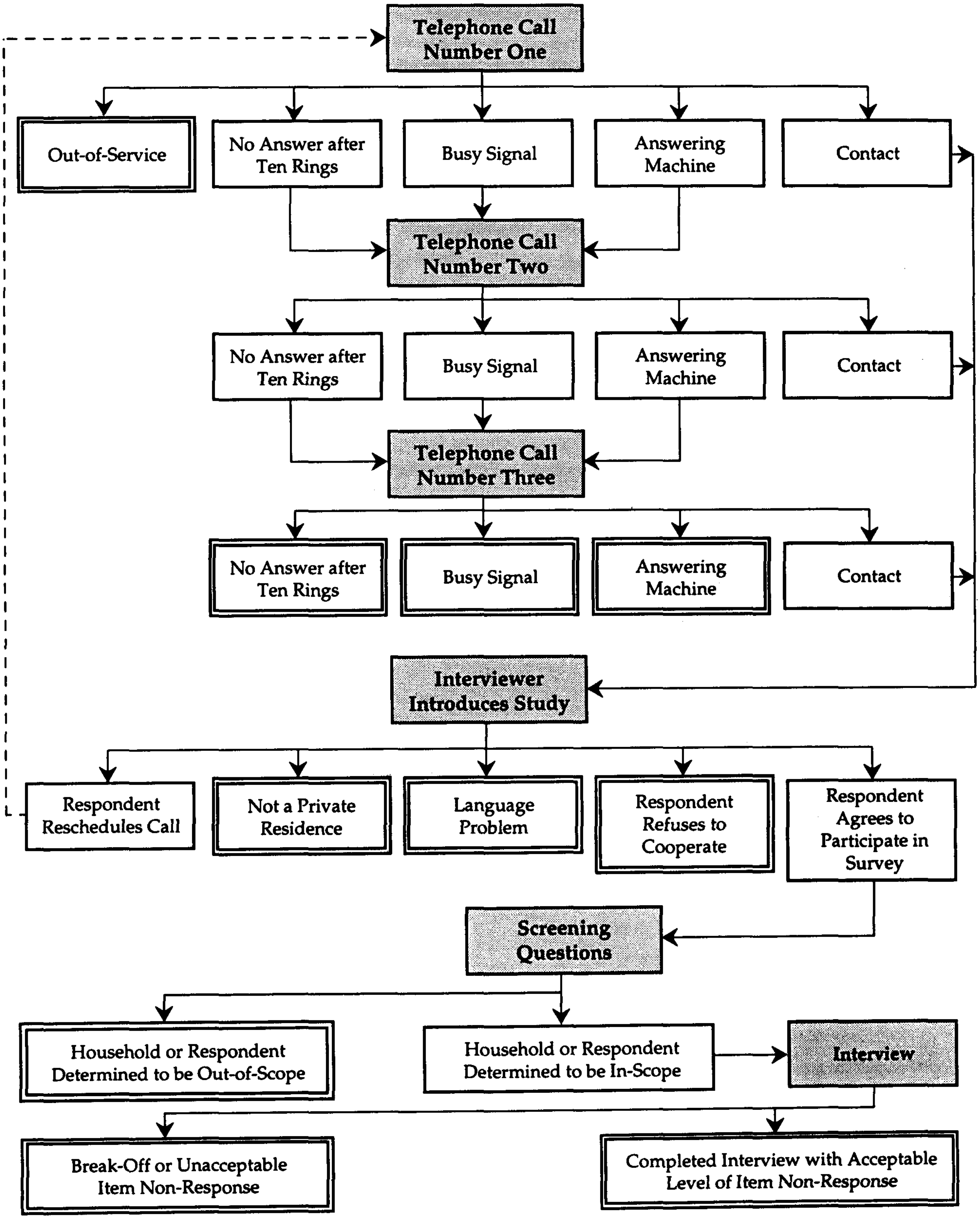
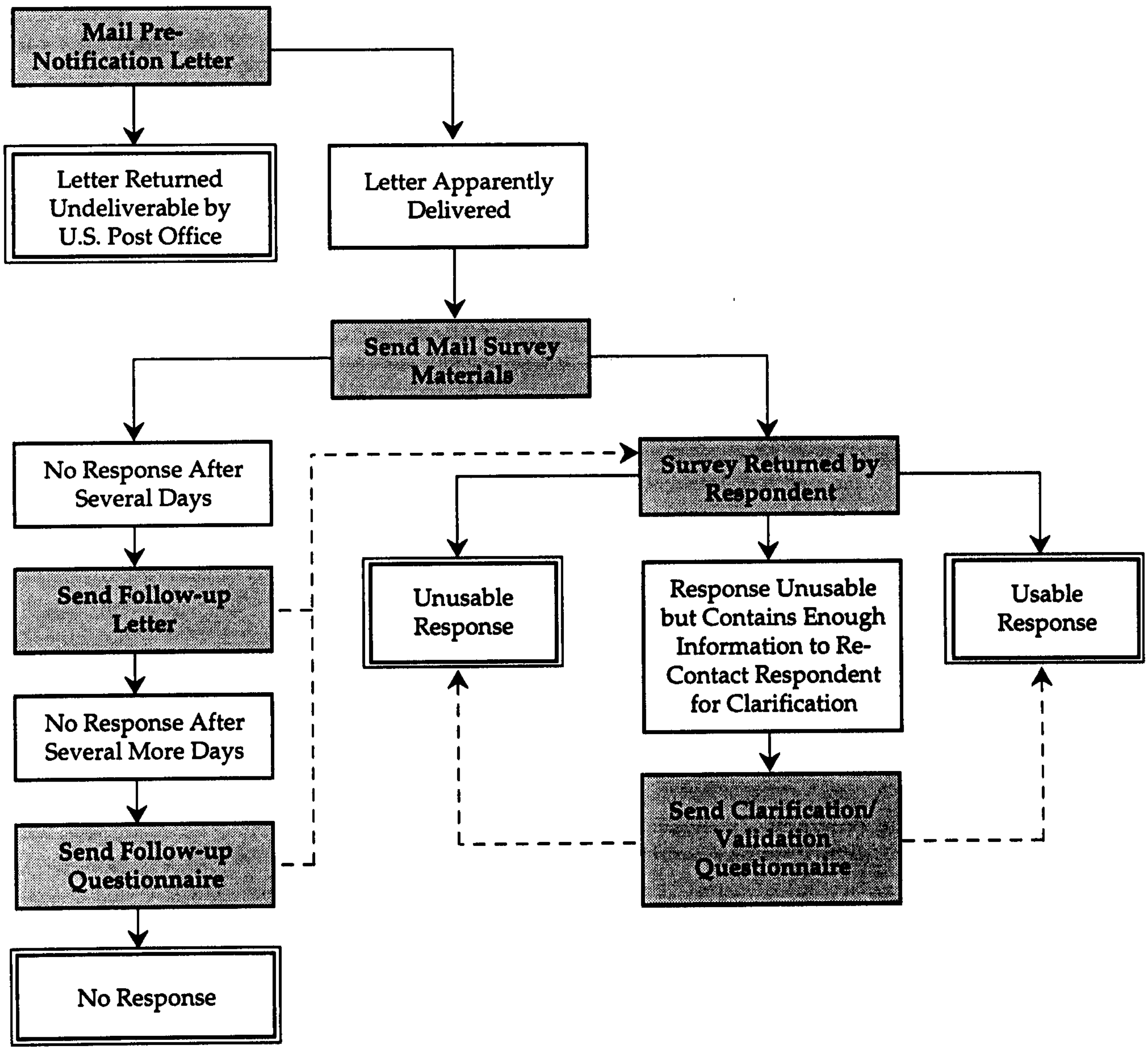


Table 3.6 Telephone Interviews

Advantages	Disadvantages
Lower costs than in-person interviews.	Sampling frame cannot be perfect because the method omits those without telephones.
Interviewer can answer respondent questions and probe, if necessary.	Relatively high nonresponse rates are associated with RDD sampling.
Best method for interviewer to administer very complex instruments, with special sequencing, skip patterns, and difficult instructions (especially if CATI is used).	Constraints on the types of questions that can be asked (no visual aids; no observations by interviewers).
Generally the quickest fieldwork schedule.	Has been found to be less appropriate for personal or sensitive questions.
Interviewer staffing and supervision and quality control are superior to in-person interviews.	
A good method for developing a rapport with respondents and to build respondent confidence.	
Likely to have better response than mail surveys.	

Figure 3.11 Process Diagram for an Example Mail Survey



that have not responded are sent a follow-up letter reminding the respondents of the questionnaire, and after a few more days, those who still have not responded are re-sent the questionnaire.

All the surveys that are returned by respondents are coded and reviewed. The surveyors then send letters requesting additional information from respondents whose questionnaires require clarification.

Table 3.7 summarizes the positive and negative aspects of self-administered mail surveys.

Combinations of Survey Methods

In travel surveys, the basic survey methods are often used in combination with one another to try to capture the benefits of more than one method. For instance, the most common approaches for conducting household travel/activity surveys combine telephone and mail survey techniques.

Figure 3.12 shows the survey methods that are generally used for the different travel surveys.

Table 3.7 Self-Administered Mail Surveys

Advantages	Disadvantages
Low cost.	Very high nonresponse rates.
Easy to present questions requiring visual aids.	Excellent questionnaire design is required.
Good method for asking batteries of similar questions, and for asking questions with long or complex response categories.	Requires respondents to have good reading and writing skills.
Respondent feels more anonymous than with interview methods.	No opportunity to probe or clarify responses.
Minimal staff and facilities requirements.	Need for good mailing addresses.
Provides access to the widest sample population.	Data editing task could be substantial, especially if detailed address information is required.
Respondents can be asked to provide thoughtful and detailed responses (e.g., travel or activity diaries).	Timeliness – respondents often forget to complete and return forms for some time after the survey can be completed. Reminders and follow-ups extend the survey period even further.

Figure 3.12 Survey Methods Used for Different Travel Surveys

Survey Data	Surveys Before or After Travel: Household Travel/ Activity	Surveys Before or After Travel: Commercial Vehicle (Fleet Manager Surveys)	Surveys Before or After Travel: Workplace/ Hotel/ Establishment (Centrally-distributed Surveys)	Surveys During the Course of Travel (Intercept Surveys): Transit Onboard	Surveys During the Course of Travel (Intercept Surveys): Vehicle Intercept/ External Station	Surveys During the Course of Travel (Intercept Surveys): Commercial Vehicle (Intercept Surveys)	Surveys During the Course of Travel (Intercept Surveys): Workplace/ Hotel/ Establishment (Intercept Surveys)	Surveys During the Course of Travel (Intercept Surveys): Special Generator	Surveys During the Course of Travel (Intercept Surveys): Parking
Single Contact Surveys									
Personal intercept in the course of travel – interview (or CAPI)	○	○	○	●	●	●	●	●	●
Personal intercept in the course of travel – self-administered (mailback or direct return)	○	○	○	●	●	●	●	●	●
Personal intercept not during the course of travel – interview (or CAPI)	◒	●	◒	○	○	○	◒	○	○
Personal intercept not during the course of travel – self-administered	○	◒	●	○	○	○	◒	○	○
Mail survey	◒	◒	◒	○	○	○	○	○	○
Telephone survey (with manual recording of results or with CATI)	○	◒	○	○	○	○	○	○	○

Notes:

- ● Data are commonly collected with this type of travel survey
- ◒ Data are sometimes collected with this type of travel survey
- ⊖ Data could feasibly be collected with this type of survey, but generally are not
- ○ Data are not collected with this survey method

Source: Cambridge Systematics and Barton-Aschman Associates, 1995.

Figure 3.12 Survey Methods Used for Different Travel Surveys (continued)

Survey Data	Surveys Before or After Travel: Household Travel/ Activity	Surveys Before or After Travel: Commercial Vehicle (Fleet Manager Surveys)	Surveys Before or After Travel: Workplace/ Hotel/ Establishment (Centrally-distributed Surveys)	Surveys During the Course of Travel (Intercept Surveys): Transit Onboard	Surveys During the Course of Travel (Intercept Surveys): Vehicle Intercept/ External Station	Surveys During the Course of Travel (Intercept Surveys): Commercial Vehicle (Intercept Surveys)	Surveys During the Course of Travel (Intercept Surveys): Workplace/ Hotel/ Establishment (Intercept Surveys)	Surveys During the Course of Travel (Intercept Surveys): Special Generator	Surveys During the Course of Travel (Intercept Surveys): Parking
Common Multiple Contact Surveys									
Personal intercept recruitment followed by a telephone survey	⊖	○	○	●	●	⊖	◒	⊖	⊖
Personal intercept recruitment followed by a mailout/mailback survey	⊖	○	○	●	●	◒	◒	⊖	⊖
Personal intercept recruitment followed by a mail survey with telephone collection of survey responses	⊖	○	○	⊖	⊖	⊖	⊖	⊖	⊖
Telephone recruitment followed by a mailout/mailback survey	●	●	◒	○	○	○	○	○	○
Telephone recruitment followed by a mail survey with telephone collection of survey responses	●	●	◒	○	○	○	○	○	○
Personal intercept or telephone recruitment followed by convened group participation	⊖	⊖	⊖	◒	◒	⊖	⊖	⊖	⊖
Observation (e.g., license plate matching) followed by a mailout/ mailback survey	○	○	○	○	●	◒	◒	◒	◒

Notes:

● Data are commonly collected with this type of travel survey

◒ Data are sometimes collected with this type of travel survey

⊖ Data could feasibly be collected with this type of survey, but generally are not

○ Data are not collected with this survey method

Source: Cambridge Systematics and Barton-Aschman Associates, 1995.

4.0 Management and Quality Control

All travel surveys will be imperfect, but effective management and strict quality control procedures will greatly enhance the accuracy and validity of the survey results. This chapter briefly describes some of the management issues that are common to most survey types. Specific procedures for maintaining quality standards for each specific type of travel survey are described in the following chapters.

■ 4.1 Travel Survey Quality; Quantity; and Resource Tradeoffs

Richardson, Ampt and Meyburg claim that:

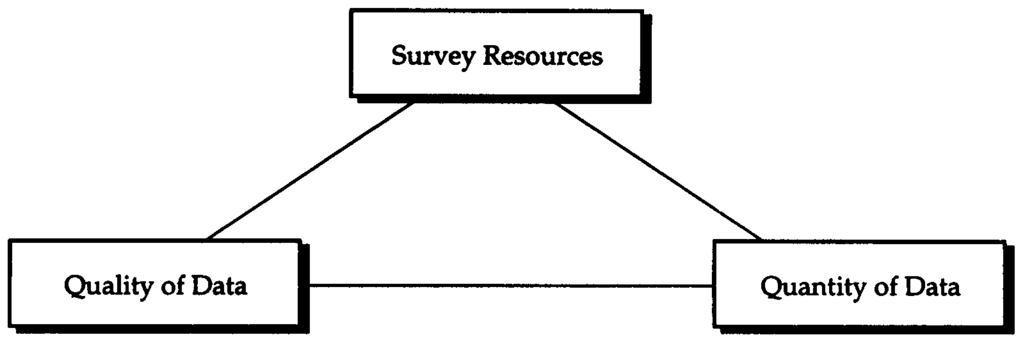
> "The essence of good survey design is being able to make tradeoffs between the competing demands of good design practice in several areas (such as sample design, instrument design, conduct of surveys, and data weighting and expansion) so as to arrive at the most cost-effective, high quality survey that meets the needs of the client within budget constraints."[1]

These authors make use of a concept called the "Architects Triangle"; as shown in Figure 4.1. In survey design, the quality and quantity of data and the cost of data collection are traded off against each other. The goal of survey designers is to produce the optimal mix of the three elements.

As the authors point out, survey budgets are generally set prior to the survey effort, so the survey team is usually in the position of making set investments in the quantity and quality of data. The quantity of data in surveys is a function of the number of survey respondents and the amount of information gathered per respondent. The quality of survey data is related to the selected survey method, the fieldwork procedures, instrument design, and the representativeness of the chosen sample. It is ineffective to collect as much information as possible to the exclusion of

[1] A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg. *Survey Methods for Transport Planning*, Eucalyptus Press, Melbourne 1995, page 8.

Figure 4.1 Richardson's, Ampt's, and Meyburg's "Architect's Triangle"



Source: A.J. Richardson, E.S. Ampt, and A.H. Meyburg, *Survey Methods for Transport Planning*, Eucalyptus Press, 1995.

ensuring that the collected data are representative of the population. On the other hand, it is not usually possible to invest in expensive survey quality control procedures without decreasing sample size (and increasing the uncertainty of many parameter estimates).

■ 4.2 Maintaining Quality in the Travel Survey Process: Total Survey Design

Recognizing that the critical elements of the success of almost any survey implementation process are the preset resource (time, staff, and budget) limitations and the necessary tradeoffs between quality and quantity concerns, many surveyors endorse the concept of "total survey design."[2] Total survey design is defined by two principles:

- Each task of the survey design and implementation is interrelated with all the other tasks, and design decisions made in one task need to be consistent with the decisions made in the other tasks.

- The overall usefulness of the survey effort is limited by the weakest element of the design. It is ineffective to invest large resources into one element of the survey if the same quality levels cannot be maintained in the other survey elements.

Dillman has developed these total survey design concepts into a detailed mail and telephone survey methodology. Many survey efforts have been based on Dillman's specific approach, including travel surveys in Southeastern and Southwestern New Hampshire.[3] But regardless of whether these specific procedures are used, the basic principles of total survey design should apply to all travel survey design efforts.

Travel survey researchers have been known to spend several person-months developing, testing, and revising a survey instrument, only to have it fielded by poorly trained, unsupervised fieldworkers. Similarly, it is common for an agency to specify in an RFP (request for proposals) a low level of sampling error for a survey, but not set limits on any not so easily quantified sources of error, such as non-response.

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[2] Don Dillman, *Mail and Telephone Surveys: The Total Design Method,* John Wiley, New York, 1978.

[3] Norman L. Marshall, Kenneth Kaliski, Leslie Rimmer, and Stephen Lawe, *Estimating Network Model Parameters from Mail Survey Data in Microcomputers in Transportation,* Proceedings of the 4th International Conference on Microcomputers in Transportation, ASCE 1992, page 109.

This is not to recommend that one should simply give up on trying to produce high quality survey instruments or on demanding high levels of precision. Rather, total survey design means that the entire process and each of the many areas where errors and biases can creep into the design should always be considered.

Figure 4.2 summarizes the many aspects of the survey implementation process that survey designers should consider. If each of the quality concern questions can be answered, "yes," the survey effort is likely to be quite successful. More likely, the answer to many of the questions will be "I don't know" or "no." The challenge is to minimize the negative effects of these problems with the limited available resources. The survey team should determine the weak links in the implementation process, and if possible, divert resources to those areas. Considering all aspects of the implementation process together will help the survey team to avoid mis-spending resources on problems which are insignificant, in the greater scheme of things.

4.3 Management of Travel Surveys

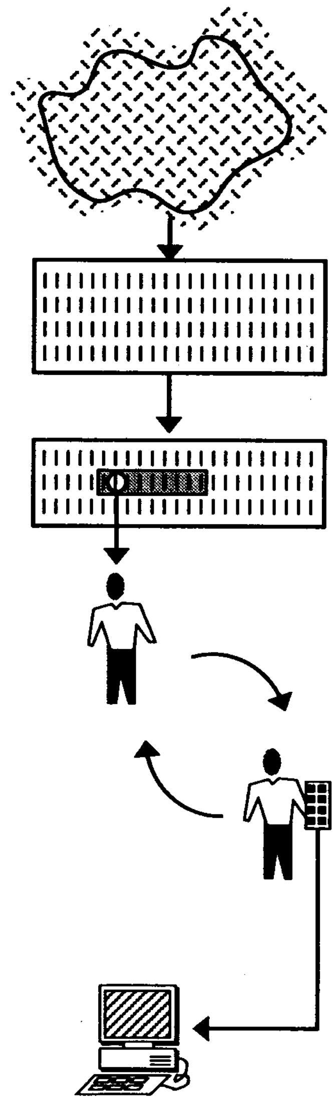
The budgeting, staffing, oversight, scheduling, and coordination needs for each travel survey effort differ, but a few general recommendations can be made.

Survey Costs

Although travel survey costs are often reported, the total cost to an agency of conducting travel surveys is often quite difficult to calculate. Typical travel surveys are collaborative efforts between client agencies and contractors. The contractor cost can be calculated, but often the internal costs of an agency are not determined on a project-by-project basis. In addition, the division of labor between the client agencies and the contractors is different for every effort, so the cited costs often include different components. Often, when survey designers apply "rules-of-thumb" in budgeting survey efforts, they find their actual costs are quite different.

The best approach for predicting the costs of a proposed survey effort is to build it up from specific anticipated labor, facility, and material costs. Appendix A provides some simplified survey cost calculation worksheets for different types of surveys.

Figure 4.2 Travel Survey Quality Concerns



Survey Implementation Task	Quality Concerns
Identify sample population	***Has the population been defined correctly?*** Have all relevant individuals been included? Are irrelevant individuals excluded?
Identify sampling frame	***Does the sampling frame adequately describe the population?*** Is everybody in the population in the frame? Do members of the population appear on the list only once? Does the sample frame exclude irrelevant individuals?
Select sampling procedures, and draw the sample	***Does the sample adequately represent the population?*** Does the selected sampling procedure allow for the cost-effective collection of data? Can the sample be expanded to the population? Is the sampling unbiased?
Select and contact the respondents and enlist their cooperation	***Are respondents available, willing, and able to cooperate?*** Are response rates acceptable? Are non-respondents representative of the population? Are all potential respondents able to perform the tasks required of them?
Survey questions and answers	***Do the survey questions accomplish the survey team's goals?*** Are all the questions relevant? Are they unambiguous? Are the questions free of wording problems? Are interviewers or written questionnaires able to ask the questions without biasing answers? Are the answers unambiguous and usable?
Clean, enter, and code the survey results, and prepare modeling data sets	***Can the survey data be efficiently processed, and transformed into usable information?*** Do survey codes unambiguously assign each answer to one and only one analytically meaningful category? Are datasets adequately documented?

Managers and Supervisors of Fieldworkers

To a large extent, the management of a travel survey will depend upon the management environment of the sponsor agency. By now, many organizations have moved beyond rigid chains-of-command, so generalizing about the best organizational and management plans for a specific effort or diagramming the best organizational structure for a survey project is difficult.

However, regardless of the overall structure of the project, there are a number of key management tasks that need to be accomplished. First and foremost, the project will need a proactive hands-on Project Manager. This person will have the day-to-day responsibility for coordinating the activities of submanagers and for keeping the data collection effort on track to achieve the study objectives. Even if most of the survey work and data analysis will be performed by consultants, the sponsoring agency project manager should expect to spend a substantial portion of her or his time on the project. Almost invariably, even with careful planning, anticipated survey procedures and methods will need to be modified as the survey effort progresses.

The second key individual in a travel survey effort is the Survey Manager. Often, this person is the Project Manager for the survey contractor or an independent consultant specializing in survey research. This person will be responsible for all phases of the survey effort, with a particular emphasis on the specific data collection tasks. The Survey Manager will direct field supervisors and fieldworkers, and monitor the progress of the survey work on a continuing basis.

The third manager required in the survey effort is a Travel Demand Manager. Because the outputs of the travel survey project will be travel modeling data, it is extremely important that an individual or individuals with a strong sense of the impending modeling tasks be included in the survey design and implementation process. This person will be a key contributor to the design of the survey, the sampling, and the development of survey instruments, and it will be his or her responsibility to ensure that the survey effort produces the desired modeling inputs. In addition, this manager should have input into the data cleaning and coding tasks, and should direct the programming work. The Travel Demand Manager could be an agency staff member or a transportation planning consultant.

For smaller surveys, these managers need not be committed to the project full-time, but larger efforts will easily consume all of their time (and perhaps some Deputy Manager time, as well). For smaller efforts, the three management positions may be filled, theoretically, with one or two people, but this practice is not recommended for two reasons. First, there will be busy periods where the amount of work at particular critical points in the survey development will be overwhelming. Second, the quality of the survey effort will be enhanced by having more managers reviewing the ongoing work, especially if the managers are looking at the data collection effort from different perspectives as a Survey Research Manager and a Travel Demand Manager would.

Each specific survey task will require one or more field supervisor and several staff members to actually perform the work. Some of these workers may be able to work on more than one task if the tasks occur at different points in time, but generally it is better for staff members to become specialists in particular tasks. A major advantage of contracting the survey work to a specialist firm is the level of staff specialization that these firms can provide.

Oversight Committees, Peer Review Panels and Expert Advice

A number of recent survey efforts have relied upon advice and assistance from knowledgeable planners and surveyors not directly involved with the day-to-day survey development tasks. These outside experts can bring to the project:

- A wider breadth of experience than is available on the survey team;
- Relatively low-cost management consulting advice;
- A "Board of Directors" oversight function for the survey project;
- A sounding board for ideas and potential innovations; and
- A forum to resolve issues on which survey team managers disagree.

One of the most effective quality control mechanisms used in recent travel survey efforts has been the peer review panel, a group of survey and modeling experts that are convened at the key stages of the survey project to provide advice and guidance to survey managers. Most recent peer review panels have consisted of:

- Key staff members from other MPOs with recent survey experience;
- University professors and consultants with expertise in transportation modeling and travel survey work; and
- State and Federal Department of Transportation staff members.

In addition, peer review panel members could also include:

- Staff members from the sponsoring agency that are not directly involved with the survey effort;

- Staff members from other local transportation agencies; and

- Survey researchers with experience outside of travel surveys.

In addition to, or instead of, the peer review panel, some recent travel survey sponsors have relied on one or more "consultant coaches" to assist with the survey planning and design work. These coaches are typically brought in early in the process to help perform preliminary planning tasks and to help the agency prepare to contract with one or more other consultants to perform the final survey design work and actual data collection.

The use of outside peer review panels and coaches can be cost-effective, because these individuals are used only at key decision points in the survey development process and because they are being asked primarily for advice, rather than for deliverable products.

Schedule

The planning and design of travel surveys can be quite time-consuming. Allocating adequate time for designing the overall survey, including time for resolving unexpected difficulties is essential. Managers of many recent travel survey efforts have found their original schedules to be infeasible once the detailed complexities of the design effort became apparent. Slippage in the design and implementation schedule can be especially damaging in travel surveys that are intended to be season-specific, because in these cases the inability to complete the fieldwork as planned causes a delay of a year before actually fielding the survey.

Therefore, as early as possible in the planning process, it is very important to prepare a realistic survey schedule which anticipates the inevitable difficulties that will occur. Because different agencies have very different funding mechanisms and consultant procurement processes, it is impossible to specify the amount of time needed to fully plan and implement a travel survey, but for large efforts, such as household travel surveys, it is not uncommon for agencies to begin the preliminary planning process one year to 18 months in advance of the fieldwork.

Because even simple travel surveys have many interrelated and parallel tasks, use of computerized CPM or PERT scheduling techniques is recommended. These methods allow the survey team to identify the key milestones in the design and implementation process, as well as crucial deadlines.

Coordination

Many agencies and private companies can be involved in travel surveys in a particular region or state. Agencies should maintain channels of communication with all relevant organizations from the inception of any survey effort. This is especially true if more than one agency will be sponsoring travel survey work. Travel demand modelers from the separate agencies will be able to use the survey data much more effectively if the survey efforts are coordinated.

At the beginning of the survey effort, the sponsoring agency should contact:

- All affected state agencies;
- Local and regional planning officials;
- Local and regional elected officials;
- Local and state police;
- Federal agencies that may be involved;
- Local transit providers;
- Active public interest groups; and
- Chambers of commerce/business groups (for workplace/establishment surveys).

In addition, the sponsoring agency may want to consider contacting the news media if the advance publicity is felt to be important. Alerting the media of the survey effort may increase the level of cooperation, reduce the number of complaints about the survey, and head off any potential negative press once the survey effort is undertaken. Coordination issues for each survey type are discussed further in the following chapters.

■ 4.4 Ethical Issues in Travel Surveying

Managers of travel surveys and surveying and demand modeling contractors should be aware that they have a number of ethical (and legal) responsibilities to each other, to their staff, and most importantly, to respondents and potential respondents.

Responsibilities of Agencies and Contractors to Each Other

The responsibilities of planning agencies and contractors to one another should be described as clearly as possible in a formal contract. Both parties should have a clear understanding of their responsibilities under the agreement and those of the other party prior to any work being conducted. Potential problems (and potential remedies) should be identified, and the responsibilities of each party under various outcomes should be assigned.

Responsibilities to Fieldworkers

The agency or firm conducting the survey has certain obligations to the survey fieldworkers, including:

- Providing the basic employer obligations for the state and region;
- Adequately preparing fieldworkers for the survey effort by explaining the effort and their responsibilities to them; and
- Dealing with fieldworkers' safety-related and personal security-related concerns.

The first obligation is straightforward, and requires little explanation. The need to adequately prepare fieldworkers for the survey effort is important to the analyst because of the potential for incomplete or incorrect data, but it is also important to fieldworkers. Fieldworkers should have a clear idea of their and fellow workers' and supervisors' responsibilities so that the potential for conflicts is minimized. In addition, fieldworkers may be put in the position of describing the survey goals and procedures to potential respondents or to police officers or other interested parties. Fieldworkers should not have to worry that they might have to provide deceptive, misleading, or inaccurate information.

The third general obligation to fieldworkers is especially important in travel surveys where fieldworkers are often asked to interact with moving vehicles or to spend time in and around high crime locations. The agency or firm conducting surveys must respect fieldworkers' assessments of the safety and security of the planned survey procedures, and should be willing to take added steps to allay the fieldworkers' concerns. In this respect, we offer the following guidelines:[4]

1. Fieldworkers should be told explicitly that the job does not require them to go somewhere under circumstances that they feel are unsafe. Forcing fieldworkers into situations with which they are uncomfortable is likely to be unproductive in any case because if the fieldworkers are overly concerned about their safety or personal security, they will not do their best jobs. Reasonable precautionary measures,

[4] These guidelines are modeled after those provided by Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, page 139.

such as additional traffic control for roadside surveys and providing interviewer escorts for transit onboard surveys and home interview surveys, should be reviewed with fieldworkers and supervisors.

2. Fieldworkers should be briefed (and rebriefed) on safety procedures and on sensible procedures for reducing the risk of crime.

3. Fieldworkers should be allowed to visit survey sites prior to deciding whether the safety and security procedures are adequate. Doing so may allow fieldworkers to more easily object to the proposed work, but from the survey management viewpoint it is far better to have the concerns voiced before the day of the actual survey work.

Ideally, the survey agency or firm will be able to make modifications to the proposed survey procedures that address any fieldworker concerns about safety and security. If reasonable modifications are not successful in reducing the level of concern in a fieldworker, the fieldworker should be replaced. If at all possible, the agency or firm should make an effort to re-assign the fieldworker to a different task. In such cases it is imperative that the survey manager advise any potential replacement fieldworkers of the specific safety and security concerns of the original worker.

Responsibilities to Respondents and Potential Respondents

Travel surveyors must take steps to ensure that respondents are not deceived, that respondents' privacy rights are not abused, and that the standard social research protections for participants are maintained. The most often cited types of deception with surveys are the use of survey techniques to disguise sales efforts and the use of survey techniques in campaigns to collect names and addresses for direct marketing firms. Fortunately, travel surveys are not typically subject to these types of deception because the sponsoring agencies usually are not trying to sell products or services.

It is generally acknowledged that these types of sales activities are detrimental to the survey field, and should be condemned, but other questionable survey activities often escape criticism. Well-meaning survey managers can easily violate the rights of respondents in an effort to maximize the amount of useful data from the survey. Common problems are:[5,6]

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[5] David A. Aaker and George S. Day, Marketing Research, 4th edition, John Wiley & Sons, New York, 1990, page 218.

[6] Ishmael P. Akaah and Edward Riordan, *Judgments of Marketing Professionals about Ethical Issues in Marketing Research: A Replication and Extension,* Journal of Marketing Research, Vol. XXVI (February 1989), pages 112-120.

- Failing to provide the respondent with information about the sponsorship of the study;

- Failing to provide the respondent with information about the contracting firm conducting the survey;

- Misleading respondents about the time needed for the survey;

- Providing respondents with inaccurate information about gift or monetary incentives;

- Failing to tell respondents about potential follow-up surveys;

- Using techniques to observe or identify respondents without their knowledge (such as hidden tape recorders in telephone interviews, one-way mirrors, and ultraviolet ink identification codes on seemingly anonymous mail surveys);

- Failing to take steps to ensure that privacy is maintained throughout the survey analysis; and

- Careless storage and/or disposal of returned questionnaires.

To avoid these problems, Fowler suggests that all survey respondents be provided with the following information before being asked any questions:

1. The name of the organization carrying out the research, and for intercept and telephone surveys, the interviewer's name.

2. The sponsor of the study.

3. An accurate, though brief description of the purposes of the research.

4. An accurate statement of the extent to which answers are protected with respect to confidentiality, bearing in mind that some states may not allow agencies to protect respondents' confidentiality as much as other states do.

5. Assurance that cooperation is voluntary, and that no negative consequences will result to those who decide not to participate.

6. Assurance that respondents can skip any questions they do not wish to answer.

Today's travel surveys generally provide the first four pieces of information, but only a few surveys explicitly provide the fifth and the sixth due to the fear among surveyors that these assurances invite non-response and due to the fact that most respondents will be familiar enough with surveys to understand that they have the right to refuse to answer all or certain questions. If the suggested guidelines are not explicitly followed, interviewers should, at a minimum, be instructed to accept refusals (and item-related refusals) without question and not to push respondents into revealing information which they are uncomfortable providing.

Protecting respondents' privacy is an increasingly important issue for travel surveys. Some surveys ask respondents to provide work schedules for all household members, travel times and school locations for young children, specific home and work addresses, and detailed vehicle data, among other information. Because these data could easily be used against the respondents, it is incumbent upon the surveying firm or agency to safeguard the data.

Travel survey data and returned forms should be treated as confidential business information by those who collect and analyze them. Fowler suggests that the following precautions be used:[7]

1. All people who have access to the data or a role in the data collection should be committed in writing to confidentiality.

2. Links between answers and identifiers should be minimized. Analyses not requiring names and addresses should be performed on datasets without these pieces of information.

3. Completed interview schedules and returned questionnaires should not be accessible to people outside the project team.

4. Identifiers should be removed from completed questionnaires if they are made available to people outside the survey team.

5. Individuals who could identify respondents from their profile of answers, such as supervisors in the case of a survey of employees, should not be permitted to see the actual questionnaire responses.

6. The link between identification numbers and sample addresses and telephone numbers in data files should be minimized.

7. During analysis, researchers should be careful about presenting data for very small categories of people who might be identifiable.

8. Upon completion of the modeling work, the project manager is responsible for seeing that the completed instruments are destroyed or are securely stored on a continuing basis.

[7] Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, page 138.

5.0 Precision and Accuracy in Travel Surveys

■ 5.1 Objectives of Survey Sampling

A primary goal of most travel surveys is to collect data that allow analysts to estimate a range of travel-related and socioeconomic parameters that are often used to develop travel demand models. Ideally, the survey output would be error-free, so that the estimates derived from the sample would reflect the true value of the parameter in the population and could be used confidently in later analyses.

In collecting data from a sample of the population, measurement error can be divided into two types:

- Sampling errors; and

- Non-sampling errors/biases.

The "total error" of a parameter estimate derived from a survey sample reflects both the sampling and non-sampling errors in the collected data.

Sampling errors are the random errors that are introduced into the survey simply because not every member of the survey population is included in the drawn sample. Sampling errors reflect the potential variability between the estimate of a parameter in the sample and its true value in the population. These errors affect the ***precision*** of the survey results.

Non-sampling errors are the assortment of problems that can occur during the survey design and data collection stages which may cause survey measures and parameter estimates to be systematically incorrect. Non-sampling errors reflect how well the information is collected, and include non-response biases often caused by refusals and response biases which reflect a systematic distortion of survey responses. These errors affect the ***accuracy*** of the survey results.

As a result, it can be stated that the goal of sampling is to:

- Reduce sampling errors that can cause the parameter estimates and other measures to be imprecise; and

- Reduce non-sampling errors or survey biases that can cause the measurements to be inaccurate.

Reliability which is a common social science term, refers to the level of precision and sampling error in the collected data. The term validity refers to the accuracy level and bias of the data.

To convey the concepts of accuracy and precision in travel surveys, Richardson, Ampt, and Meyburg use the analogy of sharpshooters firing at a target.[1] Figure 5.1 shows four ways in which a target shooter can hit a target. The top left target shows the results of a shooter who is both accurate (shots are centered on the bullseye) and precise (shots are all consistent with each other). The top right target shows the results of a precise, but inaccurate shot. This marksman's shots are consistent with each other, but are not on target. The bottom left target shows the results of an accurate, but imprecise shooter. The shots are centered on the bullseye, but they are not well-grouped. The final bullseye shows the results of a marksman who is neither accurate nor precise in his shooting.

In travel surveys, as in this analogy, precise parameter estimates are reliable and consistent whether they are accurate or not. By increasing the sample size, travel surveyors can improve the precision of parameter estimates. This is because with a larger sample, the probability that units outside the sample have different characteristics due to chance is reduced. As with the targets in the analogy, survey accuracy is defined by how well a parameter estimate conforms to the true parameter value in the popluation (as illustrated by the bullseyes.)

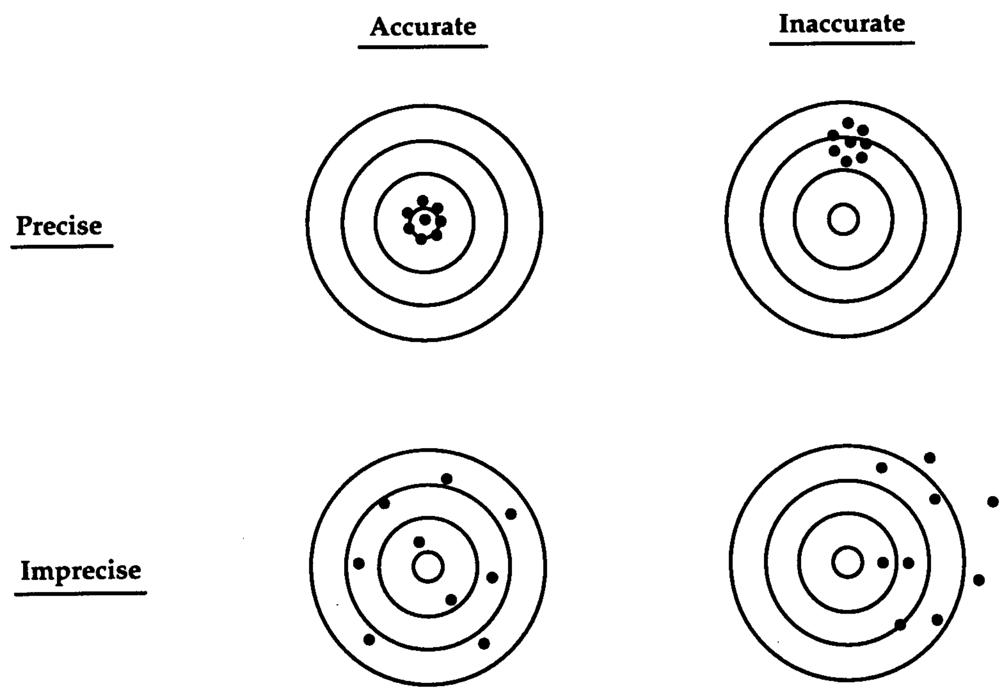
Because we can see the targets in Figure 5.1, we are able to make judgments about the success of the different marksmen. Clearly, the top left target where shots are both precise and accurate is the best outcome, while each of the others leave something to be desired. Most people would also argue that the bottom left target (accurate although imprecise shots) represents the second best outcome because the shots are on target at least, with the other targets being less desirable.

However, as shown in Figure 5.2, our ability to make judgments about the success of the different efforts is greatly diminished if the targets are removed. Without the targets, it is impossible to assess any differences between the two upper marksmen or the two lower marksmen. It is possible to discern differences between the upper and lower targets, but we really need to know whether the shots are on target to select the better of the two groups.

This later condition is the one faced by travel surveyors. The actual values of model inputs and parameters are not known – that is exactly why the survey is being conducted. Travel surveyors are left with the challenging task of expending scarce study resources to determine the appropriate

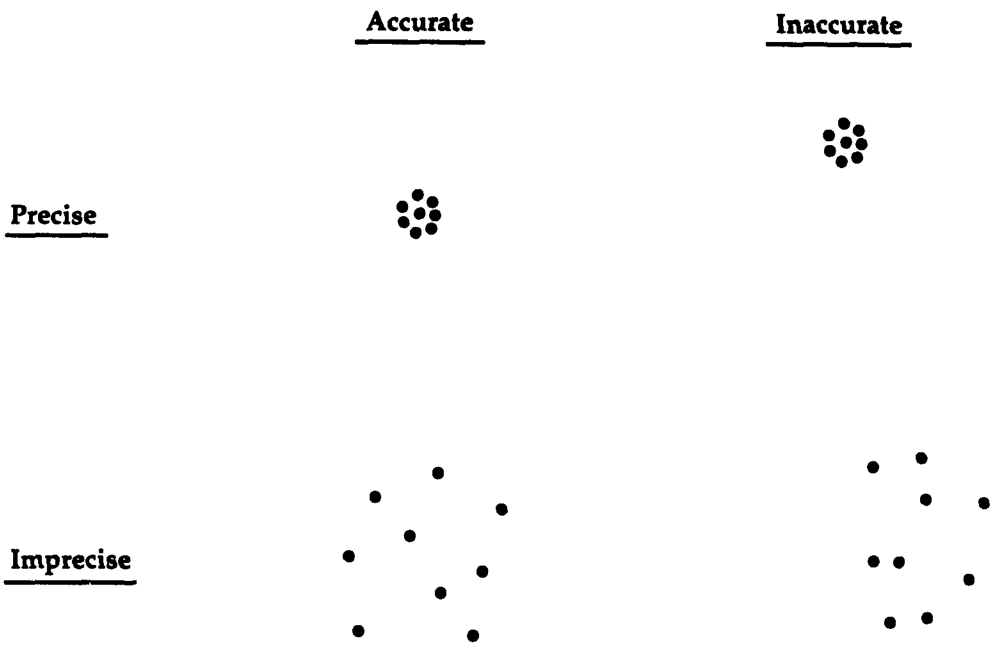
[1] A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg, <u>Survey Methods for Transport Planning</u>, Eucalyptus Press, Melbourne, 1995, pg. 97.

Figure 5.1 The Sharpshooters: An Analogy for Survey Accuracy and Precision



Source: A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg, Survey Methods for Transport Planning, Eucalytus Press, Melbourne, 1995.

Figure 5.2 The Difficulty of Measuring Accuracy and Precision in Travel Surveys



Source: A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg, *Survey Methods for Transport Planning*, Eucalytus Press, Melbourne, 1995.

levels of precision and accuracy in parameter estimates without benefit of the knowledge of the true answers.

The "total error" of a parameter estimate derived from data collected through a survey is a combination of both the imprecision and inaccuracy in the survey data. The mean squared error (MSE) is the corresponding measure of "total error" and is related to the level of precision and accuracy in the survey data as follows:

$$\text{MSE} = \sqrt{SE^2 + B^2} \qquad \text{(Eq. 5.1)}$$

where:

SE = the standard error of the estimate (a measure of sampling precision); and

B = the combination of all biases in the estimate (a measure of accuracy).

In cases where the standard error (SE) of the estimate is very large compared to the bias (B), the "total error" of the estimate is primarily a reflection of the imprecision of the survey data. Alternatively, in cases where the precision of the survey data is satisfactory leading to low values of the standard error (SE), the "total error" of the estimate primarily reflects the inaccuracy of the survey data and the corresponding biases (B).

The next several sections of this chapter (Section 5.2 through 5.8) discuss how measures of survey precision levels can be quantitatively measured and how they are influenced by sample size. The last section of the chapter (Section 5.9) then discusses bias and accuracy issues. Unfortunately, determining the level of accuracy (bias) of survey data almost always has to be a somewhat qualitative exercise. Therefore, the most practical approach for tackling this problem is to take the steps, and spend the resources necessary to feel comfortable that the parameter estimates are reasonably accurate and free of bias – that is, to feel fairly sure that the marksman is on target, and then to spend remaining resources to improve the precision of estimates (primarily by increasing the sample size).

■ 5.2 Sampling Methods and Sample Design

The development of a sample design can be characterized as an iterative process that is driven in part by the overall objectives of the survey but is often constrained by the limited resources and the information that is readily available on variables of interest. The key issues associated with sample design are summarized in Figure 5.3, which provides a step-by-step approach that could ideally be used to address each of the different dimensions of the sample design process.

However, it is often the case that there will be considerable uncertainty surrounding each of the key issues associated with sample design. For example, a travel survey may serve a variety of multiple objectives, making it difficult to define a limited number of variables of interest that could be used as criteria of precision. Furthermore, the limited available resources often dictate the survey design and methods. Finally, the sample size calculations are often based on a range of assumptions about the distribution of the variable of interest in the study population. In light of the uncertainty that may underlie different aspects of sample design, it would be useful to adopt an iterative approach to sample design, recognizing the interrelated decisions on different aspects of sample design and the limitations of the available information used to develop a sample design.

Therefore, to collect travel data for the development of policy-sensitive and statistically robust demand model inputs and parameters, it is important to identify and determine as part of the sample design process:

- The ***information*** that needs to be collected through the survey to provide the greatest degree of support to transportation planners and decision-making agencies;

- The ***study population*** of interest whose travel patterns need to be understood and for which data need to be collected;

- The appropriate ***sampling frame*** that has an exhaustive list of members of the study population from which respondents can be drawn;

- The ***sampling unit*** that is required to provide the necessary information at the level of detail that is needed for the proposed analyses;

- The ***constraints*** and their impacts on survey and sampling methods; and

- The ***sample size*** that is required to measure the socioeconomic characteristics and travel behavior of the study population in a precise and accurate manner and to provide policy sensitive and statistically robust inputs to modeling.

In the following sections we adopt a step-by-step approach to sample design and we focus on each of the key issues presented in Figure 5.3.

Figure 5.3 Key Issues in Sampling for Travel Surveys

1. What are the primary objectives and constraints of the survey?
2. What are the variables of greatest interest and the desired level of precision?
3. How should the study population, sampling frame, and unit be defined?
4. What information is readily available on the variables of interest?
5. Which sampling method should be used to meet the precision requirements?
6. What sample size is required to satisfy these precision requirements?
7. Are there enough resources to collect such a sample?
8. What is the precision and confidence level corresponding to a smaller sample size?

What are the Primary Objectives and Constraints of the Survey?

The development of the sample design, the travel survey instrument, and the data collection method should ideally be driven by the overall objectives of the analysis. The sample size requirements would thus account for the needs of the model system. Such an approach to sampling methodology, sampling frame, sampling unit, and sample size determination would focus on each individual modeling component and account for the critical variables most likely to be used in each modeling stage.

However, the available resources allocated to the development and analysis of a survey often dictate different aspects of the travel survey development and data collection. Since budgets are often set prior to any technical analysis related to sample design, little formal effort is usually given to the analyses of sample size requirements and considerations of required precision[2].

Furthermore, since data collected through travel surveys are used to support a variety of different travel modeling analyses (e.g., trip generation, trip distribution, mode choice, time-of-day) over prolonged periods of time, such datasets are used for purposes that were not initially intended. As a result, it is often difficult to identify a single measure or a limited set of measures that could be used as the ultimate criterion for developing an optimal sample design. As stated by Fielding and Gunn, no criterion for optimality can be defined since the data that are collected are used as inputs to different although interdependent analyses[3].

Although the budgetary constraints and the multiple objectives of a survey further complicate the analysis for sample size requirements, it is important to recognize them as potential limitations and undertake an analysis to assess their impacts on the precision of the data that will be collected. Such an analysis allows the examination of the tradeoffs between sample size for the whole sample and the expected degree of precision for variables that may be critical to the analysis. Similarly, the analysis of the tradeoffs between sample size and precision can also be repeated for market segments of particular interest to the analysis.

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[2] Pete Fielding and Hugh Gunn. Sample Design Workshop Summary in Ampt, E.S., Richardson, A.J. and Brög, W. (1985). New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pg. 25.

[3] Pete Fielding and Hugh Gunn. Sample Design Workshop Summary in Ampt, E.S., Richardson, A.J. and Brog, W. (1985). New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pg. 25.

What are the Variables of Greatest Interest and the Desired Level of Precision?

The identification of the variables of interest follows directly from the explicit definition of the objectives of the travel survey. A list of variables of interest that are considered critical to the analysis and reflect the primary analysis objectives can be listed both for the whole sample and/or for market segments of particular interest.

For example, a travel survey that is geared towards developing trip generation models may require a desired level of precision for variables that reflect the travel patterns of a household or an individual respondent, such as the total number of daily trips, the trip rate per household member, or the mix of trip purposes. Such a survey would likely focus on determinants of trip making including socioeconomic characteristics such as household size, number of workers in the household, income, or the level of automobile ownership.

Similarly, a travel survey that will be developed to estimate the mode choice behavior of commuters may focus either on the observed mode choice behavior by seeking a precise estimate of the transit market share for the whole sample, or for distinct market segments of interest. In this case, the survey should focus on the variability of variables that determine respondents' mode choice behavior, including the distribution of travel times and costs experienced by travelers in the study area.

The definition of a set of variables that are of greater importance to the survey and the corresponding analyses is critical in determining the required sample size. In the step-by-step approach outlined in Section 5.4, sample size requirements are assessed by using a single variable of interest which has a known mean and variability in the study population. The sample size estimation process can be repeated for each variable of interest and under a variety of desired precision and statistical significance options to arrive at a sample size that satisfies the requirements of the analysis.

Finally, the same process can be repeated for each market segment of interest. In such a case, the objective of the analysis would be to ensure an adequate sample size for each distinct market segment of interest so that the estimates obtained within each of those segments would be accurate and precise.

How Should the Study Population, Sampling Frame, and Unit be Defined?

The definition of the ***study population,*** discussed in Section 3.2, is critical in determining the respondents who would be eligible to be included as part of the study.

Following the definition of the study population, a ***sampling frame*** provides the means to reach each member of the study population who would be eligible to be surveyed. A potential limitation of a sampling frame is that it may provide only a partially complete list of all eligible sampling units and may thus require to be augmented by additional sources. When two or more data sources need to be combined, care must also be taken to minimize the duplicate entries that may appear in both sampling frames.

Finally, the definition of a ***sampling unit*** is related to the type of information that needs to be collected and the desired degree of detail in the data. For example, a study focusing on transit users' travel patterns will be limited in collecting information from transit riders while a survey aimed at analyzing activity patterns may use the household as the sampling unit.

What Information is Readily Available on the Variables of Interest?

The calculation of the required sample size can be undertaken for each random variable for which a certain level of precision is required. However, the sample size calculations based on a particular random variable rely in turn on existing values for the *mean* and the *variability* of that variable in the study population. Thus, it is important to define early in the sample design process different sources that could provide such information including:

- Recent household and/or travel survey(s) undertaken in the same study area;
- Surveys in the study area that may have been collected for different purposes;
- Expert or review panels and/or staff from local agencies familiar with the area;
- The 1990 U.S. Census which provides a wealth of socioeconomic and travel-related information at different levels of geographic detail; or
- The Journey-To-Work data from the U.S. Census.

These sources would be part of the background data assembly task, discussed in Section 2.2.

Which Sampling Method Should be Used to Meet the Precision Requirements?

The selection of a sampling method is interrelated with the broad objectives of the survey; the study population, and the corresponding appropriate sampling frame, and sampling unit; and the desired level of precision[4]. Sampling methods can generally be classified in three different ways. These categories differentiate probability versus non-probability sampling methods; single- versus multi-stage sample selection methods; and methods with a uniform versus differential probability of selecting an element in the population.

The ***non-probability*** methods can be used only in cases where the survey is ***not*** used to make inferences about the travel characteristics or the travel behavior of the study population as a whole. The non-probability methods include:

- Convenience sampling such as the administration of a travel survey of workers in a single office building;
- Judgment sampling such as the administration of a vehicle ownership survey to residents of a higher-income suburb; and
- Quota sampling such as the completion of 50 surveys per city block irrespective of and without controlling for differences in residential density.

In most cases, however, it is necessary to use a ***probability sampling method*** to obtain statistically valid estimates of population characteristics. This requires the advance knowledge of, or the ability to assess, the probability of selection for each member of the sample. To accomplish that, a ***probability sampling method*** is used where each sampling unit has a non-zero probability of being selected as part of the sample; this probability can be estimated by the analyst. Since this represents the situation for most travel surveys, the remainder of this chapter focuses on probability-based methods.

Probability sampling methods also allow the analyst to define different probabilities of selection for elements of the population in particular segments of the market and accordingly expand the sample to make it

[4] G.A. Churchill.. Marketing Research: Methodological Foundations, The Dryden Press, 1984.

representative of the study population. The probability sampling methods allow statistically valid inferences to be made about the population as a whole and include[5]:

- *Simple random sampling* where each population element has the same probability of being chosen;

- *Systematic sampling* where sample items are chosen in a systematic manner (e.g., every 20th name in a telephone directory);

- *Stratified sampling* where the population is divided into smaller groups and a random sample is chosen within each group;

- *Cluster sampling* where a sample of groups is selected and every member of the group is selected; and

- *Choice-based* sampling which is a special case of stratified sampling and groups are formed based on an endogenous variable.

The differences among these methods and their relative merits are described in detail in Section 5.8. The final choice of sampling method depends on the distribution of the variables of interest among the population. If all variables of interest – for example, auto ownership levels, household size, income levels, mode shares, etc. – are evenly distributed in the population, then a simple random sample of sufficient size may provide adequate representation of all variables. However, it is often the case that a very large simple random sample would be needed to obtain a sufficient representation of different values for particular variables. For example, there may be few households without cars, or few users of a particular transit mode. In this case, a stratified or choice-based sampling plan may be required. The choice of sampling method must be made in conjunction with the definition of sample size and the constraints on existing resources.

What Sample Size is Required to Satisfy these Precision Requirements?

To estimate the total sample size needed to measure the variables of interest with a pre-determined desired degree of precision and a level of confidence, the mean value of the variable and its variability in the population need to be known. Assuming that the sample method, sampling frame, and sampling unit have been determined and that the proposed data collection

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[5] A.J. Richardson, E.S. Ampt, and A.H. Meyburg. Survey Methods for Transport Planning, Eucalyptus Press, 1995.

method minimizes the sampling bias, the calculation of sample size can be viewed from two different perspectives. The analyst may be interested in determining:

- The sample size that would be required to provide a desired degree of precision under a specific level of statistical confidence for each of the variables of interest; or alternatively; and

- The precision or level of confidence that can be expected for each variable of interest by collecting information from a given sample size.

The process of determining sample size and relating it to precision and level of confidence can be conducted either for the whole sample or for individual market segments of greater interest. Although the same sampling principles are used in both cases, collecting an adequate sample for different market segments is expected to result in a larger sample size than would be required for the whole sample under the same precision and level of confidence requirements.

Are There Enough Resources to Collect Such a Sample?

The sample size calculations will result in a range of sample size estimates that would be necessary to satisfy the level of confidence and degree of precision desired for each of the variables of interest. However, it is likely that the cost of the survey effort based on the calculated sample sizes may exceed the budget allocated for the survey. If budget constraints dictate a sample size that is smaller than the "ideal" calculated sample size, the corresponding degree of precision and/or the level of confidence would be lower for at least some of the variables of interest.

In such a case, the methodology for sample size calculations can be further used to address the tradeoffs between various sample sizes and the corresponding degree of precision and level of confidence. Furthermore, at this stage it is important to explore whether different sampling methods such as stratification, cluster, or choice-based sampling can be used to improve the expected precision and level of confidence of particular variables either for the whole sample or for the market segments of greatest interest to the analysis.

What is the Precision and Confidence Level Corresponding to a Smaller Sample Size?

The same methodology used for sample size calculations can be used to quantify the tradeoffs between sample size, the level of confidence, and the degree of precision. However, instead of calculating the sample size required for a desired degree of precision and level of confidence for the variables of interest, the question needs to be restated.

Thus, the objective of the analysis is now to calculate the level of confidence and degree of precision that correspond to sample sizes that would be smaller than the "ideal" sample size. Such calculations allow the analyst to finalize the iterative sample design process by identifying the tradeoffs among sample size, level of confidence and degree of precision, and recognizing the strengths and weaknesses of each alternative sampling plan.

Finally, although smaller sample sizes would result in less precise estimates for some variables, a new travel survey would still provide a wealth of updated detailed data. Thus, a new survey is likely to offer a considerably more accurate picture of travel patterns and socioeconomic characteristics than older dated data sources that are probably used for planning purposes.

■ 5.3 A Brief Discussion of Sampling Principles

A tradeoff between the costs of data collection that reflects the sampling method, and between the sample size and the quality of the data, which in turn reflects both the accuracy and the precision of the measures resulting from the drawn sample, forms the core issue in survey sampling. Since travel surveys are used to make inferences about the characteristics and the travel behavior of the study population, it is important to determine the range of sample sizes that would be required to achieve a desired level of precision and level of confidence[6] for selected variables of interest. Alternatively, it is equally important to determine the degree of precision and level of confidence that would be expected for each variable of interest under a range of sample sizes. Thus, the analysis of sample size seeks to measure the tradeoffs between sample size and the corresponding levels of precision and confidence that can be achieved for selected variables of interest.

Sample size is determined by the distribution of values for the variable of interest and by the desired degree of precision and level of statistical significance or confidence. The two pieces of information that convey the information about the distribution of the variable of interest in the study population include:

[6] In this chapter, the level of confidence (1-I, often taking a value of 95 percent) is used for discussion purposes instead of the corresponding level of statistical significance (I, often taking a value of 0.05).

Sample size is determined by the distribution of values for the variable of interest and by the desired degree of precision and level of statistical significance or confidence. The two pieces of information that convey the information about the distribution of the variable of interest in the study population include:

- The mean value of the variable in the study population; and
- A measure of its variability in the study population.

The mean value (m) provides a measure of the central tendency of the variable while its variance ([2) and standard deviation ([) provide measures of the variability/spread of the variable values (Table 5.1). Similarly, the coefficient of variation (CV), which is equal to the ratio of the standard deviation of the variable and its mean, provides a measure of the relative variability of the variable values around the mean.

The most commonly used estimator in sample size determination is the average value of a variable in the sample denoted by $\bar{x}$. The sample average ($\bar{x}$) is an estimator of the true mean value in the study population (m) and its standard error SE ($\bar{x}$) provides the basis for estimating sample size. The standard error of the sample mean $\bar{x}$ depends on the variability of the variable in the population (as reflected on its variance, σ^2) and the sample size (n) and is equal to:

$$SE(\bar{x}) = \sqrt{\frac{\sigma^2}{n}}$$

This suggests that for a given variability of the variable x in the population (given by [2) the standard error can be reduced by increasing the sample size (n). Furthermore, for a given sample size (n) the magnitude of the standard error will reflect the spread of the variable values in the population as captured by the variance (σ^2). In cases where the variable values are clustered closely around the mean, the standard error will be small; in cases where the variable values are spread out, the standard error will have a correspondingly higher value.

The other two pieces of information that are used to determine sample size relate to the desired value of the standard error and include:

- The degree of precision required for the analysis; and
- The desired of confidence/statistical significance that corresponds to the estimates used in the analysis.

Table 5.1 Notation Used in Sample Size Estimation

N:	Population size
m:	Mean of random variable in the population
$\bar{x}$:	Estimate of mean (m) from the sample
p:	Proportion of discrete random variable in population[1]
$\hat{p}$:	Estimate of proportion from the sample
σ^2:	Variance of random variable in the population
s^2:	Estimate of variance from the sample
σ:	Standard deviation of random variable in the population
s:	Estimate of standard deviation from the sample
CV:	Coefficient of variation
$\cap$:	Significance level
$1-\cap$:	Confidence level
z:	Z-statistic
D:	Absolute precision
d:	Relative precision
SE($\bar{x}$):	Standard error of the average
n′:	Sample size *not* corrected for finite population
n:	Sample size *corrected* for finite population

[1] A discrete variable x_i takes a value of 1 if true and 0 otherwise for example, to calculate transit market share, a value of 1 is used for transit riders and a value of zero for all others. The proportion of transit riders, p, is equal to:

$$p = \sum_{i=1}^{N}\left(\frac{x_i}{N}\right)$$

These two pieces of information can in turn be used to calculate the ***desired standard error*** of the average under a variety of precision and level of confidence scenarios. As outlined in Section 5.4, the integration of the formulas that calculate the standard error of the average and the corresponding desired standard error allows the calculation of the sample size for a variable with a given mean population and variance values and under the desired precision and level of confidence. Since both of these dimensions of the sample design reflect the ability of the sample to precisely measure the variable of interest, a larger sample needs to be collected to achieve a higher level of desired precision and/or statistical confidence.

The degree of precision can be expressed either as an absolute (D) or as a relative deviation (d) from the mean variable value and reflects the difference between the true mean in the population and its estimate of the average from the sample (Table 5.1). Thus, for a study population characterized by an average income of $45,000, the desired degree of precision could be expressed as a D=±$1,800 or as a d=±4 percent deviation from the mean income. As either measure of deviation decreases, the size of the sample that is required to achieve the corresponding degree of precision increases.

The level of confidence (1-I) is expressed as a percentage and represents the probability that another sample drawn under the same circumstances from the same study population will result in an estimate of the mean value of the variable that satisfies a given degree of precision. The level of confidence is reflected on the corresponding z-statistic value taken from the standard normal distribution. For a higher level of confidence in the sample estimates, a larger sample size is required.

■ 5.4 Calculation of Sample Size for a Simple Random Sample

The simple random sampling method provides the foundation upon which each of the more complex probability sampling methods is based. According to this sampling method, each population unit has an equal selection probability.

To estimate the sample size needed to measure any variable with a predetermined degree of precision, the following information is required (Table 5.1):

- The mean variable value in the study population;
- A measure of the variability of this variable in the study population;

- The desired degree of absolute or relative precision; and

- The desired statistical level of confidence.

The process of calculating the required sample size for a study based on a simple random sample can be best illustrated by using an example of a hypothetical household travel survey. A Metropolitan Planning Organization that covers an area with a population of about 200,000 residents and 120,000 households, is interested in conducting a household travel survey to better understand the travel behavior of study area residents.

To accomplish that, the agency planners need to draw a representative sample of households in the study area. The study area is characterized by differences ***in income*** that are believed to have an important effect on the travel options available to the study area residents and their resulting mode choices and travel behavior. Furthermore, one of the primary thrusts of the modeling effort would be to model the determinants of ***transit market share***. As a result, the sample size calculation process needs to be repeated twice, once using household income as the variable of interest and once using the transit market share as the variable of interest.

To account for the variability in the study population and to obtain measures with a reasonable degree of precision, the MPO staff want to collect a large enough sample that will allow them to estimate the household income within ±4% of the mean household income in the study area that is currently $45,000. Furthermore, to assess the determinants of transit market under a variety of service improvements, MPO planners want to collect enough observations to be able to estimate the transit share from the survey with a relative precision of ±10% of the observed transit market share of 35 percent. For both the household income and the transit market share estimates that will be obtained from the household survey, MPO planners want to have a 95 percent confidence level.

The formulas that are used in the sample size calculations are summarized in Table 5.2. For all practical purposes, the "correction" that applies to the sample variance (s^2) estimate that enters Equation 5.9a has a negligible impact on sample size and can safely be omitted. Thus, the remainder of this chapter will rely on the formulas assuming the population variance σ in Table 5.2 and Equations 5.2 to 5.9.

The sample size calculations based on household income are presented in Table 5.3 while the sample size calculations that are based on the transit market share are shown in Table 5.4. As shown in Table 5.3, a sample size of just under 500 observations is needed to ensure that the estimate of average household income from the survey would be within four percent of the mean income value in the population at a 95 percent confidence level. Similarly, about 700 observations would be needed to estimate

Table 5.2 Formulas Used in Sample Size Estimation Based on Population Variance

Mean: $m = \sum_{i=1}^{N} \left(\frac{x_i}{N} \right)$ for continuous variables (Eq. 5.2)

Proportion: $p = \sum_{i=1}^{N} \left(\frac{x_i}{N} \right)$ for discrete variables (Eq. 5.2.a)

Variance: $\sigma^2 = \frac{1}{N} \sum_{i=1}^{N} (x_i - m)^2$ for continuous variables (Eq. 5.3)

$\sigma^2 = p * (1 - p)$ for discrete variables (Eq. 5.4)

Coefficient of Variation: $CV = \frac{\sigma}{m}$ (Eq. 5.5)

Desired Standard Error: $SE(\bar{x}) = \frac{D}{z}$ (Eq. 5.6)

or: $SE(\bar{x}) = \frac{d * m}{z}$ (Eq. 5.7)

Uncorrected Sample Size: $n' = \frac{\sigma^2}{\left(SE(\bar{x})\right)^2}$ (Eq. 5.8)

or: $n' = (CV)^2 \frac{z^2}{d^2}$ (Eq. 5.8a)

Corrected Sample Size*: $n = \frac{n'}{1 + \frac{n'}{N}}$ (finite population correction) (Eq. 5.9)

* If the variance of the sample rather than that of the entire population is used, then s, the sample standard deviation, should be used rather than □, the population standard deviation. In this case:

$n = \frac{n'}{1 + \frac{n' - 1}{N}}$ corrected for finite population (Eq. 5.9.a)

Table 5.3 Sample Size Estimates Based on Household Income

Inputs			Formulas	Estimates	
Population Size	N	120,000	SE($\bar{x}$) Equation 5.7	Inputs: SE($\bar{x}$) =	m, d, z $918.4
Mean	m	$45,000			
Standard Deviation	[	$20,000			
Confidence Level	1-I	95%	n′ Equation 5.8	Inputs: n′	SE(mean), [474
Z-Statistic	z	1.96			
Relative Precision	d	±4% of mean	n Equation 5.9	Inputs: n =	N, n′ 472
Population Size	N	120,000	n′ Equation 5.8a	Inputs: n′ =	CV, d, z 474
Coefficient of Variation	CV	0.444			
Confidence Level	1-I	95%	n Equation 5.9	Inputs: n =	N, n′ 472
Z-Statistic	z	1.96			
Relative Precision	d	±4% of mean			

Table 5.4 Sample Size Estimates Based on Transit Market Share

Inputs			Formulas	Estimates	
Population Size	N	120,000	SE($\bar{x}$)) Equation 5.7	Inputs: SE($\bar{x}$)) =	m, d, z 0.9%
Transit Share	p	35.0%			
Standard Deviation	σ	47.7%			
Confidence Level	1-I	95%	n′ Equation 5.8	Inputs: n′ =	SE($\bar{x}$), [713
Z-Statistic	z	1.96			
Relative Precision	d	±10% of share	n Equation 5.9	Inputs: n =	N, n′ 709
Population Size	N	120,000	n′ Equation 5.8a	Inputs: n′ =	CV, d, z 713
Coefficient of Variation	CV	1.363			
Confidence Level	1-I	95%	n Equation 5.9	Inputs: n =	N, n′ 709
Z-Statistic	z	1.96			
Relative Precision	d	±10% of share			

transit market share from the survey at the desired precision and confidence levels. As a result, a sample size of 700 observations would ensure that both variables of interest would be estimated satisfactorily from the collected survey data.

A Step-by-Step Approach to Sample Size Determination

Although the tables summarize the sample size calculations, a step-by-step approach to sample size calculations that outlines in greater detail each of the formulas used in calculating sample size based on the household income variable is presented below.

Step 1. Estimate the Mean and Standard Deviation or the Coefficient of Variation

First, estimates of the mean value and its corresponding standard deviation for household income need to be made. These two measures provide a snapshot of the income distribution and can be calculated based on previous surveys, census data, or can be derived from estimates provided by other analysts and expert panels.

Mean: $m = \$45{,}000$ (See Eq. 5.2)

Standard deviation: $\sigma = \$20{,}000$ (See Eq. 5.3)

In cases where the mean and the standard deviation are not known and cannot be estimated with a reasonable degree of confidence, the coefficient of variation could also be used. This measure reflects the ***relative magnitude*** of the standard deviation with respect to the mean and provides a measure that is readily comparable across different application environments and travel surveys.

Coefficient of variation: $CV = \frac{\sigma}{m} = \frac{\$20{,}000}{\$45{,}000} = 0.444$ (See Eq. 5.5)

Step 2. Set the Desired Confidence Level

The desired statistical confidence level is set by selecting a confidence level and calculate the corresponding value for the z-statistic. The values most often used in sample design and statistical analyses are the 95 percent confidence level and the corresponding z-statistic value of 1.96. Although the z-statistic values vary with the sample size, for a sample with 1,000 or more observations, the values in Table 5.5 can be used.

Step 3. Determine the Desired Degree of Precision

The acceptable range around the mean household income value reflects the degree of precision that is desired for the household survey estimates of income. The desired degree of precision could be defined as relative (e.g., precision within ± 4 percent of the mean) or absolute (e.g., deviation of ± $1,800 from the mean).

Relative precision: $d = \pm\frac{D}{m} = \pm 4\%$

Absolute precision: $D = \pm \$1{,}800$

Step 4. Calculate the Standard Error of the Average

The desired standard error of the average (SE ($\bar{x}$)) encompasses three pieces of information that are important in sample size determination: the mean (m) of the variable in the study population, the desired degree of precision (D or d), and the desired confidence level in the estimate from the survey (z statistic). By applying Equation 5.7, we obtain:

$$SE(\bar{x}) = \frac{\left[\frac{D}{m}\right]}{z} * m \Rightarrow SE(\bar{x}) = \frac{d}{z} * m \Rightarrow SE(\bar{x}) = \frac{4\%}{1.96} * \$45{,}000 = \$918.4$$

Step 5. Calculate the Uncorrected Sample Size

An initial value of sample size can now be provided. This uncorrected sample size value *does not* account for the size of the study population and may thus require a correction for the potential finite population effect. By applying Equation 5.8 we obtain:

Uncorrected Sample Size: $n' = \frac{\sigma^2}{(SE(\bar{x}))^2} = \frac{\$20{,}000^2}{\$918.4^2} = 474\ obs.$

Table 5.5 Correspondence Between Confidence Level and z-Statistic Values[1]

Confidence Level (1-α)	z-Statistic
50.0%	0.67
60.0	0.84
70.0	1.04
80.0	1.28
90.0	1.64
95.0	1.96
99.0	2.58
99.9	3.29

[1] R.J. Jessen. *Statistical Survey Techniques,* Wiley, 1978.

Step 6. Adjust Sample Size for the Finite Population Correction

A finite population adjustment is not critical if the population for which we wish to draw inferences is rather large. However, such an adjustment may have a measurable impact if the sample estimate is smaller than 10 percent of the study population. To adjust for the finite population correction, an estimate of the size of the study population is needed. Assuming a population size of N = 120,000 households and by applying Equation 5.9, we obtain:

$$\text{Corrected Sample Size: } n = \frac{n'}{1+\frac{n'}{N}} = \frac{474}{1+\frac{474}{120{,}000}} = 472 \; obs.$$

■ 5.5 Sensitivity of Sample Size to its Determinants

It is important to realize that the required sample size for a simple random sample depends on a multitude of variables, as shown in Table 5.2. Key variables include the desired confidence interval and level of precision, the mean and standard deviation (or variance) of the variable in the population, and the size of the population. This section demonstrates the sensitivity of the sample size requirement to each of these variables, using the example of the previous section. It should be noted that although the patterns noted here would hold for almost any travel survey context, some of the results shown are specific to this application. A sensitivity analysis that is tailored to any problem under study can be set up in a spreadsheet using the same table structure and the equations presented in Section 5.4.

Sensitivity to Confidence Level

Table 5.6 shows that the required sample size is extremely sensitive to the chosen confidence interval. Dropping the confidence level from 95 percent to 90 percent in the example would result in a reduction in sample size by about 30 percent. Conversely, increasing the confidence level to 99 percent would result in a 75 percent increase in the required sample size. Since the required sample size is proportional to the square of the z-statistic (as shown in Equations 5.7 and 5.8), the percentage changes in the sample size would hold for any sample size computation. Given the cost implications of different sample sizes and the fact that the survey analyst can choose the desired confidence interval, this is a significant observation.

Table 5.6 Sensitivity of Sample Size to Confidence Level

Population Size	Mean	Standard Deviation	Confidence Level	z-Statistic	Relative Precision	Standard Error	Sample Size	
N	m	[	1-I	z	d	$SE(\bar{x})$	n′	n
120,000	$45,000	$20,000	50.0%	*0.67*	4.0%	$2,687	55	55
120,000	45,000	20,000	60.0	*0.84*	4.0	2,138	88	87
120,000	45,000	20,000	70.0	*1.04*	4.0	1,731	134	133
120,000	45,000	20,000	80.0	*1.28*	4.0	1,404	203	203
120,000	45,000	20,000	90.0	*1.64*	4.0	1,095	334	333
120,000	**45,000**	**20,000**	**95.0**	***1.96***	**4.0**	**918**	**474**	**472**
120,000	45,000	20,000	99.0	*2.58*	4.0	698	822	816
120,000	45,000	20,000	99.9	*3.29*	4.0	547	1,336	1,322

Sensitivity to the Desired Degree of Precision

Table 5.7 shows that the required sample size is even more sensitive to the desired level of precision. Equations 5.7 and 5.8 show that the sample size is inversely proportional to the square of the desired precision level. So doubling the precision level would cut the required sample size by three quarters; halving the level would quadruple the required sample size. The implications of this sensitivity are tremendous given the analyst's ability to choose the desired precision level.

Care must be taken, however, not only in defining the precision level, but the variables to be analyzed. For example, say an area has existing mode shares of two percent transit and 98 percent auto. If auto mode share is chosen as the analysis variable, a one percent or two percent precision level appears quite reasonable, and choosing the two percent level would require only one quarter of the sample size required for one percent. However, this implies going from a 50 percent precision level for the estimate of transit mode share to 100 percent. In this case, it would make sense to choose the transit mode share as the variable of interest. Of course, since this variable would have a much lower mean, the resulting required sample size, even if the level of precision went up to five percent or even 10 percent, would still be greater than that for the auto mode share since the mean is much smaller (see Equations 5.7 and 5.8 and Table 5.8).

Sensitivity to Mean and Standard Deviation

Since the required sample size is inversely proportional to the square of the mean and directly proportional to the variance of the analysis variable, differences (or errors) in the mean and the variance can have a significant effect on the sample size requirement. For example, Table 5.8 shows that a 10 percent change in the mean results in approximately a 20 percent change in the sample size requirement. Table 5.9 shows similar results for changes in the standard deviation. Given the uncertainty of estimates of means for certain variables, especially those not included in census data, this table demonstrates the caution that must be applied when determining sample sizes based on outside data sources.

Sensitivity to Population Size

Table 5.10 shows the sensitivity of the required sample size to the population size. For large populations of over 50,000, the sample size is within one percent of the theoretical maximum given the population mean and variance and the desired precision and confidence level. For smaller populations (which, except in small MPOs or cities, would imply some sort of market segmentation), the sample size could be reduced somewhat.

Table 5.7 Sensitivity of Sample Size to Desired Degree of Precision

Population Size N	Mean m	Standard Deviation [	Confidence Level 1-I	z-Statistic z	Relative Precision d	Standard Error $SE(\bar{x})$	Sample Size n′	n
120,000	$45,000	$20,000	95.0%	1.96	*0.5%*	$ 115	30,353	24,226
120,000	45,000	20,000	95.0	1.96	*1.0*	230	7,588	7,137
120,000	45,000	20,000	95.0	1.96	*2.0*	459	1,897	1,868
120,000	45,000	20,000	95.0	1.96	*3.0*	689	843	837
120,000	**45,000**	**20,000**	**95.0**	**1.96**	***4.0***	**918**	**474**	**472**
120,000	45,000	20,000	95.0	1.96	*5.0*	1,148	304	303
120,000	45,000	20,000	95.0	1.96	*10.0*	2,296	76	76
120,000	45,000	20,000	95.0	1.96	*15.0*	3,444	34	34
120,000	45,000	20,000	95.0	1.96	*20.0*	4,592	19	19
120,000	45,000	20,000	95.0	1.96	*25.0*	5,740	12	12
120,000	45,000	20,000	95.0	1.96	*30.0*	6,888	8	8
120,000	45,000	20,000	95.0	1.96	*40.0*	9,184	5	5
120,000	45,000	20,000	95.0	1.96	*50.0*	11,480	3	3

Table 5.8 Sensitivity of Sample Size to the Mean

Population Size	Mean	Standard Deviation	Confidence Level	z-Statistic	Relative Precision	Standard Error	Sample Size	
N	m	[	1-I	z	d	SE($\bar{x}$)	n′	n
120,000	$10,000	$20,000	95.0%	1.96	4.0%	$ 204	9,604	8,892
120,000	25,000	20,000	95.0	1.96	4.0	510	1,537	1,517
120,000	30,000	20,000	95.0	1.96	4.0	612	1,067	1,058
120,000	35,000	20,000	95.0	1.96	4.0	714	784	779
120,000	40,000	20,000	95.0	1.96	4.0	816	600	597
120,000	**45,000**	**20,000**	**95.0**	**1.96**	**4.0**	**918**	**474**	**472**
120,000	50,000	20,000	95.0	1.96	4.0	1,020	384	383
120,000	60,000	20,000	95.0	1.96	4.0	1,224	267	266
120,000	70,000	20,000	95.0	1.96	4.0	1,429	196	196

Table 5.9 Sensitivity of Sample Size to Standard Deviation

Population Size N	Mean m	*Standard Deviation* [	*Coefficient of Variation* *CV*	Confidence Level 1-I	z-Statistic z	Relative Precision d	Standard Error $SE(\bar{x})$	Sample Size n′	n
120,000	$45,000	*$ 5,000*	*0.111*	95.0%	1.96	4.0%	$918	30	30
120,000	45,000	*10,000*	*0.222*	95.0	1.96	4.0	918	119	118
120,000	45,000	*15,000*	*0.333*	95.0	1.96	4.0	918	267	266
120,000	**45,000**	***20,000***	***0.444***	**95.0**	**1.96**	**4.0**	**918**	**474**	**472**
120,000	45,000	*25,000*	*0.556*	95.0	1.96	4.0	918	741	736
120,000	45,000	*30,000*	*0.667*	95.0	1.96	4.0	918	1,067	1,056
120,000	45,000	*40,000*	*0.889*	95.0	1.96	4.0	918	1,897	1,862

Table 5.10 Sensitivity of Sample Size to the Finite Population Correction

Population Size N	Mean m	Standard Deviation [	Confidence Level 1-I	z-Statistic z	Relative Precision d	Standard Error SE($\bar{x}$)	Sample Size n′	Sample Size n	Ratio n/n′
500	$45,000	$20,000	95.0%	1.96	4.0%	$918	474	243	51.3%
1,000	45,000	20,000	95.0	1.96	4.0	918	474	322	67.8
2,000	45,000	20,000	95.0	1.96	4.0	918	474	383	80.8
3,000	45,000	20,000	95.0	1.96	4.0	918	474	410	86.3
4,000	45,000	20,000	95.0	1.96	4.0	918	474	424	89.4
5,000	45,000	20,000	95.0	1.96	4.0	918	474	433	91.3
10,000	45,000	20,000	95.0	1.96	4.0	918	474	453	95.5
20,000	45,000	20,000	95.0	1.96	4.0	918	474	463	97.7
30,000	45,000	20,000	95.0	1.96	4.0	918	474	467	98.4
40,000	45,000	20,000	95.0	1.96	4.0	918	474	469	98.8
50,000	45,000	20,000	95.0	1.96	4.0	918	474	470	99.1
120,000	**45,000**	**20,000**	**95.0**	**1.96**	**4.0**	**918**	**474**	**472**	**99.5**
250,000	45,000	20,000	95.0	1.96	4.0	918	474	473	99.8
500,000	45,000	20,000	95.0	1.96	4.0	918	474	474	99.9
1,000,000	45,000	20,000	95.0	1.96	4.0	918	474	474	100.0
10,000,000	45,000	20,000	95.0	1.96	4.0	918	474	474	100.0

In summary, the required sample size can be very sensitive to several variables, especially the desired precision and confidence level set by the survey analyst. If resource constraints require a reduction in the scope of the survey, a good deal of reduction in required sample size (and, therefore, cost) can often be bought by relaxing the confidence level or precision somewhat.

■ 5.6 Assessment of Degree of Precision

To quantify the tradeoffs between sample size and the corresponding degree of precision, the same principles underlying the sample size calculations can be used. The objective of such an analysis is to calculate the degree of precision that corresponds to a sample size that would be smaller than the "ideal" sample size that has already been calculated based on one or more variables. Such calculations could be repeated for a range of sample sizes and variables to identify the precision that would be expected under alternative sample size scenarios for each variable of interest.

To assess the absolute or relative degree of precision that can be expected for a given sample size and a desired level of confidence, the following information is required (Table 5.11):

- The variance of the variable in the study population (σ^2);
- The desired statistical level of confidence ($1-\alpha$) and the corresponding z-statistic;
- The sample size (n) and the population size (N); and
- The mean (m) of the variable in the population (required only in case the relative degree of precision is to be estimated).

The calculations for the degree of precision that corresponds to a given sample size can be best illustrated by relying on the same hypothetical household travel survey example mentioned earlier. The formulas that are used in the precision calculations are summarized in Table 5.11. First, the standard error of the average that corresponds to the variance of the variable and the given sample size and population size is calculated (Eq. 5.10). Then, the absolute degree of precision can be calculated by accounting for the z-statistic value that corresponds to the desired level of statistical confidence ($1-\alpha$) (Eq. 5.11).

There are two variations to these calculations. First, in cases where the *relative* degree of precision needs to be calculated, Equation 5.11 is slightly modified to take into account the mean value of the parameter (Eq. 5.12). Second, in cases where the parameter variance and/or its mean are not

Table 5.11 Formulas for Precision Given Sample Size n

Standard Error: $SE(\bar{x}) = \sqrt{\frac{\sigma^2}{n} * \frac{(N-n)}{N}}$ (Eq. 5.10)

Absolute Precision: $D = SE(\bar{x}) * z$ (Eq. 5.11)

Relative Precision: $d = \frac{SE(\bar{x}) * z}{m}$ (Eq. 5.12)

If the coefficient of variation (CV) is used instead of the mean and the standard deviation, the relative precision is given by the following equation:

$$d = \sqrt{\frac{(CV)^2}{n} * \frac{N-n}{N}}$$ (Eq. 5.13)

readily available, the coefficient of variation (CV) can be used instead. In such a case, since the standard error cannot be calculated directly, the degree of relative precision can be calculated as shown in Equation 5.13.

The precision equations outlined here have been applied to the household income example used in the previous section. Table 5.12 illustrates the calculations using two sets of inputs. In the first case, the mean and the variance of the parameter are assumed known, allowing us to calculate both the relative and the absolute degree of precision that correspond to a given sample size and confidence level. In the second case, the relative degree of precision is calculated based on the coefficient of variation instead of the mean and variance of the variable which are not known with certainty. Using the "ideal" sample size that was earlier derived based on household income, the calculations presented in Table 5.12 result in a relative degree of precision of ±4% and a corresponding absolute degree of precision of ±$1,800.

The same process can then be repeated for a range of sample sizes and for a variety of variables to identify the tradeoffs between sample size and the corresponding degree of precision that would be expected for variables of interest to the analysis. Such an analysis would show that for sample sizes that are smaller than the ideal sample size, a lower degree of precision would be expected for particular variables. To properly assess the value of the proposed survey, such a drop in precision would need to be contrasted with the possible lack of precision of the existing estimates currently used for planning purposes.

■ 5.7 Assessment of the Confidence Level

An alternative way of assessing the tradeoffs between sample size and the corresponding quality of data would be by comparing the confidence level expected for a particular variable under different sample size scenarios. The principles of such an approach are also rooted in the methodology used for sample size calculations and the approach would be very similar to the one used for estimating the degree of precision for a given sample size. Again, the calculations for the expected confidence level could be repeated for a range of sample sizes and variables to identify the confidence level that would be expected under alternative sample size scenarios for each variable of interest.

To estimate the confidence level corresponding to a given sample size and a desired degree of precision, the following information is required (Table 5.13):

Table 5.12 Degree of Precision for Household Income

Inputs			Formulas	Estimates	
Population Size	N	120,000	SE($\bar{x}$)	Inputs:	N, n, [
Standard Deviation	[	$20,000	Equation 5.10	SE($\bar{x}$) =	$919
Sample Size	n	472			
Confidence Level	1-I	95%	D	Inputs:	SE($\bar{x}$), z
Z-Statistic	z	1.96	Equation 5.11	D =	± $1,801
Mean	m	$45,000	d	Inputs:	SE (m), z, m
			Equation 5.12	d =	± 4.0%
Population Size	N	120,000			
Sample Size	n	472			
Coefficient of Variation	CV	0.444	d	Inputs:	CV, N, n, z
			Equation 5.13	d =	± 4.0%
Confidence Level	1-I	95%			
Z-Statistic	z	1.96			

Table 5.13 Formulas for Confidence Level Given Sample Size n

Standard Error: $SE(\bar{x}) = \sqrt{\frac{\sigma^2}{n} * \frac{(N-n)}{N}}$ (Eq. 5.9)

z-statistic: $z = \frac{D}{SE(\bar{x})}$ (Eq. 5.14)

or: $z = \frac{d * m}{SE(\bar{x})}$ (Eq. 5.15)

z-Statistic	Confidence Level
0.67	50.0%
0.84	60.0
1.04	70.0
1.28	80.0
1.64	90.0
1.96	**95.0**
2.58	99.0
3.29	99.9

If the coefficient of variation (CV) is used instead of the mean and standard deviation, the z-statistic corresponding to the desired confidence level is given by the following equation:

z-statistic: $z = \frac{d}{\sqrt{\frac{(CV)^2}{n} * \frac{N-n}{N}}}$ (Eq. 5.16)

- The variance of the variable in the study population (σ^2);
- The desired absolute or relative degree of precision (D or d);
- The sample size (n) and the population size (N); and
- The mean (m) of the variable in the population (in case the relative degree of precision is provided).

The calculations for the level of confidence corresponding to a given sample size are again illustrated by relying on the hypothetical household travel survey and the formulas that are used are summarized in Table 5.13. First, the standard error that corresponds to a given sample size, population, and variance of the variable is calculated (Eq. 5.10). Then, the z-statistic that corresponds to a given absolute degree of precision can be calculated (Eq. 5.14) along with the confidence level (1-α) that corresponds to the calculated z-statistic.

There are two variations to these calculations. First, in cases where the relative degree of precision is provided, the mean value of the variable is incorporated into the calculations (Eq. 5.15). Second, in cases where the variable variance and/or its mean are not readily available, the coefficient of variation (CV) can be used instead. In such a case, since the standard error cannot be calculated directly, the confidence level calculations are based on the relative degree of precision as shown in Equation 5.16.

These level of confidence equations have again been applied to the household income example used earlier. Table 5.14 illustrates the calculations using two sets of inputs. In the first case, the mean and the variance of the variable are assumed known, allowing us to estimate both the level of confidence that correspond to a given sample size and either the relative or the absolute degrees of precision. In the second case, the confidence level is calculated based on the coefficient of variation instead of the mean and variance of the variable. As before, using the "ideal" sample size that was derived for household income, the calculations presented in Table 5.14 result in a z-statistic of 1.96 which in turn corresponds to a confidence level of 95 percent.

The same process can then be repeated for a range of sample sizes and for a variety of variables to identify the tradeoffs between sample size and the corresponding confidence levels that would be expected for variables of interest to the analysis. By definition, the confidence level that corresponds to sample sizes that are smaller than the "ideal" sample size would be lower than the desired 95 percent confidence level. However, such a drop in the confidence level would again need to be viewed in light of the existing data sources and the level of confidence that can be placed on the existing estimates. Since transportation planning applications often rely on dated data sources, the value of new information may overshadow the lower confidence level justifying the collection of new, more detailed travel and socioeconomic data.

Table 5.14 Level of Confidence for Household Income

Inputs			Formulas	Estimates	
Population Size	N	120,000	**SE($\bar{x}$)**	Inputs:	N, n, [
Standard Deviation	[	$20,000	Equation 5.9	**SE($\bar{x}$) =**	$918.8
Sample Size	n	472			
Absolute Precision	D	± $1,800 of mean	**z-Statistic**	Inputs:	SE($\bar{x}$), D
			Equation 5.13	**z =**	1.96
Relative Precision	d	± 4% of mean	**z-Statistic**	Inputs:	SE($\bar{x}$), d
Mean	m	$45,000	Equation 5.14	**z =**	1.96
Population Size	N	120,000			
Sample Size	n	472			
Coefficient of Variation	CV	0.444	**z-Statistic**	Inputs:	CV, N, n, d
			Equation 5.15	**z =**	1.96
Relative Precision	d	± 4% of mean			

■ 5.8 Complex Sample Designs

The selection of a sampling method is also interrelated with the broad objectives of the survey; the study population and the corresponding appropriate sampling frame and unit; the desired level of precision, level of confidence, and accuracy; and the sample size requirements for the whole sample or specific segments of the market. The ***simple random sampling*** method offers the most straightforward means of selecting a sample since it results in an unbiased, self-weighting sample that is representative of the study population. This method presents many advantages to the surveyor, including the following:

- If the sample (both recruited and the final respondents) are truly randomly selected, the survey should be unbiased, eliminating the need for post-survey weighting.
- Every potential respondent is eligible to be recruited at any time. In a stratified sample, some potential respondents might be members of strata for which the sample has been filled. It may be impossible to tell if a respondent is eligible until he has been recruited.
- It is cheaper than the more complex methods, both because no effort is wasted recruiting ineligible respondents, and because the development of the sampling plan itself will take fewer resources.
- It is easy to understand and be accepted by non-technical decision makers and the public.

However, in cases where market segments of particular interest to the analysis may be underrepresented in a simple random sample design, other probabilistic methods such as ***stratified sampling*** and ***cluster sampling*** may be employed to provide the desired level of precision for variables and market segments of interest. Furthermore, ***choice-based sampling*** procedures may also be used to enhance the sample in cases where a particular segment of the population which exhibits a behavior of particular interest to the study is difficult to reach due to its low incidence in the population.

Systematic Sampling

With the systematic sampling approach, as opposed to the random selection of sampling units from a sampling frame, sampling units are selected based on sequences that are separated by a preset interval. Provided that the sampling frame order is relatively unbiased, this approach is essentially equivalent to the simple random sample.

In personal intercept surveys, field workers could be instructed to approach every 'nth' person passing a certain point. Similarly, random-digit-dialing (RDD) telephone surveys could be conducted by calling every 'nth' telephone number within a pre-specified set of telephone exchanges.

Assuming that the systematic sampling methods is as random as the simple random sample, the choice between the two survey method is a simple question of logistics. For intercept surveys, it may be difficult for a survey field worker to choose a truly random sample; a systematic method would be much easier.

Stratified Sampling

The stratified sampling method is particularly useful in cases where segments of the study population need to be studied in greater detail requiring a greater degree of precision and in cases where the grouping of observations will result in homogeneous groups of respondents. The homogeneity of each segment reflects the similarity in socioeconomic characteristics and travel behavior of respondents within each segment.

This method allows us to identify, focus on, and collect information from particular segments of the study population (also referred to as strata) of interest to the analysis by using either uniform or variable sampling rates. Stratified sampling offers a means of differentiating among strata and reducing the sampling error *within* each stratum of interest. Similarly, stratified sampling can also be used to reduce the amount of data collection needed by segmenting the survey population into more homogeneous strata and sampling at a higher rate from strata with a higher degree of variability/heterogeneity.

The definition of strata can be based on:

- Geographic boundaries such as strata that correspond to different towns or counties;
- Characteristics of the travel environment under study such as low- versus high-density areas, or areas with a good versus poor level of transit service; or
- Socioeconomic characteristics of the sampling unit such as household income categories or automobile ownership.

The statistical theory behind the stratified sampling shares many similarities with the discussion presented under simple random sampling. Since the most likely objective of the analysis under both sampling methods is to make inferences about the travel behavior of the population as a whole, a random sample of respondents needs to be drawn *within* each stratification stratum.

The sampling rate within each stratum also often varies across the various strata. Initially, a uniform sampling rate can be examined as part of the sample design to allocate the sample size to different strata and to assess the expected effective yield of observations by stratum. If the resulting number of observations for particular strata of interest is below the minimum number of observations required for the desired level of precision for that stratum, a range of variable sampling rates can be considered. In such a case, higher sampling rates would be used to oversample lower-incidence strata while lower sampling rates would be applied to higher-incidence strata.

The two most common forms of stratified sampling in household travel surveys are geographic and demographic. Geographic stratification may be done based simply on political boundaries or may include land use or transportation-based measures to define the stratification areas. Stratification simply by political boundaries is most useful when there are other survey objectives besides demand model development, where differences based on such boundaries rarely comes into play. However, if information about households or travelers were desired for, say, county level data summaries, then political stratification would make sense.

As an example, consider the 1994 household activity survey conducted in the Portland, Oregon area by Metro. This survey used 10 geographically-defined strata for the Oregon part of the Portland metropolitan area.[7] The strata are shown in Table 5.15. In this sampling plan, four of the strata (6 though 9) represent individual counties. Five strata represent parts of Multnomah County, which contains the city of Portland. These strata are defined by pedestrian environment and transit availability. The tenth stratum represents a choice-based sample of park-and-ride users.

Demographic stratification has been used in many surveys where the primary purpose has been to gather information for trip generation models. Commonly, a two-way cross-classification based on the expected form of the trip generation models, such as household size by income or auto ownership, is used. Table 5.16 shows the sampling framework for a 1990 household travel survey in the Pittsburgh, Pennsylvania area.[8] In this survey, a cross-classification plan using two variables, persons per household and autos per household, was employed. The agency conducting the survey, the Southwestern Pennsylvania Regional Planning Commission, had decided that developing a trip production model for home-based trips was their survey objective and had found through previous survey efforts that these two variables were significant in explaining trip production rates.

[7] NuStats, Inc. "Sample Productivity Plan." Technical Memorandum, 1994.

[8] Theodore B. Treadway, "Small Scale Stratified Sample Home Interview Survey for the Pittsburgh Region." *Proceedings of the Fourth National Conference on Transportation Planning Methods Applications*, September 1993.

Table 5.15 Portland Travel Survey Stratification

1. Multnomah County – good pedestrian environment, land use mix, and transit
2. Multnomah County – bad pedestrian environment and transit
3. Multnomah County – good pedestrian environment and transit
4. Multnomah County – light rail corridor
5. Remainder of Multnomah County
6. Clackamas County
7. Washington County
8. Columbia County (part)
9. Yamhill County (part)
10. Park-and-ride users

Table 5.16 Pittsburgh Travel Survey Stratification

	Person/Household					
Autos/Household	**1**	**2**	**3**	**4**	**5+**	**Total**
0	25	25				50
1	25	29	50			104
2		52	61	35	29	177
3+			48	29	25	102
Total	**50**	**106**	**159**	**64**	**54**	**433**

Note: Blank cells are included with those on the right or above. For example, there are 25 samples for 0 autos, 2+ persons and 25 for 1 person, 1+ autos, etc.

It should be pointed out that in geographic stratification, it may be known (or approximately known) where a household fits into the stratification plan before they are recruited. While telephone exchanges provide imperfect matches with political or census boundaries, there is some correspondence that can be used. However, it will be impossible to determine a household's income, number of autos, or number of persons without asking. This means that under a demographic stratification, there may be recruitment calls made to households who would cooperate, but would not fit the required stratification. This reduces the effective response rate for the survey.

Cluster Sampling

Cluster sampling is a multi-stage sampling method. With this approach, the sampling units at the first stage are actually groups (clusters) of the survey elements rather than individual elements. At the second stage, all of the units within a selected cluster may be included in the sample, or a second-stage subsample may be drawn randomly within each selected cluster.

Work place/establishment surveys are examples of cluster surveys. A small number of establishments is first selected from the population of all establishments within a study area. Employees and visitors/customers are then sampled within the selected establishments.

Household surveys can also be conducted using cluster sampling. First, the study area is divided into tracts and a sample of tracts is drawn. Second, within each tract, households are drawn randomly and within each randomly selected household, a respondent may also be drawn at random. This is particularly effective for in-home interviews so that survey field workers can minimize travel time between households. However, for mail and telephone surveys, cluster surveying appears to be an unnecessary complication.

The statistical theory on cluster sampling again follows the discussion presented under simple random sampling. Since the most likely objective of the analysis remains to make inferences about the travel behavior of the study population, a random sample of sampling units needs to be drawn at each stage of the cluster sampling.

Cluster sampling would be chosen as a result of a specific choice of survey type and data collection method, not in response to issues concerning information about travel behavior which the survey is attempting to obtain. For certain types of surveys – for example, work place surveys – cluster sampling is the only practical option. For others, such as surveys to obtain travel information about entire households, there is no rationale for choosing cluster sampling unless an in-home survey is being conducted.

Choice-based Sampling[9,10]

The choice-based sampling method offers a means of identifying respondents in low-incidence market segments which may need to be represented in the analysis and collecting the corresponding information. Respondents who belong to such low-incidence market segments are therefore characterized by their choice behavior that forms the basis for the sampling frame. Common examples of the use of a choice-based sampling method is the collection of data from transit users in low-density areas not adequately served by transit, bicycle users, or intercity bus and rail riders.

The most common use of data collected from choice-based sampling methods is in the development of mode choice models. Even with the application of stratified sampling and variable sampling rates within different strata, it is possible that the low incidence for particular segments of the study population may result in too few observations for these groups. A small number of observations from a particular group makes it difficult to study the determinants of its behavior and often results in its exclusion from model development and estimation. However, despite the low incidence, it is often desirable to account for the behavior of smaller segments of the population to better understand the factors underlying their behavior.

Choice-based sampling offers a methodology to ***augment*** the existing sample drawn as a simple random or stratified sample. In particular, respondents who belong in low incidence segments are intercepted and recruited for a pre-specified quota of additional surveys. For example, transit riders in a corridor dominated by automobile traffic can be randomly sampled at transit stops while bike riders can be contracted and get randomly sampled through clubs that organize activities. As a consequence of including such observations in the analysis, the variability in the behavior observed and analyzed increases considerably resulting in an enriched model and providing valuable insights into behavioral determinants. Furthermore, analytical (weighting) procedures for generating unbiased, consistent estimates with a choice-based sample can be used to control for any biases that may be introduced with the combination of randomly drawn and choice-based samples.

While the recruitment procedures may necessarily be different for respondents that are part of a choice-based recruitment process, the conducting

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[9] M. Ben-Akiva and S. Lerman. *Discrete Choice Analysis: Theory and Application to Travel Demand*, The MIT Press, 1985.

[10] S.R. Lerman, C.F. Manski, and T.J. Atherton. *Non-random Sampling in the Calibration of Disaggregate Choice Models*, Final Report prepared by Cambridge Systematics for the U.S. Department of Transportation, December 1975.

of the interviews may not have to be. While transit users, for example, could be asked questions while riding or waiting, they could also simply be recruited and then contacted for data retrieval in the same way as other respondents. This provides an opportunity to collect more comprehensive information. It should also be noted that all information obtained through a choice-based recruitment process will not necessarily be associated with the behavior targeted by the sampling method. A transit user may make other trips by auto or other modes, or may have others in the household who do so.

5.9 Bias in Travel Surveys

Up to this point, this chapter has concentrated on ways of minimizing ***sampling*** errors that arise from and reflect the use of a sample of respondents, and the inherent variability of their responses. As the examples have shown, it is possible to determine the impacts of sample size and sampling strategies on the precision of parameter estimates from survey data, and to use this information to develop mathematical estimates of sampling errors. Survey teams can measure and, if resources permit, decrease sampling errors by increasing sample sizes and improving sampling strategies.

The other major sources of errors in survey data are the ***non-sampling*** errors that are associated with survey biases. These errors can be at least as important as sampling errors, but to reduce their effect, survey teams need to apply different strategies. Non-sampling errors differ from sampling errors in that they:

- Originate from several unrelated sources;
- Are non-random – they have a constant effect on parameter estimates;
- Are almost always unquantifiable; and
- Do not improve with increased sample sizes.

Survey bias results from the failure to adequately address the variety of quality concerns raised in Figure 4.2. The survey design and implementation problems that are generally responsible for bias include:

- Misidentification of the survey population;
- Imperfect sampling frame and sampling loss (non-coverage);
- Non-response;

- Poor questions and survey instruments;
- Field worker and interviewer errors; and
- Coding, entry, and data processing errors.

The misidentification of the survey population, sampling frame problems, and sampling loss all have the potential to bias the survey results because valid units are left out of the sample. If the units that are left out have different characteristics than those that are in the sample, then the survey results will be biased.

Table 5.17 shows an example of how an incomplete sampling frame can bias survey results. In this example, a telephone household survey is being conducted for an area with 50,000 households. Ten percent of the households in the region do not have phones, and those households without phones tend to have lower incomes. The actual percentage of households with incomes of less than $20,000 is 12 percent, but because only households with phones are included in the survey, the estimated percentage is 8.3 ± 2.7 percent. This estimate assumes that the income distribution of the survey respondents matches that of the households with telephones.

Non-response is probably the most serious potential bias. Even if the survey team is able to create a complete and accurate sampling frame, they still cannot ensure that every sampling unit will be willing or available to respond to the survey. If the responding units are different than the non-respondents, which is usually the case, then the survey results will be biased.

Table 5.18 shows how non-response can affect survey results. The table continues the example from the previous table. For this example, the response rate is assumed to be 50 percent, so the survey team needs to contact 6,000 of the 45,000 households with phones. The income distribution of the 6,000 households should closely resemble the income distribution of the sampling frame, but the income distribution of survey respondents may be significantly different. In the example, households with incomes between $40,000 and $100,000 are more likely to respond than the higher or lower income households. The effect is that the estimated income distributions are biased. Too few households are assigned to the lowest income categories, and too many are assigned to the middle-income categories.

The remaining three sources of survey bias – problems with questions and response categories, interviewer/field worker errors, and survey office worker errors – contribute to bias because they affect the survey results in non-random ways. If survey questions are misleading or confusing, then some percentage of respondents will provide the wrong answer to the question by accident. Other respondents will skip the particularly confusing questions and questions that seek private information. Additionally, survey workers can record the wrong answer or influence respondents' answers in some way when they ask questions, or office staff can miscode responses or enter them into the database incorrectly.

Table 5.17 An Example of Bias Due to an Incomplete Sampling Frame

Income Categories	Households: With Phones	Households: Without Phones	Households: Total	Actual Household Distribution	RDD Survey Results (90% Confidence)		
Under $20,000	3,755	2,245	6,000	12.0%	8.3%	+/-	2.68%
$20,000-$39,999	8,021	979	9,000	18.0	17.8	+/-	2.53
$40,000-$59,999	8,313	687	9,000	18.0	18.5	+/-	2.52
$60,000-$79,999	8,075	425	8,500	17.0	17.9	+/-	2.53
$80,000-$99,999	9,044	456	9,500	19.0	20.1	+/-	2.50
$100,000 or more	7,792	208	8,000	16.0	17.3	+/-	2.54
All Categories	45,000	5,000	50,000	100.0%	100.0%		

Note: Assumes an RDD survey of 3,000 households, a 100% response rate, and no field or office problems.

Table 5.18 An Example of Bias Due to Non-Response

Income Categories	Sampling Frame Distribution		Drawn Sample Distribution		RDD Survey Results (90% Confidence)			
Under $20,000	3,755	8.3%	500	8.3%	162	5.4%	+/-	1.76%
$20,000 - $39,999	8,021	17.8	1,070	17.8	345	11.5	+/-	1.66
$40,000 - $59,999	8,313	18.5	1,108	18.5	624	20.8	+/-	1.66
$60,000 - $79,999	8,075	17.9	1,076	17.9	589	19.6	+/-	1.66
$80,000 - $99,999	9,044	20.1	1,207	20.1	768	25.6	+/-	1.64
$100,000 or more	7,792	17.3	1,039	17.3	512	17.1	+/-	1.67
All Categories	45,000	100.0%	6,000	100.0%	3,000	100.0%		

Note: Assumes an RDD survey of 3,000 households, a 50% response rate, and no field or office problems.

These survey problems can further affect bias levels for the survey results. Table 5.19 continues the example from the previous tables to illustrate bias from these sources. In the table, it is assumed that the overall non-response levels are the same as for Table 5.18. The item non-response rate for income is 10 percent, so even though the survey team has 3,000 total responses, only 2,700 of them have valid income categories. As is usually the case, the respondents who fail to provide income data are not representative of the whole sample. They are more likely to be in the highest income category. The results shown also could include the response errors that are suspected to be fairly common in income questions.

The total bias of a parameter estimate is the combined effect of these individual components. Biases from each individual source can work in the same direction or work in different directions, so that they partially cancel out one another. The bias introduced by using the imperfect sampling frame and the bias introduced by non-response both work to artificially decrease the estimate of the number of households of the lowest income category. On the other hand, the imperfect sampling frame biases the estimated number of households in the highest income category upwards, while the question wording and the field and office errors decrease the estimate.

It is important to note that bias is unrelated to sample size. If the examples from above assumed that the sample size was 10,000 instead of 3,000, only the level of precision would change. The survey team would be more certain that the actual percentage of households in the lowest income category is around 5.4 percent (the 90 percent confidence limits would be ± 0.6 percent, rather than ± 1.7 percent). Unfortunately, the actual answer would be 12 percent.

Although it is usually impossible to eliminate all bias, it may be possible to correct for it. When the magnitude of the total bias of a parameter estimate can be measured through independent means, the total error of an estimate can be calculated. In these cases, the survey results can often be weighted so that they more accurately reflect actual conditions. For instance, for income levels and other socioeconomic measures, the survey team may be able to use Census data to determine the overall level of bias.

However, for many key survey results, such as trip rates or the socioeconomic characteristics of certain subpopulations, such as transit riders, there is no way to determine the amount of bias in the survey results. The only way to determine the actual parameter value would be to conduct another survey or a census, which would be vulnerable to the same biases.

The most common approach to dealing with potential survey bias is to take as many steps as possible to limit its presence while designing the survey, to correct for those biases which can be corrected, and then to assume that the overall level of bias is negligible compared to the imprecision in the survey-derived parameter estimates. In reporting survey error, surveyors commonly report sampling errors and simply discuss potential

Table 5.19 An Example of Bias Due to Question Wording, Field Errors, and Office Errors

Income Categories	Sampling Frame Distribution		Actual Survey Respondent Distribution		RDD Survey Results (90% Confidence)			
Under $20,000	3,755	8.3%	162	5.4%	145	5.4%	+/-	2.85%
$20,000-$39,999	8,021	17.8	345	11.5	321	11.9	+/-	2.76
$40,000-$59,999	8,313	18.5	624	20.8	608	22.5	+/-	2.56
$60,000-$79,999	8,075	17.9	589	19.6	557	20.6	+/-	2.58
$80,000-$99,999	9,044	20.1	768	25.6	705	26.1	+/-	2.47
$100,000 or more	7,792	17.3	512	17.1	364	13.5	+/-	2.64
All Categories	45,000	100.0%	3,000	100.0%	2,700	100.0%		

Note: Assumes a survey of 3,000 households, a 50% response rate, and some field and office problems.

biases qualitatively. This approach is probably naively optimistic in many cases, but the difficulty or impossibility of measuring and correcting for many biases makes the strategy reasonable and often preferred.

The potential problem with this common approach is illustrated by an example. Suppose a household travel survey measures the average daily person trip rate to be 3.4 trips, with a standard deviation of 2.2 trips. The trip information is collected through travel diaries which require respondents to record all their trips in a 24-hour period. Further suppose that actual respondent trips can be determined for the period (perhaps through the use of hand-held GPS tracking devices as many have suggested is feasible), and that the travel diary data is found to bias the survey results by 0.1 trips per person.

As Equation 5.1 shows, the "total error" for the survey trip rate estimate is the combination of the standard error of the survey and the total bias (B). For smaller sample sizes, the precision errors dominate the bias. For example, for a sample size of 100:

$$SE^2 = \frac{\sigma^2}{n} = 0.0484$$

$$B^2 = (0.1)^2 = 0.01$$

The sampling error term is roughly five times the bias term. However, as the sample size increases, the constant bias becomes more important compared to the decreasing sampling error. When the sample size is 500, the standard error term is about 0.01, approximately the same as the bias term. When the sample size is 5,000, the bias term dominates the sampling error. Using the sampling error as a measure of total error is reasonable for smaller sampling sizes (and larger sampling errors), but as the sample size increases, the sampling error estimates no longer accurately reflect the potential error in parameter estimates.

6.0 Household Travel and Activity Surveys

Household travel surveys have traditionally provided the most important data inputs into regional and statewide travel models. These surveys have generally been the largest and most complex travel survey efforts, and, therefore, not very many of these efforts have been undertaken on a routine basis. However, pressures being placed on travel demand modeling by the CAAA and ISTEA have led to renewed interest into improving the quality of available survey data in many regions of the country. This has led to an increased interest in household travel and activity surveys.

In the 1960s and 1970s, household travel surveys were generally designed as in-home surveys, where survey fieldworkers would actually go in to sample households and conduct in-person interviews with the household members. Variations on this method are still widely used in other countries, but the high costs of fieldwork labor, the logistical difficulties (including quality control issues and fieldworker security concerns), and the relatively high rate of telephone availability in the U.S. have led travel surveyors to use telephone-based or mail survey techniques.

The terms, "Household Travel Survey" and "Household Activity Survey," may be used generically to refer to any surveys in which respondents are contacted at their homes and asked travel-related or activity questions, or they may be used more specifically to refer to surveys that record detailed trip information (usually with survey diary methods) and that are used as inputs to travel behavior models. For the most part, this chapter (like the other chapters in this manual) is aimed at describing the implementation of surveys that would be suitable for developing travel demand models. However, many of the survey elements and procedures described in this chapter also apply to the other types of household surveys that would fall under the more generic survey definitions.

■ 6.1 Organization of this Chapter

As more and more new household travel and activity survey procedures are applied, it has become quite difficult to determine the best procedures for future efforts. This chapter is intended to provide a brief overview of the available options, to discuss advantages and disadvantages of each option, and to make recommendations (where possible) on how to proceed with each option. The chapter covers common household travel/

activity concerns, but each household travel/activity survey effort is somewhat unique, and each is likely to require the resolution of many issues not covered in this manual.

The first five sections of this chapter cover the steps of the survey implementation process described in Chapter 2.0. Sections 6.2 through 6.6 discuss the survey design stage, including:

- Assembling Background Information;
- Survey Design;
- Survey Organization;
- Sampling; and
- Drafting and Constructing Survey Instruments.

Then, field implementation aspects of household travel/activity surveys are addressed in Sections 6.7, 6.8 and 6.9:

- Pretesting the Household Travel/Activity Survey;
- Training and Briefing Survey Fieldworkers; and
- Interviewing and Questionnaire Distribution.

Finally, the survey data preparation tasks are discussed in the remaining three sections, 6.10 through 6.12.

- Coding and Data Entry;
- Editing and Data Cleaning; and
- Programming and Compilation of Survey Results.

The key issues discussed in each section are briefly outlined in Table 6.1.

Each of the sections begins with a figure presenting the key issues related to the specific survey implementation step, and outlining the content of the section. The sections are then organized by these key issues. However, decisions related to issues at one point in the implementation process are likely to affect decisions at several other points in the process. It will soon become obvious to the reader that the survey steps for the household travel/activity survey are greatly interrelated. Even though this manual and other guidance documents tend to organize the survey process into finite steps for the sake of presentation, we recommend that household travel/activity survey designers understand the process, as a whole, and the interrelationships between the steps before beginning survey development.

Table 6.1 Organization of the Household Travel/Activity Chapter

Chapter Section	Discussion Topics
Section 6.2 – Background Data	Use of Census data to design the household survey. Use of past survey experience in survey design. Data for sampling frames.
Section 6.3 – Survey Design	Design considerations for special data needs. Selection of survey method (telephone vs. mail, etc.) Selection of survey techniques (CATI vs. PAPI, etc.) Accuracy enhancing measures (including response improving steps such as incentives, follow-up)
Section 6.4 – Organization	Staffing needs, including contractors. Coordination and public participation.
Section 6.5 – Sampling	Selecting sampling approach. Determining sample sizes. Estimating parameter precision.
Section 6.6 – Questionnaire Construction	Data elements. Writing questions. Designing survey materials, including diaries
Section 6.7 – Pretesting	What to pretest and how to pretest.
Section 6.8 – Training Fieldworkers	Training and briefing topics. Designing the training and briefing sessions.
Section 6.9 – Fieldwork	Quality control during data collection.
Section 6.10 – Coding and Data Entry	Coding procedures.
Section 6.11 – Editing and Cleaning	Data cleaning tasks. Validation of survey results. Imputation of missing responses.
Section 6.12 – Compiling Data	Database structure. Expansion of data. Reporting and tabulations.

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6.2 Assembling Background Information

■ Key Issues in Assembling Background Information

1. What data are available about the characteristics of study area households?
2. What past survey experiences can be used in designing the new household travel/activity survey?
3. What data are available about travel behavior in the study area?
4. What data are available for developing the survey sampling frame?
5. What data are available for geocoding household travel/activity locations?

■ Section Summary

6.2 Assembling Background Information (continued)

■ 6.2 Assembling Background Information

Prior to getting extensively involved in the household travel/activity survey implementation process, it is highly desirable for a planning agency to assemble as much relevant background data as possible. As noted in Chapter 2.0, available independent data sources are useful in three ways:

- In lieu of some or all of the household travel/activity survey work;
- For developing household survey samples; and
- For validating the household travel/activity survey results.

The section summary describes the key issues that need to be addressed in the assembly of background data. These five key issues are described, in turn, in this section.

Background Data on Study Area Households

Household travel/activity surveys are conducted because the surveyors and modelers have recognized the unique importance of the household in travel. In most regional travel models, households are the basic unit of trip production, and they are usually assumed to be peoples' unit of travel decision-making, as well.

Therefore, when beginning a household survey effort, the survey designer will want to have as much information about study area households as possible. The best sources of this information are generally U.S. Census data files and local planning agency datasets.

U.S. Census Data

The most comprehensive database containing detailed information about persons and households available in the U.S. is the Decennial Census of Population and Housing. The 1990 Census database contains a wide array of data on the characteristics of U.S. households and individuals. Relevant Census data items are discussed in Appendix B of this Manual.

Other Household Data

While the Census data files are likely to include the most detailed household information available within a region, the data apply to 1990 conditions. Census data are usually significantly outdated before the new data are collected 10 years later. To the extent possible, travel survey planners should use locally-updated household data to improve upon the Census information. The availability and applicability of locally-developed household data and estimates varies throughout the country.

Background Data on Past Survey Efforts

The household travel/activity survey team should attempt to locate the results of all past travel surveys performed in the area. These survey results will help to:

- Determine which survey methods are likely to be the most successful in the household survey;
- Provide more relevant travel-related data for survey respondents than the Census or other household data sources;
- Define the range of expected responses to specific questions;
- Help define expected variation in survey results and, thus, help determine sample sizes and accuracy levels;
- Provide measures of cooperation and response rates, and potential non-response problems;
- Furnish the survey designer with information on how well particular questions worked; and
- Define the specific conditions for coordination between the new survey and old surveys that may also be used in the travel demand model development.

Actual survey experiences are invaluable resources in the development of new surveys. Surveyors should make use of any and all survey techniques from the previous studies. However, the survey designer should critically review the past efforts to avoid propagating the errors of earlier surveys.

The last full-fledged household travel survey effort may have occurred too far in the past to be of much use in deciding the best approaches for the new survey effort. Nevertheless, the survey designer should examine the previous household surveys to determine how each piece of data was used in model development. This is an excellent way to determine the data and question needs of the new survey.

Survey experiences outside the realm of travel surveys may also be valuable in designing household travel/activity surveys. Although an agency or survey team will have only a small amount of travel survey experience to build upon, it is likely that the households in the region have been surveyed extensively on other topics in recent years. These experiences can help travel survey teams predict:

- Response and cooperation rates;
- The effects of survey length on response levels and quality;
- The efficacy of different survey methods;
- The efficacy and cost-effectiveness of different response-enhancing mechanisms, such as incentives; and
- Data collection costs per completed survey.

Assembling this information on past survey efforts usually requires utilizing the experience and knowledge of survey subcontractors and consultants (and paid or unpaid advisors).

Background Data on Travel Behavior within The Study Area

All local planning agencies in the U.S. have developed transportation planning databases that can be used to plan household travel/activity surveys. Most are based, in part, on the Census data and travel survey data discussed above, but other data sources will be reflected as well. Existing trip generation, trip distribution, and mode choice data, and inventories of transportation infrastructure and services, can be used to:

- Identify the study area boundaries (and thus establish the population for the household travel/activity survey);
- Provide estimates of the variances of key survey sampling measures;
- Help determine the amount of information respondents are likely to provide;
- Help determine the range of valid responses for specific survey questions.

Another type of background data that is useful in designing the household survey is the existing travel demand models themselves. The household survey planner should evaluate the models and determine their adequacy for the new generation of travel models. Some models, or specific aspects of models, will still be valid. In these cases, the new survey effort should seek to provide the necessary information to update model parameters to the current year. Modelers will want to replace other aspects of the modeling system with newer or different statistical approaches. In these cases, the household survey will need to collect new types of data or more detailed data than the previous survey effort.

Background Data for Developing Sampling Frames

The survey designer will also need to investigate the various data sources that can be used to define the survey "sampling frame." The sampling frame is the list of households from which sample households are chosen. Often, the availability or non-availability of high quality sampling frame data will determine the best survey method to be used.[1]

Properly drawn samples provide information appropriate for describing the elements of the sampling frame – not the survey population. Therefore, it is imperative to develop a sampling frame that closely approximates the population of interest. Sometimes, surveyors select samples from a given sampling frame, and then erroneously make generalizations about populations similar to, but not identical to, the population defined by the sample frame.

For samples of households, the most appropriate sampling frames are those that will contain the addresses and/or telephone numbers for the target population of households. Usually, available sampling frames do not truly include all the elements that their names imply. Omissions are almost inevitable. For example, telephone directories do not include new subscribers or householders with unlisted numbers. During the background data assembly task, survey teams should assess the extent of omissions (and the resultant extent of bias) in all potential sampling frames.

Ideally, for a household survey, the address, location, and phone number of all households within the model study area are known or can be known. In practice, survey planners usually do not have the ability to obtain all these data items for all households. The selected survey method will determine whether address-based data sources or telephone-based sources (or both) are needed. Household travel/activity surveys that rely on mail survey methods or in-person methods to recruit respondents will need to rely on address-based data sources for the sampling frame; survey methods with telephone recruitment will need a telephone-based sampling frame. During the background data assembly task, survey planners should evaluate potential sample frame data sources of all types.

Address-based data sources are likely to be more complete than telephone-based data sources, but also usually involve more time and effort to obtain and to prepare for use by the survey team. Potential address-based sampling frame data sources include the following:

- Property tax records;

[1] Sampling frames are discussed in more detail in Chapter 5 of this manual.

- Public utility records;

- Official town maps; and

- Field listings from land-use inventories.

While most of these data sources are maintained by public and quasi-public agencies, they are often quite difficult to obtain because of privacy concerns. Survey planners should be prepared to provide reassurances that the data will be protected to the maximum extent possible (including documentation of planned data storage and use procedures).

Address-based data usually requires fairly extensive manipulation by survey teams. Each data source can be problematic. Property owners listed in tax roles are not necessarily the persons who reside at a particular address. Public utility listings may have one address for all units in a multi-unit complex. Maps and inventories can become out-of-date in very short periods of time. Survey teams usually need to combine data from multiple sources to develop address-based sampling frames, and they usually must perform at least some field verification.

Usually the most appropriate sampling frame for telephone survey methods is a list of telephone exchanges (or prefixes) within the study area of interest from which random-digit-dialing (RDD) respondent selection can be conducted. Sometimes, telephone survey samples are developed using telephone directories as the sampling frames. This approach reduces the cost of contacting respondents, because (unlike the random dialing approach) it is known that these numbers are for telephones that are in service, are residences, not businesses, and are within the study area. However, the high (and increasing) percentage of unpublished and unlisted telephone numbers in most U.S. cities usually precludes this approach for household travel surveys. Table 3.5 shows the unlisted rates for the 100 largest metropolitan areas in the U.S. Some agencies have used a combination of listed and unlisted numbers for their household sampling frames.

Assuming that an RDD approach is utilized (at least in part), the survey designer needs to assemble a complete listing of all prefixes for telephone lines within the modeling study area. Since study area boundaries and telephone prefix boundaries generally do not coincide, a number of the prefixes will apply to areas that are both within and outside of the study area. These prefixes should be included in the compiled list (interview screening techniques can be used to determine whether respondent contacts with these telephone exchanges live within the study area). The geographic coverage of telephone exchanges are usually available from local telephone companies.

In cases where the telephone company data are insufficient, survey designers generally obtain the information from reverse directories. Reverse directories present telephone numbers on a geographical basis and a numerical basis, rather than by people's names as standard telephone directories do. There are several publishers of reverse directories, and nearly every part of the country is covered in one or more of these directories.

In addition to compiling the list of relevant prefixes, it is usually helpful to estimate the number of working lines in each prefix and any numerical ranges of suffixes that are not in service. This information allows the survey team to generate random telephone numbers in the proportion that each prefix exists within the sampling areas, so the final sample will be stratified by prefix. Again, the best source of this information is the local telephone company, with reverse directories as backup sources.

Professional marketing research firms specializing in telephone surveys usually keep current information on telephone exchange geography and the number and ranges of working suffixes. Alternatively, a number of firms sell randomly generated telephone lists for client-specified geographic areas. These lists can be tailored to include specified numbers of listed and unlisted telephone numbers. Unlisted numbers can be "cleaned" to remove numbers in non-working exchanges or ranges of suffixes and commercial numbers. Listed numbers can be provided with name and address information.

In some special cases, it may be desirable to use available lists of telephone numbers or addresses that have (or are likely to have) a characteristic of special interest. For instance, to ensure that transit riders were included in the household survey in sufficient numbers, a few recent household survey efforts relied partially on lists of telephone numbers of people who had claimed to be transit riders in other newly completed surveys. Similarly, there are commercial marketing research firms that develop lists of telephone numbers of people with particular circumstances and characteristics. Though not perfect, these lists can greatly improve the chances of being able to include people of specific types (such as people who ride transit) in the survey effort. If oversampling of specific hard-to-reach groups appears to be desirable, the survey designer should seek out available lists, and look into the possibility of purchasing an enriched sample.

It is important to note that telephone interview data obtained from respondents that were identified from non-random lists need to be expanded carefully. These data cannot be arbitrarily incorporated into an otherwise random sample. The list-generated data needs to be analyzed separately from other data, or they need to be adjusted with differential weights for some or all analyses.

If a telephone-based sampling frame is chosen, the survey designer should determine whether there are any available data sources for households without telephones. Generally, there are no lists of such households. However, there may be reasonably good sources describing the geographic areas where these households are located. The survey designer can use this information to decide whether supplemental sampling of non-telephone owning households can be accomplished in a cost-effective manner.

Background Data for Geocoding Household Travel/Activity Survey Data

As discussed in Chapter 14.0, one of the key elements of processing travel survey data is the association of activity and travel locations to a pre-defined geography, such as latitude/longitude (or another planar coordinate system), traffic analysis zones, or census tracts. To accurately and efficiently geocode household travel/activity survey data, one or more geographically-referenced databases will be needed. Three types of electronic data files are commonly used for geocoding purposes:

- Census "TIGER" files;
- Commercially-available address-matching databases; and
- Emergency response data files.

The files are discussed in detail in Chapter 14.0.

In addition to the electronic data files, a host of low-technology geocoding tools invariably prove to be essential to a household travel/activity survey effort. These include:

- Up-to-date street maps;
- Telephone directories; and
- Visitor guides to the region.

It is generally a good idea for all survey team members to be aware of the need for such resources so that these materials can be collected and assembled.

Output of the Background Data Assembly Task

At the end of the background data assembly task, the survey team should have a strong understanding of the many data sources that can be used in the survey design and implementation. In later tasks, the survey team will use information from these sources to design the survey, develop a sampling strategy, and to code survey responses.

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6.3 Survey Design

■ Key Issues in Survey Design

1. What are the anticipated data needs from the household travel/activity survey? How do these needs affect the design of the survey?
2. Which survey method should be employed for the household travel/activity survey?
3. Given the selected survey method, what data collection techniques should be employed?
4. What accuracy-enhancing (bias-reducing) measures should be employed?

■ Section Summary

6.3 Survey Design (continued)

■ 6.3 Survey Design

The survey design task requires planners of household travel/activity surveys to address a series of successively more detailed survey design issues, beginning with the determination of the survey's role in the sponsoring agency's long-term planning processes, and including the selection of the best survey methods and data collection techniques. Each survey design decision needs to be guided by the agency's time and budget constraints and by the practical realities facing transportation agencies today.

The section summary shown above reviews the key issues that the survey team needs to address during the survey design phase of the project. These issues frame the lengthy discussion of design issues that follows.

The Data Needed from the Household Travel/Activity Survey and the Survey Design Implications of the Required Data Analyses

As is the case for any survey effort, the design of a household travel/activity survey needs to be informed by the foreseeable uses of the collected data. At the beginning of the design task, the sponsoring agency should define the goals of the data collection effort. Most household surveys are used as inputs into broadly-defined planning applications, such as the development or refinement of regional travel demand models. Other survey efforts are designed for more narrowly focused analyses, such as infrastructure project analysis. For instance, the California Department of Transportation (Caltrans) sponsored a recent analysis of the feasibility of high-speed rail service in California which utilized a household survey technique. Some household travel/activity surveys are designed as part of a larger data collection effort. Others are essentially stand-alone analyses.

It is recommended that the sponsoring agency develop a Statement of Goals for the survey effort that can be used as a guide in survey design. This statement should describe:

- The data needs that have led the agency to conclude that survey work is necessary;
- The expected analyses and uses of the survey data; and
- The guiding principles of the data collection.

The Statement of Goals should be as detailed as possible in defining potential analyses that will rely on the household survey data, because many types of analyses will not only determine survey question content, but will also have implications on the choice of overall survey strategies and survey methods.

The Statement of Goals is a valuable document for ensuring that the data collection effort provides the necessary information to the sponsoring agency. It can be used throughout the survey planning process to help make survey design decisions, and to provide staff not directly involved with the survey and other agencies and firms with information on the survey project.

A wide range of analysis issues affect the overall design of household travel/activity surveys. Prior to the household travel/activity survey, the survey team should define specific analyses to the maximum extent possible. Some analysis issues that affect the overall design of household/travel activity surveys which survey teams have recently considered include the following:

- Are the needed data related to entire households or to individuals within households?
- Are the needed data cross-sectional in nature (data representing a single point in time), or are the likely analyses going to rely on longitudinal analyses?
- Do the likely uses of the data involve traditional trip-based analyses or activity-based modeling approaches?
- How complete do the travel/activity data need to be?
- Do the likely analyses require only revealed travel behavior data, or is there a need to obtain hypothetical choice and attitudinal information, as well?
- Are the needed data specific to certain seasons of the year?
- Are the needed data specific to certain time periods?

Survey teams should consider analysis issues such as these very early in the survey design process because the selection of survey methods and techniques will be influenced by them. The implications of each of the analysis issues listed above are described below.

The Household versus the Individual as the Basic Unit of Analysis

Household travel/activity surveys are usually complex surveys. Provided that special care is applied in the organization and expansion of the data for analysis, the survey data can typically be analyzed using several different units of analysis, including households, individuals, vehicles, and trips or activities.

However, before any data are collected or any analyses are performed, the survey team needs to define what the basic unit of analysis will be, the household or the individual.

For analyses that treat study area households as the tripmaking unit and the travel decision-making unit, it is necessary to collect survey data about entire households. For instance, trip generation models are generally developed at the household level, and thus need survey information on all trips made by household members over some period of time. On the other hand, analyses that are based on individuals' travel behavior require the survey team to collect data on only a representative sample of study area residents, so data on only one household member are needed. Stated-response household surveys often will seek out a single individual within a household.

The distinction between these two types of analyses is of critical importance in survey design. Household travel/activity surveys used to obtain information on entire households are usually longer, much more complicated, and more burdensome for respondents than surveys that obtain similar information for only a single household member. Among the issues that need to be addressed for the household-based data collection are:

- Procedures for identifying individuals within the household, and for distinguishing between them throughout the survey data collection;

- Procedures for communicating with each household member or having household members communicate through a designated spokesperson; and

- The potential need for proxies, in which one member of a household answers the survey questions for a member who cannot, either because he or she is too young or because he or she is unavailable.

Person-based survey efforts are far less complicated. The key issue for person-based surveys is how to select the proper household member for the survey. It is widely acknowledged that asking the household members who answer the door, open the mail, or answer the telephone to participate in a survey leads to a non-representative sample of a study area, and so travel surveyors have used a number of techniques for randomly selecting a household member. For instance, a common approach is to select the household member who is the next to have a birthday.

The survey team should determine whether the survey analyses will be based on household-based analyses or person-based analyses. The survey effort is significantly reduced if the latter is true, but more importantly, the analysis needs for household travel/activity surveys typically require that all household members be included in the survey effort.

Cross-Sectional versus Longitudinal Analyses

Traditional travel models rely almost exclusively on cross-sectional data, so household travel/activity surveys which are designed to capture people's behaviors and attitudes at a single point in time have always been the most appropriate data collection tool. However, in recent years, researchers have recognized that many of the behaviors that travel models attempt to forecast are actually related to people's decisions over time.[2,3] The renewed interest in how people's behaviors change over time has led to the use of longitudinal survey designs, such as panel studies, cohort studies, trend studies, and before-after studies.

From analyses conducted thus far, it appears that longitudinal data collection efforts, in general, and panel studies, in particular, hold a great deal of promise for travel demand modeling. Chapter 13.0 discusses survey-related issues related to the emerging and promising use of longitudinal analyses and surveys, but as that section discusses, if longitudinal analyses of household travel/activity survey data are anticipated, the survey team needs to be prepared to make a continuing commitment to high quality data collection, and to expending significantly more resources to address:

- Additional complexity of the survey recruitment;
- Sample maintenance and replacement;
- Wider scope of survey questions;
- Use of responses in past waves to frame questions;
- Attrition (for panel surveys);
- Weighting of longitudinal data; and
- Additional reporting requirements.

Decisions about how to incorporate these issues into the survey design will certainly affect the cost and time estimates for the survey, and may also help determine which survey methods and techniques to use.

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[2] David A. Hensher, *Longitudinal Surveys in Transport: An Assessment* in Ampt. E.S., Richardson, A.J., and Brög, W. (1985). New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pp. 77-78.

[3] T. Keith Lawton and Eric I. Pas, *Survey Methodologies*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995).

Trip versus Activity Analyses

For many years, transportation planners have recognized the fact that travel is a derived demand – the demand for travel is related to the activities from which and to which people travel. In the early 1970s, a number of researchers proposed the development of a new set of models that would predict the activities in which households would take part, and then determine the household's future travel patterns.[4]

In the past few years, there has been growing interest in looking at activity-based modeling again. One region is currently developing a prototype activity-based model system, and a great deal of research is underway to improve the state-of-the-art in this field.[5] The initial activity-based model system differs from conventional modeling approaches in that it predicts the numbers and types of activities households will perform, then relies on a set of behavioral rules to forecast how household members will travel to and from activities. The model system relies on stochastic microsimulation techniques to forecast activity and travel patterns.

The choice between trip-based analyses and activity-based analyses has a basic effect on the design of household travel/activity surveys. The survey team needs to determine whether to collect detailed information on people's trips directly, or to collect information on people's activities and their travel to and from the activities (assuming the respondents need to travel to the activity).

Household surveys can be divided into three types in this regard:

- *Trip-based* surveys that directly gather information on people's trips over some period, using either diary methods or recall methods;
- *Activity-based* surveys that gather information on activities to which respondents need to travel during a set time period; and
- *Time Use-based* surveys that gather information on all activities in which respondents participate during a set time period.

The primary advantages of trip-based surveys is that they use the most efficient data collection approach, in terms of survey time and respondent burden. Respondents are asked directly about the subject of interest, their travel. The primary disadvantage of the approach is that typically the

[4] S.S. Chapin, *Human Activity Pattern in the City*, John Wiley & Sons, 1974.

[5] R. Kitamura, D. Reinke, C. Lula, E.J. Pas, and R. Pendayala, *Data Needs for Development of Activity based Travel Demand Models: The Implementation of AMOS for the Metropolitan Washington Council of Governments*, Presentation at the 5th National Conference on Transportation Planning Methods Applications, Seattle: June 1995.

only information gathered on why the respondent is traveling is a non-detailed trip purpose. These surveys do not typically provide the information to examine the activities that people perform which produce their travel.

Activity-based surveys were developed as a means to improve upon traditional trip-based surveys. Surveyors have found that people do a better job remembering and recording trip information when they are asked about what they did rather than simply about where they went.[6] Of course, the survey also needs to query respondents about their travel to and from activities, so these questionnaires require more information than the trip-based approach. This translates into more work for respondents and longer data retrieval questionnaires, which in turn is likely to translate into higher non-response rates and more complaints about the survey effort. Although surveys of this type are commonly referred to as activity surveys, they are generally not suitable for activity-based modeling, because they do not provide the full set of activities for respondents.

The final type of household survey, the time use-based survey, asks respondents to record all of their activities over some period of time. These include activities that take place within people's homes as well as those to which respondents need to travel. The surveys also collect the travel data for any trips between activities. These surveys provide a basis from which either traditional trip-based modeling approaches or activity-based modeling approaches may be developed, and because respondents are asked to record all of their activities over the time period, the number of trips that are accidentally left out is likely to be smaller than either of the other types of surveys.

On the other hand, the time use-based surveys are necessarily much longer than the other types and the respondents are asked to supply a great deal of personal information. These surveys have been found to be too invasive by a number of potential respondents in the regions where they have been fielded. A recent household activity survey in New Hampshire attempted to record both in-home and out-of-home activities, but respondent complaints to the Department of Transportation led the survey team to revise the data collection and analysis approach so only out-of-home activities were collected.

New generation travel demand models, like TRANSIMS, will likely require very detailed time use-based survey data.

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[6] Peter R. Stopher, *Use of Activity-based Diary to Collect Household Travel Data, Transportation*, 1992, Volume 19, pp. 159-176.

The Comprehensiveness of the Travel/Activity Data

Many analyses require that all travel within a time period for a household (or for a person within a household) be reported in the survey data. For instance, to measure daily household trip generation rates, the survey team would want a full accounting of the trips made by each sample household in a 24-hour period. On the other hand, some analyses focus on a few specific trips made by household members, such as work trips or trips by certain modes.

The distinction between these two types of analyses has a very important impact on the household travel/activity survey because it is the primary determinant of whether formal travel or activity diary procedures are needed, or whether the use of respondent recall will be sufficient.

If the survey team is seeking a complete listing of travel and activities for a household, as is often the case, recent household travel/activity survey experience would suggest that the team use either travel or activity diaries, and not rely on respondent recall questions. As Richardson, Ampt, and Meyburg suggest, one needs only to try to remember in detail what they did, and where they went yesterday to realize that it is extremely difficult to obtain reliable and complete information using recall survey questions.[7] By the early 1980s, the use of travel diaries supplanted recall surveys for collecting travel model input data. for the simple reason that they are more effective at capturing people's trips. Diary methods consistently outperform trip recall questions in capturing:

- Short trips;
- Off-peak trips; and
- Non-work trips.

Travel and activity diaries are thought to be better than recall methods in these instances, because:

- Respondents are asked to complete diaries for a pre-specified future time period, so they are probably more cognizant of their travel during the particular time period than they would otherwise be; and
- Respondents are asked to record travel and activities as they occur, so the likelihood of forgetting an activity or trip is reduced.

[7] A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg. *Survey Methods for Transport Planning*, Eucalyptus Press, Melbourne 1995, p 155.

The many diary types are discussed in Section 6.6. The use of the less-expensive and more simple recall method may be a better approach when:

- The survey team is interested only in certain types of travel and activities;

- The survey data are not being used to develop travel volume estimates for the person or household; or

- The survey team is willing to weight trip rates according to known (or estimated) volumes.

The recall method may also serve as a backup approach to try to get households who have refused to participate in a more detailed diary survey.

If limited travel or activity information is needed from a household, then a recall technique might be successful. With careful questioning, and perhaps interviewer probing, respondents can generally be induced to remember specific trips in the recent past, particularly if the trips can be defined specifically (e.g., a trip between home and work) or are somehow noteworthy or unique for the respondent.

The need (or lack of need) for diaries has an important effect on the selection of the survey method. If diaries are required, then the chosen survey method will be required to have a mail or in-person component to physically get the diaries to the household. If only recall methods are required, the household travel/activity survey can be accomplished with a single-contact interview (in-person or telephone) or a simple mail survey.

Stated Response Analyses

The emphasis of household travel/activity surveys has traditionally been to collect people's actual travel behavior (their revealed travel preferences), but as the analysis demands on the survey data are being increased, travel surveyors have begun to experiment with collecting hypothetical choice information from household travel/activity surveys.

Stated response survey questions can provide the survey team with information such as:

- How people are likely to react to changes in transportation services and infrastructure;

- How people are likely to react to potential new government policies; and

- Confirmation (or rejection) of revealed preference modeling results.

This emerging use of stated response techniques and the survey design issues related to them are described in Chapter 13.0 The key design issues include:

- The added costs and complexity of designing survey questions;
- The potential need for delivering stated-response survey materials to respondents;
- The added burden on respondents of figuring out and answering the stated-response questions; and
- The different analysis requirements of such survey data.

The inclusion of stated response questions on a household travel/activity survey will affect the decision of the best survey method since these questions work best when an interviewer is available to answer respondent questions and to explain the sometimes complex instructions. In addition, including these exercises will affect the sample selection and the need for advanced fieldworker training.

Seasonal Analyses

In general, household travel/activity surveys capture travel conditions over a small period of time during a year. Usually, the data and analyses are extended to look at other times of the year by factoring trips using travel volume data, but because it is generally acknowledged that people's travel patterns vary between seasons along many dimensions, including trip purpose, duration, frequency, and destination choice, it is highly likely that the household travel or activity data represent the time period for which they were collected to a much higher degree than other periods.

Traditionally, household travel/activity surveys are conducted in either the Spring or Fall. These seasons coincide with the most common traffic data collection periods. In addition, they represent time periods when schools are in session, and when potential respondents are least likely to be away from their homes on vacation.

However, the survey team should consider the analyses that will need to be performed before scheduling the household/activity survey. For the past five years, a primary driving force behind travel demand modeling has been the need to better measure and track air quality. Most regions concerned with air quality issues are most interested in Summer conditions (due to increased ozone levels) and Winter conditions (due to cold start emissions). Nevertheless, most surveys and models continue to be for the Spring or Fall, because they seek to capture specific "average" or "peak" conditions. Agencies whose primary concerns are air quality-related should determine which season is the most important to have accurate travel data, and schedule the survey accordingly.

Some recent household travel/activity survey efforts have collected data from respondents in more than one season in a year. The survey data are allowing the sponsoring agencies to compare travel between seasons, and the resulting analyses of the data are likely to describe "average" travel conditions better than a single season survey would. Unfortunately, this approach is not cost-free. First, many agencies do not have the luxury to add six or nine months on to the survey development schedule to spread out the data collection. Second, the cost per completed survey is likely to be higher since there are economies-of-scale related to many survey cost components. For most common survey methods, it is less expensive to conduct one large household survey than several smaller ones. Third, to perform seasonal comparisons, the total sample size is likely to have to be higher, further increasing costs.

To summarize, the selection of the survey season (or seasons) should be based on the following considerations:

- Are the expected analyses of the survey data seasonal in nature, like air quality analyses?

- Are travel patterns in a particular season predictable based on another season's travel patterns and available interseasonal travel volume information?

- How do respondent contact and cooperation rates vary by season for the different survey methods? What effects do these variations have on survey cost?

- Do time and budget constraints preclude the possibility of collecting the household travel/activity survey data over two or more seasons?

Analysis Time Periods

Just as some analyses are related to particular seasons, many transportation modeling analyses are related to particular days of the week and hours of the day. Based on the anticipated analyses, the survey team has three important survey design decisions to make with regard to analysis time periods:

- How much travel or activity data are needed from each respondent or respondent household?

- For which weekday time periods are data needed?

- Are data for weekends also needed?

Based on the analysis needs for the survey data, the survey team must determine the days and hours for which travel or activity information will be sought. In the U.S., household surveys have traditionally asked that respondents record travel or activities over a 24-hour period. Some smaller survey efforts, including surveys in Keene, NH (1991) and Southeastern New Hampshire/Southern Maine (1992) and a survey on Staten Island (1990), have asked for this information only for peak travel periods, but most survey efforts collect the full day information, even when only peak-hour analyses are conducted. In Europe, some travel diary periods are as long as two weeks, but European respondents are generally much more tolerant of survey efforts than North American respondents. Diary periods of this length are not likely to be successful in the U.S.

A few recent major household travel/activity survey efforts in the U.S. have asked for the data for 48-hour periods. These surveys have sought to describe day-to-day variation in activities and travel behavior. Although some of the second day trip information is duplicative of the first day information, the surveyors have found that the multi-day survey data better explains day-to-day variation in household and personal trip generation rates, and provides more mode choice data. In addition, the multi-day diaries can provide the survey team with insights about travel behavior that one-day diaries cannot.

The primary reservations that surveyors express about multi-day diaries is that the increased respondent burden of the multi-day diaries will lead to higher fatigue levels and higher non-response rates. In addition, many surveyors worry that because of the fatigue factor, respondents would be more likely to under-report trips and activities on the later days of the multi-day diary. Research on the subject confirms that this is a problem for longer travel periods (seven days or more), but the evidence on two and three day diary periods is less conclusive. Lawton and Pas have found that two-day diary periods are not subject to declining trip reporting.[8] On the other hand, the recent Dallas-Fort Worth pretest data showed that the second day of the 48-hour diary had significantly fewer reported weekday trips than the first day of the 48-hour diary. The pretest also recorded slightly fewer reported trips in the first 24 hours of the two-day diary than in the 24-hour diary.

The collection of multi-day diary data complicates the development of 24-hour travel models because the daily trip patterns within individual diaries are not independent. Analysts need to account for the dependencies in developing 24-hour travel models, or estimate models for the multi-day period that corresponds to the diary length. Because the recent multi-day diaries have only just been completed, it has not yet been shown whether and how the additional data improve travel models.

[8] T. Keith Lawton and Eric I. Pas, *Survey Methodologies,* Resource Paper for Household Travel Surveys: New Concept and Research Needs Conference, Irvine, CA (March 1995).

In addition to deciding the duration of the diary period, survey teams must also consider for which days of the week to seek the travel and activity data. Most transportation planning analyses have traditionally sought to describe an average weekday's conditions. This has led most surveys teams to seek travel information for Tuesdays, Wednesdays, or Thursdays of non-Holiday weeks. In recent years, a number of agencies have identified the need for analyses based on special conditions, such as weekends or Friday afternoon peak periods. Household travel/activity surveys need to reflect these analysis requirements, and travel survey teams need to consider the effect that these special investigations have on required sample sizes, respondent requirements, and survey cost.

Selection of the Survey Method

Once the effects of the likely analyses of the survey results are well-understood, the most basic survey design issue for the household travel/activity survey is the selection of the survey method to be used. This decision needs to be based on the strengths and weaknesses of the different survey methods and the overall goals of the survey team. Most survey implementation issues that will be encountered (and are discussed in this chapter) will relate back to the basic selection of the survey method, and conversely the selection of the survey method should be guided by the survey team's preliminary evaluation of later key issues.

The Components of A Household Travel/Activity Survey

To define the universe of available survey method options for household travel/activity surveys, it is useful to consider the fieldwork components of a household survey separately. Household surveys consist of the following key components:

- **Screening and Recruitment** – Enlisting the cooperation of potential respondents and ensuring that a contact meets the geographic and demographic requirements of the study (as needed by the travel demand models);

- **Distribution of Materials** – Delivery of survey forms and related documents to respondents; and

- **Collection or Retrieval of Survey Responses** – Obtaining the survey responses from the respondents.

The different survey methods can be defined by how they accomplish each of these component tasks. Some methods combine the basic components. Others do not include one of the components. However, decisions about the three main components, screening and recruitment, distribution of materials, and collection of survey responses, define the available survey methods.

Commonly Used Household Survey Methods

Based on the strengths and weaknesses of the data collection procedures for each survey component, surveyors have applied many combinations of recruitment, materials distribution, and data retrieval in their survey designs. As Figure 6.1 shows, combining all the different methods for each component of the household travel/activity survey yields more than a dozen feasible survey methods.

The household travel/activity survey team may want to consider the strengths and weaknesses of each feasible method for their particular survey effort. However, because most of these methods have not been proven to be efficient for household travel/activity surveys, this Manual focuses on only a few of the methods listed above.

Tables 6.2 through 6.7 summarize the most relevant household travel/activity survey methods. Table 6.2 discusses the simple single contact telephone survey, and Table 6.3 describes the basic mail survey. Table 6.4 and Table 6.5 describe the two most common combinations of mail and telephone survey methods for household travel/activity surveys, the telephone-mailout-mailback survey and the telephone-mail-telephone survey. These four survey methods are the primary focus of the remaining discussion of household travel/activity surveys.

Table 6.6 describes the simple in-home survey that was commonly used in the 1960s household travel surveys. Table 6.7 summarizes the two stage in-home survey method that was developed as an extension to the traditional in-home survey when the need for travel diaries was recognized. As Tables 6.6 and 6.7 indicate, in-home methods for household travel/activity surveys are probably relevant only in very specialized situations. The use of these two methods is not recommended for most new travel surveys.

Selection of Data Collection Techniques for Household Travel/Activity Surveys

Once the survey team has selected one or more methods for further survey design, the next survey design task is to determine the best data collection techniques for each method.

As we discuss below, the quality of data collection using mailback surveys can be enhanced by a number of design factors, but the data collection techniques for these types of surveys are essentially the same. The respondent is expected to complete the survey materials as instructed and to send the completed forms back to the survey team.

Figure 6.1 Some Feasible Household Survey Methods

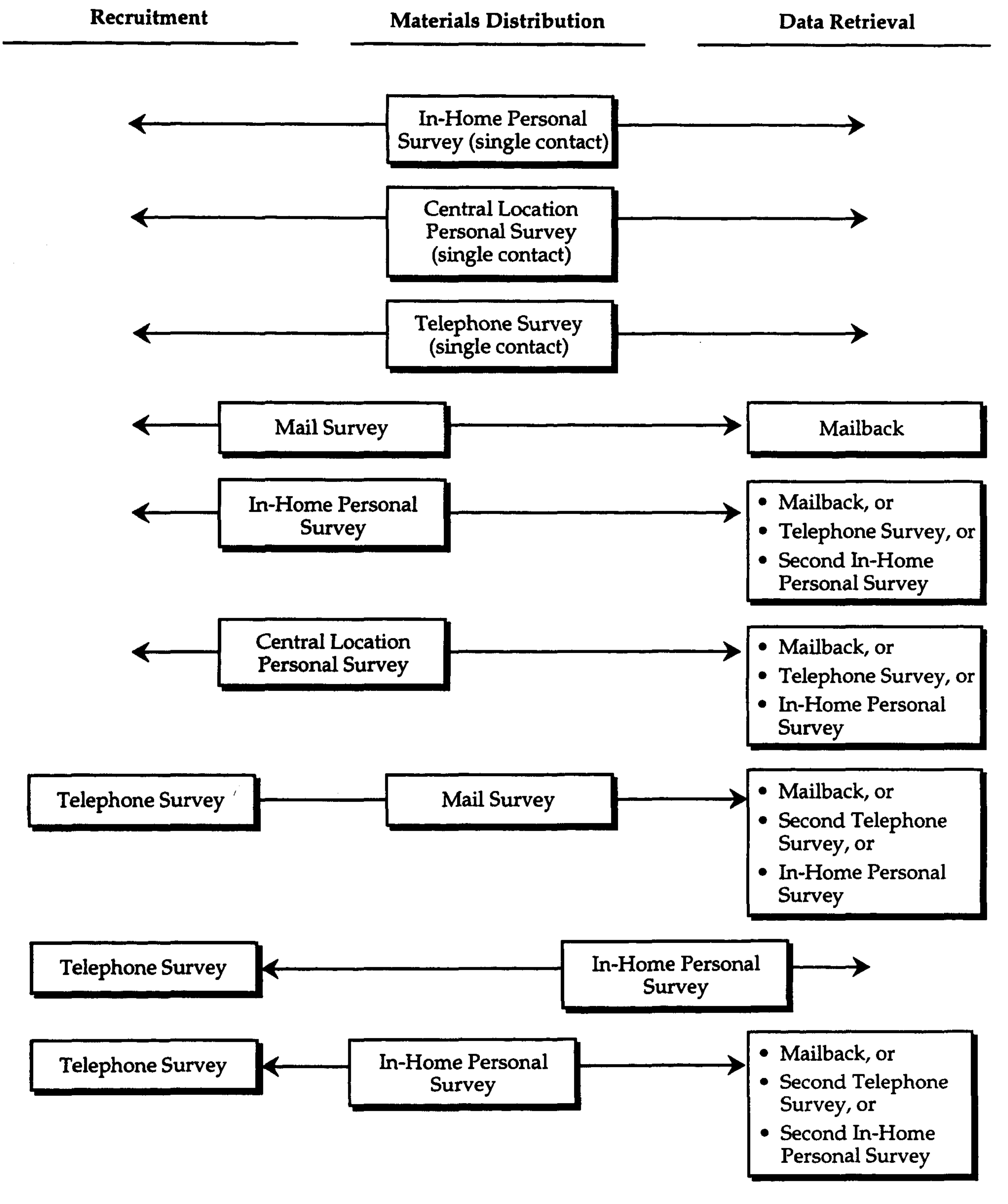

Table 6.2 Household Travel/Activity Survey Methods: The Single-Contact Telephone Survey

Procedures

1. Respondent households are selected via RDD methods or a combination of RDD and listed number methods.

2. Interviewers call potential respondents, and obtain respondent data and respondent travel data (relying upon recall rather than diary methods).

Advantages and Disadvantages

- Because telephone surveys are interviews (rather than self-completion instruments), this method retains a number of the positive aspects of the traditional in-home interviews, (including the ability to probe for more detailed responses and to assist respondents if they become confused), but at a substantially lower cost.

- This method requires the least amount of time to finish the survey fieldwork. It is the best method for survey teams who need data immediately (perhaps to study the transportation effects of an unforeseen change in the transportation network from a strike or a natural disaster).

- Households without telephones cannot be reached.

- Like the single contact in-home survey, the interview needs to rely on respondent recall of past travel and activities (a diary approach is not feasible). The telephone method does not allow for visual aids, nor does it allow interviewers to observe respondents.

- Telephone surveys are the best method to administer a reasonably complex survey instrument, with special sequencing, skip patterns, and difficult instructions, because CATI techniques can be employed.

Usage of the Method

- This method is essentially the application of telephone survey techniques to the traditional single-contact in-home survey method. Since recalled data are less accurate than diary data, it is not the best approach for collecting comprehensive travel data, like those needed for regional travel modeling.

Table 6.2 Household Travel/Activity Survey Methods: The Single-Contact Telephone Survey (continued)

- However, for analyses that do not require respondents to have any survey materials, the telephone survey is usually an excellent choice. The survey can be completed quickly, response rates are likely to be superior to mail surveys (even with the incomplete sampling frame of the telephone method), and the survey team has the ability to supervise and monitor the data collection.
- Single-contact telephone surveys are the most common survey method in the U.S. outside of the transportation planning field.
- Recent major North American applications of this method in transportation include:
  - 1989 New York MTA Comprehensive Telephone Travel Survey - A survey of 20,500 individuals within households that provided an inventory of trips that were relevant to MTA services;
  - 1990 Nationwide Personal Transportation Survey;
  - 1991 Toronto Transportation Tomorrow Survey - A survey of 24,500 households that provided household, person, and travel data for 24-hour periods for all household members;
  - 1991 Madison, WI Travel Survey; and
  - Countless non-modeling-related surveys by transportation providers and planning agencies.

Table 6.3 Household Travel/Activity Survey Methods: The Mail Survey

Procedures

1. Sample households are selected from an address-based sampling frame.
2. Respondent households are mailed questionnaires with travel diaries, trip questions, and respondent questions.
3. Respondents record travel and/or activity data for the pre-specified time on the diary forms and complete the other parts of the questionnaires, and then mail the responses back to the agency.
4. Follow-up and pre-notification mailings can be used to improve response rates.

Advantages and Disadvantages

- Simple mail surveys usually work out to be the lowest cost survey method.
- Available sampling frames for mail surveys are superior to other sampling frames. Households without telephones can be reached, as can households within high-security buildings and subdivisions.
- Mail surveys can use questions requiring the respondent to have the survey materials. They can be used to collect diary data and to ask questions with complex response categories. On the other hand, mail surveys are not appropriate for questionnaires with complicated sequencing and skip patterns.
- Mail surveys require the least staff and facilities of all the methods.
- There are no interviewers, so the survey team loses the ability to probe or clarify responses. In addition, the opportunity for computer-assisted questioning (which limits the data entry, cleaning, and editing tasks) is lost. Excellent questionnaire design is essential for mail surveys.
- Item non-response tends to be higher in mail surveys than in other types of surveys, because respondents may accidently skip questions. In addition, with mail surveys, the survey team is unable to ensure that certain questions do not influence how respondents reply to other questions.
- The most common criticism of mail surveys is that the yield low response rates. U.S. evidence suggests that mail survey response rates do tend to be lower than for other methods, but there are a number of strategies to improve mail survey response. With response rates for telephone and in-person surveys declining, this disadvantage is becoming less important.

Table 6.3 Household Travel/Activity Survey Methods: The Mail Survey (continued)

Usage of the Method

- For recent household travel/activity surveys in the U.S., the mail survey method has been used as the low-cost approach. Mail surveys have been performed, for the most part, by agencies that have recognized the need for data, but that had inadequate data collection budgets. However, there is a tradeoff between cost and data accuracy.

- Because of this, many mail survey efforts have had to cut corners so poor survey design and procedures were used, resulting in low response rates and data that are likely to be more biased than for the other methods..

- Survey results are improved somewhat by high-quality survey design, such as that of the recent Chicago household travel/activity survey. In other parts of the world, mail surveys are commonly used with great success.

- Recent U.S. household travel/activity surveys that have been performed with this method include efforts in:

  - Chicago (1990);
  - Des Moines (1991);
  - Montgomery County, Maryland;
  - Tampa-St. Petersburg (1991);
  - Portsmouth, NH (1993); and
  - Vermont (statewide) (1994).

Table 6.4 Household Travel/Activity Survey Methods: The Telephone-Mail-Telephone Survey

Procedures

1. Respondent households are selected via RDD methods, a combination of RDD and listed telephone number survey methods, or a combination of address-based sampling and listed telephone number survey methods.

2. Interviewers call potential respondents, collect some basic respondent information, ask the respondents to participate in a travel diary survey, and then obtain respondents' mailing addresses;

3. Travel or activity diary forms are mailed to respondents, and in most studies, the respondent is called shortly before their diary effort is scheduled to begin to ensure receipt of the survey materials and to remind them of the diary effort;

4. Respondents record travel and/or activity data for the pre-specified time on the diary forms that were mailed to them;

5. Shortly after their diary efforts are completed, respondents are called again and are asked to read the diary information to the interviewer and to answer more questions about themselves and their travel.

Advantages and Disadvantages

- By combining mail and telephone survey methods, the survey team can take advantage of the positive aspects of both.
- The mail survey component can be used to ask questions requiring the respondent to have the survey materials. They can be used to collect diary data and to ask questions with complex response categories.
- The telephone survey elements of the method allow survey teams to take advantage of the fact that there are interviewers (allows probing and clarification of responses), and that there is an opportunity to use CATI for complex skip patterns and sequencing, as well as for reducing the coding, entry, and editing tasks.
- The multiple survey methods make this method relatively expensive.
- With this method, the survey team is able to sequence questions in ways that ensure that certain questions do not influence how respondents reply to other questions.
- The survey team does not (necessarily) get back the actual diary forms completed by the respondents.

Table 6.4 Household Travel/Activity Survey Methods: The Telephone-Mail-Telephone Survey (continued)

- The survey frame for multiple-contact survey methods is related to the recruitment method. For this method, respondents are recruited by telephone and therefore only households with telephones can be included.

Usage of the Method

- Despite its higher costs, the advantages of this method have made it the most commonly used household travel/activity survey method in the U.S.

- Recent applications of this method for household travel/activity surveys have been completed in:

  - Albuquerque (1992);
  - Atlanta (1991);
  - Baltimore (1993);
  - Boise (1994);
  - Boulder County, CO (1993);
  - Detroit (1994);
  - Houston (1994);
  - Los Angeles (1991);
  - Minneapolis-St. Paul (1990);
  - Portland, ME (1994);
  - Portland, OR (1994/5);
  - Raleigh/Durham (1995);
  - Sacramento (1991);
  - San Francisco-Oakland (1990);
  - St Louis (1990);
  - Tucson (1993);
  - Washington DC (1994);
  - California Statewide (1991);
  - New Hampshire Statewide (1995); and
  - Oregon Statewide (1995).

Table 6.5 Household Travel/Activity Survey Methods: The Telephone-Mailout-Mailback Survey

Procedures

1. Respondent households are selected via RDD methods or a combination of RDD and listed telephone number survey methods.

2. Interviewers call potential respondents, collect some basic respondent information, ask the respondents to participate in a travel diary survey, and then obtain respondents' mailing addresses.

3. Travel or activity diary forms are mailed to respondents, and in most studies, the respondent is called shortly before their diary effort is scheduled to begin to ensure receipt of the survey materials and to remind them of the diary effort.

4. Respondents record travel and/or activity data for the pre-specified time on the diary forms that were mailed to them.

5. Respondents return completed survey materials by mail.

Advantages and Disadvantages

- Like the telephone-mail-telephone survey, this method seeks to combine mail and telephone survey methods, so that the survey team can take advantage of the positive aspects of both.

- The method is less expensive than the telephone-mail-telephone method because there is no lengthy retrieval call. However, the response rate to telephone-mailout-mailback surveys tends to be lower.

- Most respondents find the method less burdensome than the telephone-mail-telephone survey, in which the respondents have to both write down their survey answers and then read them to someone over the phone.

- The survey team does not have the ability to take advantage of CATI during the critical data retrieval phase of the survey, but the survey team does get the original forms back from respondents, unlike with telephone data retrieval.

- Respondents who are unwilling to endure a long telephone data retrieval interview may still be willing to mail back survey materials, so the method can be used as a "back-up" to the telephone-mail telephone survey.

Table 6.5 Household Travel/Activity Survey Methods: The Telephone-Mailout-Mailback Survey (continued)

Usage of the Method

- The method has been widely applied in the U.S., including recent survey efforts in:
  - Boston (1991);
  - Buffalo (1993);
  - Kansas City (1991);
  - Little Rock (1993);
  - Miami (1993);
  - Salt Lake City – Provo (1993).; and
  - Seattle (started in 1989, and ongoing).

Table 6.6 Household Travel/Activity Survey Methods: The Single Contact In-Home Survey

Procedures

1. Sample households are selected from an address-based sampling frame.
2. Interviewers contact potential respondents by going to their homes, where the interviewers proceed to collect the needed respondent information.

Advantages and Disadvantages

- Personal interviews are usually the most effective way to enlist respondent cooperation in surveys, because interviewers can show credentials and better demonstrate the authenticity of the survey effort, but a growing number of potential respondents are becoming uncomfortable with being contacted by strangers in their homes.
- In-home interviewers can help respondents understand and reply to survey questions better than telephone interviewers, because they can show respondents what to do as well as describe it. The interviewers can mitigate the biasing effect of having to obtain information from illiterate (or functionally-illiterate) respondents.
- The interview needs to rely on respondent recall of past travel and activities (a diary approach is not feasible with this method). But given this limitation, the interviewer can administer a reasonably complex survey instrument, with special sequencing, skip patterns, and difficult instructions. This is particularly true if CAPI techniques are employed.
- The method is likely to be quite costly, labor-intensive, and time consuming because of the low productivity of traveling fieldworkers.
- Trained interviewers that are geographically near the study area may be difficult to find.
- The method is susceptible to disruptions due to fieldworker errors and to problems with interviewer security. Increasing fieldworkers' security generally requires assigning extra staff and thus increasing labor costs.

Usage of the Method

- For many years, this was the most common household travel survey approach, but all recent North American household travel/activity surveys have been conducted by other means. There are no recent North American examples of the application of this method.
- *The method is probably inappropriate* for almost any new household survey effort because of the disadvantages cited above.

Table 6.7 Household Travel/Activity Survey Methods: The Two-Stage In-Home Survey

Procedures

1. Sample households are selected from an address-based sampling frame.
2. Interviewers contact potential respondents by going to their homes, where the interviewers collect some basic respondent information, ask the respondents to participate in a travel or activity diary survey, and then give the respondents the diary materials.
3. Respondents record travel and/or activity data for some pre-specified time on diary forms provided by the interviewers.
4. After the diary period is completed, the interviewers return to the respondents' homes, review and clarify the diary answers, and collect additional respondent information, if needed.

Advantages and Disadvantages

- Personal interviews are usually the most effective way to enlist respondent cooperation in surveys, but a growing number of potential respondents are becoming uncomfortable with being contacted by strangers in their homes.
- In-home interviewers can help respondents understand and reply to survey questions better than telephone interviewers. The interviewers can mitigate the biasing effect of having to obtain information from illiterate (or functionally-illiterate) respondents.
- The survey method allows for the use of travel or activity diaries, and both the in-person distribution of the diary methods and the in-person retrieval of the data will have a positive effect on the quality of the diary data obtained, because interviewers can ensure that respondents understand what is required. The interviewer can administer a reasonably complex survey instrument, with special sequencing, skip patterns, and difficult instructions. This is particularly true if CAPI techniques are employed.
- The method is even more costly, labor-intensive, and time consuming than the single-contact in-person survey because of the low productivity of traveling fieldworkers.
- Trained interviewers that are geographically near the study area may be difficult to find.
- The method is susceptible to disruptions due to fieldworker errors and to problems with interviewer security. Increasing fieldworkers' security generally requires assigning extra staff and thus increasing labor costs.

Table 6.7 Household Travel/Activity Survey Methods: The Two-Stage In-Home Survey (continued)

- It has become relatively common for access to be restricted to residential buildings and subdivisions.

Usage of the Method

- This method corrects for one of the fundamental problems of the single-contact in-person survey: the inability to collect diary information, but because of its very high costs and logistical difficulties, it is not generally considered to be feasible.
- The sponsor of the most recent U.S. household survey effort to attempt an in-home data retrieval chose to switch the survey to a different data collection method after about two-thirds of the survey was completed because of the higher-than-expected costs of the in-home method.
- The method was used for non-telephone owning households in the 1990 San Juan, Puerto Rico Household Travel Survey.
- The method would only be reasonable for surveys for which the survey team is willing to pay a premium for data quality, and even if this is the case, the method can only be considered if the survey area has enough available trained interviewers, the area is safe (in terms of personal security concerns), and the area does not have high security buildings and gated subdivisions. Given these issues, this method is not considered feasible in most cases.

Materials for Any Survey Method

Collecting data by interviewing respondents, either by phone or in person, can be accomplished in more than one way. If the survey team is considering one of the interview techniques for the household travel/activity survey, they will need to make the following decisions about the data collection techniques:

- Is the use of qualitative survey techniques viable or desirable for the survey effort?
- For telephone surveys, should centralized interviewing facilities be used?
- Should computer-assisted interviewing techniques be employed?

Qualitative Survey Techniques

Typical travel surveys are designed to be highly structured. Whenever possible, respondents are asked to answer closed-ended questions that have predetermined response categories. Sometimes a few open-ended questions are included in the surveys, but usually only when absolutely necessary. For almost all travel modeling applications, a highly structured survey instrument is necessary or at least highly desirable.

However, some planners outside of the U.S. have found that removing the tight structure of the interview is an effective way to obtain information about how respondents actually think and believe about certain issues.[9] These planners have developed and applied household travel surveys that rely on unstructured (or semi-structured) interactions between respondents and interviewers.

Qualitative surveys (or interactive surveys) are in-depth interviews where respondents' answers are used to guide the format and topics of the interview. They are similar to focus group discussions, except they are conducted on a one-on-one basis, either in-person or by telephone. Interviewers probe and ask supplementary questions about the most interesting topics raised in the interview, and in some cases the interviewer will ask purposely biased questions to challenge the strength of a response or to clarify the respondent's opinions. Typically, interviewers work from discussion guides, rather than questionnaires, and the interviews

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[9] For a discussion of several such studies, see Peter Jones. *Interactive Travel Survey Methods: The State-of-the-Art* in Ampt, E.S., Richardson, A.J. and Brög, W. (1985). New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pp. 99-127.

are tape recorded so that responses can be analyzed in detail at a later date.[10]

Unfortunately, the costs related to qualitative surveys and the special skills needed to perform them often make these surveys infeasible. For interactive surveys to be successful, the interviewers have to be highly skilled and must understand the survey topic and the issues facing the sponsoring agency. Therefore, the number of interviewers that are able to perform these types of surveys is small. In addition, the analyses of the tape recorded interviews requires special talents and a significant amount of time.

In general, travel demand models are designed to use structured data, so transportation planners typically do not see any reason to perform qualitative surveys. However, special household travel/activity surveys that are seeking to obtain large amounts of opinion and attitude data could benefit from an interactive approach. Some of the next generation travel models, like TRANSIMS, will likely benefit from the data available from qualitative surveys.

The Use of Centralized Telephone Interviewing Facilities

A telephone interviewer can complete his or her task from virtually any telephone. Many early telephone surveys were conducted from interviewer homes or offices. In these cases, each telephone interviewer was given a subset of the telephone numbers in the sample. The interviewer would contact as many of the households as possible, and then after a prespecified time they would deliver the completed survey instruments to survey managers.

A very serious problem with this approach is that the ability to supervise interviewers as they conduct the surveys is lost. The survey team needs to rely on the skill and professionalism of the interviewers to conduct the surveys correctly and without biasing results.

For this reason, it is recommended that all travel telephone surveys be conducted from centralized locations with supervisors. Supervisors are able to observe interviewers while they work to ensure that they are following procedures correctly, and if problems are identified, they can be rectified immediately. Interviewers are able to ask questions if needed, and if a respondent wishes to speak to a supervisor to verify the authenticity of the survey or to complain, they can be easily transferred. In

[10]Peter Jones. For a discussion of several such studies, see Peter Jones. *Interactive Travel Survey Methods: The State-of-the-Art* in Ampt, E.S., Richardson, A.J. and Brög, W. (1985). New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pp. 104.

addition, interviewers at centralized locations are able to learn from each other as they conduct the interviews.

Using a centralized telephone interviewing facility also allows the survey team to establish regulations on telephone interviewing hours. A common complaint that telephone survey respondents (and non-respondents) have is that they were contacted too late at night or at an inconvenient time. Professional marketing research firms usually have guidelines with regard to calling times. For instance, many firms avoid making calls after 9:00 p.m. Different limits on calling times are likely to be appropriate for different survey populations, so survey teams need to establish the regulations individually for each study.

The central telephone survey location can be either a professional marketing research interviewing facility or a temporary facility fashioned out of an agency's or firm's office. Since most telephone interviewing is conducted in the evenings and on weekends, it is possible to transform an office into a primitive telephone interviewing facility during off-hours and then switch back to an office in time for regular business hours. Open plan offices with individual phone lines, which are currently quite common, are especially easy to turn into telephone interviewing facilities.

The facilities are not ideal, however, because monitoring calls and providing general supervision are somewhat difficult. In addition, interviews that require toll calls are best handled from professional facilities with WATS lines and other more sophisticated telephone equipment.

The Use of Computer-Assisted Interviewing Techniques

In the past, the most common technique used to record the results of personal interviews and telephone interviews was the pencil-and-paper interview (PAPI), in which:

1. Interviewers record answers on survey instruments or on interview schedules;

2. Trained coders translate the answers into codes, and record them on coding sheets; and

3. Data entry specialists enter the codes into a computer data file.

However, the widespread availability of desktop and notebook computers has led to the development and wide acceptance of computer-assisted telephone interviewing (CATI) and computer-assisted personal interviewing (CAPI) software. Most household travel/activity surveys in the last few years that have involved telephone interviewing have been performed using CATI techniques.

CATI Advantages

CATI reduces the three step data collection-coding-data entry process into one automated, on-line procedure. A computer screen prompts an interviewer to ask a question, then the interviewer records the response, and the computer codes it and saves it to a data file.

CATI techniques have the following interviewing advantages:[11,12]

1. They can be designed to permit the entry of only legal codes in any particular field (preventing many data entry errors);

2. They can be used to check entries to make sure that they are consistent with other previously entered data (preventing data inconsistencies);

3. They automatically route interviewers through the interview (ensuring that respondents are asked all the relevant questions and are not asked ones that should be skipped);

4. They can use information from previous questions or previous interviews to make interview questions or the sequencing of questions specific to a particular respondent; and

5. They can be used to help combine the survey's data collection and management functions; for example, once a telephone interviewer has finished with one respondent, the CATI system can check whether she or he has arranged to return a call to another number, or search the non-contacted numbers for instances where the current time has not yet been tried.

Appendix C shows an example of a recent household travel survey that illustrates the advantages of using a CATI approach.

In addition to improving interviewing capabilities and reducing editing and coding requirements, CATI systems have a number of other advantages, including:[13]

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[11] Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, pp. 130-134.

[12] Peter Jones and John Polak, *Computer-based Personal Interviewing: State-of-the-Art and Future Prospects*, Journal of the Market Research Society 1993, Volume 35, No. 3, p. 222.

[13] William L. Nicholls *Computer-Assisted Telephone Interviewing: A General Introduction* in Groves, R.M., Biemer, P.P., Lyberg, L.I., Massey, J.T., Nicholls, W.L., and Waksberg, J. Telephone Survey Methodology, John Wiley & Sons: New York, p. 378.

- **Sample Management** – The CATI system maintains the sample status of each case and links input data to the interview and output record.

- **On-Line Call Scheduling and Case Management** – The CATI system sets the priority, sequence, and timing of calls.

- **On-Line Monitoring** – The CATI system is able to reproduce any interviewer's screen at a supervisor's terminal where audio monitoring may occur as well.

- **Automatic Recordkeeping** – The CATI system stores information on on-line calls, their outcomes, response rates, and interviewer productivity, and makes the information accessible to managers in on-line and printed reports.

CATI Disadvantages

As noted above, CATI systems are now commonly used for household travel/activity surveys. However, despite the advantages of the computer-assisted techniques discussed above, there are also negative aspects of the computer-assisted technologies.

First, CATI surveys require a great deal of lead time so that they can be programmed to produce the desired range-checking, question sequencing, and calculations. The CATI programs need to be perfect before the survey is fielded, because interviewers will not generally be able to fix them as they go along. Testing and debugging complex CATI programs could take several weeks and require well over a person-month to complete.

Second, even though the systems can be taught to accept only answers that fall within an acceptable range, they cannot control the quality of data entry. When a CATI interview is completed, the only record of the interview is the data file. There are no source records like in pencil and paper interviews to verify that the survey data was entered into the computer accurately. In addition, it is often difficult for interviewers to include special notes or extra information.

Third, if the CATI program is not carefully designed so that interviewers can avoid collecting duplicative information and can insert missing information from previous responses, the CATI interview can take longer than a pencil-and-paper interview. The paper-and-pencil phone retrieval of Portland's two-day diary survey took about the same respondent time as the CATI retrieval of a one-day diary pretest in Dallas/Forth Worth. The diary format for the Dallas survey was subsequently modified to allow the CATI data collection to run much more smoothly.

Finally, CATI systems are highly specialized software routines. Most agencies do not have the resources to develop software of this nature in house, so by selecting to use computer-assisted methods, a survey team is probably also ensuring that they will need to enlist marketing research contractors for the survey effort. Most CATI household travel/activity survey efforts have used the commercial packages that the marketing research contractors purchased or licensed and have customized for collecting data.

It is possible to combine CATI and PAPI techniques within the same survey effort. Some recent household travel/activity surveys have used CATI techniques for recruitment, but PAPI techniques for data retrieval. It is also possible to combine the techniques within the same survey, such as by using CATI to retrieve household and person record information and PAPI to collect trip and activity diary information.

Procedures to Enhance the Accuracy of Household Travel/Activity Surveys

Along with determining the survey methods and data collection techniques to be used for the household travel/activity survey, the survey team needs to consider the different available procedures for managing survey bias and inaccuracy. Chapters 4.0 and 5.0 identified the following sources of survey bias:

- Misidentification of the survey population;
- Imperfect sampling frames and sampling loss;
- Non-response;
- Poor questions and survey instruments;
- Fieldworker and interviewer errors; and
- Coding, data entry, and data processing errors.

Procedures to minimize the last three items in household travel/activity surveys are discussed in detail later in the chapter, but if the survey team is to effectively reduce the biases associated with the first three sources of bias, it will be necessary to address them while the survey is first being designed. Procedures to improve household travel/activity survey accuracy should be viewed as integral to the survey design, rather than "extras," and the costs associated with these procedures should be considered before the final selection of survey methods and techniques are made.

Procedures for Improving the Identification of the Survey Population

The survey population for a household travel/activity survey is either the collection of all households within a study area or some collection of the people who live within those households. In designing the household travel/activity survey, the survey team must:

- Ensure that the anticipated analyses can be accomplished with household-based data, as opposed to data based on other sampling units like trips within a particular analysis corridor; and

- Define the boundaries of the study area for which analyses will be required.

In most cases, these concerns will have been addressed prior to the detailed household travel/activity survey design. Presumably, the anticipated analyses have led to the need for household-based data because otherwise, different (and usually less expensive) types of surveys would be considered. In addition, the study area for the survey is usually set independently of the survey design effort based on particular analyses needs and political boundaries. Definition of the study area boundary is discussed in a greater detail in Chapter 7.0.

Most regional agencies define the geographical extent of their survey by county (political) boundaries. Often this is expedient since Metropolitan areas are defined by county boundaries, and it is easy for executive boards to understand. In cases where a county may extend very far beyond the urbanized area boundary, a cordon line may be used to determine areas for inclusion or exclusion in the survey.

Procedures for Improving the Sampling Frame and For Reducing Sampling Loss

It is likely that the household travel/activity survey team will be faced with an imperfect sampling frame. Because all the most common address-based and telephone-based sampling frames are designed for other purposes, it is not surprising to find that they often need to be cleaned, edited, and augmented for the survey effort. The most common procedures for improving the sampling frame for a household travel/activity survey include:

- Field validation of address-based data sources;
- Combination and cross-checking of two or more sampling frame databases; and
- Special efforts to include identifiable underrepresented groups.

Procedures for Reducing Non-Response

Survey non-response is commonly categorized into unit non-response, referring to the failure of potential respondents to reply to the survey as a whole, and item non-response, referring to respondents' failure to respond to particular items on the survey. Methods to reduce item non-response are discussed later in the description of questionnaire design. Methods to reduce unit non-response are described in this section.

Four general approaches are commonly used for reducing unit non-response in household travel surveys:

- Pre-notification of the survey effort;
- Survey follow-up techniques;
- Offering potential respondents tangible incentives to complete the survey; and
- Response facilitators (elements of the mail or telephone surveys that decrease the likelihood that potential respondents will refuse to participate).

These approaches can all have a large effect on the overall design and cost of the household travel/activity survey effort.

Pre-Notification as a Method of Improving Survey Response

Pre-notification of the household travel/activity survey consists of contacting potential respondents by telephone or mail prior to soliciting participation in the survey. The pre-notification contact is used by surveyors to build respondent interest in the survey effort, and to help allay respondent doubts about the validity of the survey. There is evidence that pre-notification improves survey response rates, response speeds, and response quality.[14] Another potential benefit of pre-notification is that it can provide an early measure of likely response rates and non-response trends.

Pre-notification can be used for household surveys with mail, telephone, or in-person methods, or any combination. In theory, the pre-notification contact can be accomplished in any of the three common ways:

[14]Jacob Hornik. *Impact of Pre-Call Request Form and Gender Interaction on Response to a Mail Survey*. Journal of Marketing Research, Vol. XIX (Feb. 1982): p. 144.

1. Telephone pre-contact;

2. Pre-contact with a letter, brochure, or postcard; and

3. Face-to-face personal pre-contact.

However, in general, the cost of in-person surveying precludes this approach as a pre-notification procedure. In addition, it is not common for telephone pre-notification to be used prior to household surveys with telephone recruitment. In this situation, mail pre-notification or no pre-notification at all are more commonly used. The short recruitment call probably achieves many of the same goals of the telephone pre-notification.

Pre-notification of some type is usually always warranted in the case of mail surveys and surveys with in-home recruitment. Since the sampling frames for these surveys are usually address-based, respondent phone numbers are generally not known. Therefore, the most common approach is to send a postcard or letter of introduction.

In a sense, pre-notification is a sales technique to convince potential respondents to participate in the survey effort. Consequently, the most successful pre-notification efforts tend to employ sales techniques.

A few recent household travel/activity surveys have used formal pre-notification techniques, and those that have seem to have benefited from it. For instance, prior to conducting recruitment calls for their travel survey, the Metropolitan Washington Council of Governments (MWCOG) sent out an introductory letter signed by the directors of the Departments of Transportation in the region. The letter simply provided an overview of the survey and the study, and asked for the recipients' participation in the upcoming survey. MWCOG estimates that the pre-notification letter increased survey participation by between five and ten percent.[15]

Survey Follow-up Techniques for Improving Survey Response

One of the most effective ways to reduce survey non-response is to follow-up with respondents who do not complete the survey. Survey follow-up procedures are generally used with mailback surveys, but the concept can be applied to telephone and in-home surveys, as well.

Survey Follow-Up for Mail and Telephone-Mailout-Mailback Surveys

Mail survey follow-up techniques are used for two reasons:

- To clarify responses on returned questionnaires (corrects item non-response); and

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[15] Phone conversation with Robert Griffiths of MWCOG, September 22, 1994.

- To convert refusals and other non-responses into completed usable responses (corrects overall non-response).

Follow-Up for Item Non-response and for Clarification of Responses in Mail and Telephone-Mailout-Mailback Surveys

Clarification of responses is generally done by phone to expedite the process and to ensure that the corrected/edited responses are adequate. In telephone-mailout-mailback designs, the respondent has been recruited by phone, so it is relatively easy to recontact him or her to ask about specific responses (provided that the responses with the problems do not require the respondent to have any survey materials on hand).

Many recent travel survey efforts have used this technique to clarify and correct spurious, suspicious, or out-of-range answers. In general, the surveyors found that the number of clarification calls needed was small, and that because most problems were quickly corrected or clarified, most follow-up calls were short.

To clarify or correct the responses on simple mailout-mailback surveys by telephone, it may be necessary to request telephone contact information from respondents. Ironically, asking for this information to correct item non-response may actually increase the overall non-response rate because of people's confidentiality concerns. Surveyors may be able to determine some respondents' telephone numbers from telephone directories and/or reverse directories, but if this approach is adopted, the surveyor must understand that she or he could end up with different quality data for those with listed numbers and those without listed numbers. Since the problems that need to be clarified will probably be minor, the potential bias is generally ignored.

Follow-Up for Overall Non-response in Mail and Telephone-Mailout-Mailback Surveys

The second type of follow-up survey seeks to increase the overall response of the survey by reminding non-respondents that they have not yet completed the survey. Because the overall response rate for mailback surveys is generally fairly low, follow-up techniques are often used to increase the response. Fowler claims that:

> "While attractive presentation of the study and good questionnaire design will help, there is no question that the most important difference between good mail surveys and poor mail surveys is the extent to which researchers make repeated contact with non-respondents."[16]

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[16]Floyd J. Fowler, *Survey Research Methods*, SAGE Publications, 1988, p. 54.

There are several different follow-up approaches for mailout-mailback surveys, including:

- **Follow-Up Postcards** – respondents are sent a reminder postcard stressing the importance of their responses to the survey;
- **Follow-Up Letters** – respondents are sent a brief letter (usually from an elected official, such as the one who signs the cover letter for the initial mailing) restating the goals of the survey and its importance;
- **New Survey Materials** – respondents are sent a new set of survey materials under the assumption that they have misplaced the original set;
- **Telephone Reminders** – respondents are called, reminded about the survey and are usually asked if they need a new set of survey materials;
- **Telephone Retrieval** – respondents are called and asked to provide the survey information by telephone; and
- **Combinations** of any or all of the above.

The best follow-up method will depend on the available budget, available time, the initial response rate, and the surveyor's level of concern about non-response. Experts differ on the best approach.

The following mail survey sequence is recommended:[17,18,19]

1. Send pre-notification letter one week prior to the initial survey mailing or recruitment call;
2. Recruitment call (if chosen method requires it);
3. Initial survey mailing;
4. Send postcard reminder or make telephone reminder call one week after initial mailing;
5. Send letter and new materials three weeks after initial mailing;

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[17] Dan Dillman, *Mail and Telephone Surveys: The Total Design Method,* John Wiley & Sons, New York, 1978.

[18] A.J. Richardson, Elizabeth Ampt and Arnim Meyburg. *Survey Methods for Transport Planning,* Eucalyptus Press, Melbourne, 1995.

[19] Floyd J. Fowler, *Survey Research Methods,* SAGE Publications, 1988, p. 54.

6. Send letter reminder four weeks after initial mailing; and

7. If response rate is still unsatisfactory, after six weeks send letter and new materials, or make telephone reminder calls for respondents with listed numbers.

Peterson, Albaum, and Kerin recently compared 27 alternative pre-notification and follow-up strategies for mailout-mailback surveys.[20] Their results are particularly interesting because they used a survey instrument that was designed to generate relatively low response rates, similar to mailed household travel and activity surveys. They compared the contact strategies based on response rates and cost per completed response. Figure 6.2 summarizes some of their findings.

The simple mail survey without pre-notification or follow-up yielded a 10 percent net response rate at a cost of $6 per completed response. Introducing pre-notification increased the response rate to 11 percent (for postcard notification) and 14 percent (for letter notification), and increased survey costs to $8 per completed response. Introducing a single follow-up contact without pre-notification produced a 13 percent return at a cost of $9 per response for postcard follow-up, and an 18 percent return at a cost of $8 per response for a follow-up letter with a copy of the questionnaire. Combining pre-notification and a single follow-up contact produced response rates between 15 and 20 percent at costs between $8 and $10 per response.

As the figure shows, the most successful strategies (in terms of response rate) involved pre-notification and two follow-up contacts. The cost per completed response for these strategies are slightly higher than the simple survey effort, but the response rates were more than double the simple effort. At these low response levels, the higher response rates almost certainly would outweigh the slightly higher costs.

Richardson, Ampt, and Meyburg also conclude that pre-notification and follow-up are cost effective investments for household travel/activity mail surveys.[21] Table 6.8 shows a cost comparison based on a 1993 Australian

[20] Robert A. Peterson, Gerald Albaum, and Roger A. Kerin, *A note on alternative contact strategies in mail surveys.* Journal of the Marketing Research Society Volume 31, No. 3.

[21] A.J. Richardson, Elizabeth Ampt and Arnim Meyburg. *Survey Methods for Transport Planning,* Eucalyptus Press, Melbourne, 1995.

Figure 6.2 Alternative Contact Strategies for Mail Surveys

Pre-Notification *Day -5*	Mail Questionnaire *Day 0*	First Follow-Up *Day +5*	Second Follow-Up *Day +10*	Net Response Rate	Net Cost per Response
	Questionnaire			10%	$6
Postcard Notification/Reminder	Questionnaire			11%	$8
Letter Notification	Questionnaire			14%	$8
	Questionnaire	Postcard Notification/Reminder		13%	$9
	Questionnaire	Reminder Letter and Another Copy of the Questionnaire		18%	$8
Postcard Notification/Reminder	Questionnaire	Postcard Notification/Reminder		15%	$8
Postcard Notification/Reminder	Questionnaire	Reminder Letter and Another Copy of the Questionnaire		20%	$8
Letter Notification	Questionnaire	Reminder Letter and Another Copy of the Questionnaire		18%	$10
Postcard Notification/Reminder	Questionnaire	Postcard Notification/Reminder	Postcard Notification/Reminder	22%	$6
Letter Notification	Questionnaire	Postcard Notification/Reminder	Postcard Notification/Reminder	22%	$7
Postcard Notification/Reminder	Questionnaire	Reminder Letter and Another Copy of the Questionnaire	Postcard Notification/Reminder	18%	$11
Postcard Notification/Reminder	Questionnaire	Reminder Letter and Another Copy of the Questionnaire	Reminder Letter and Another Copy of the Questionnaire	20%	$12
Postcard Notification/Reminder	Questionnaire	Postcard Notification/Reminder	Reminder Letter and Another Copy of the Questionnaire	24%	$8
Letter Notification	Questionnaire	Reminder Letter and Another Copy of the Questionnaire	Postcard Notification/Reminder	18%	$11
Letter Notification	Questionnaire	Reminder Letter and Another Copy of the Questionnaire	Reminder Letter and Another Copy of the Questionnaire	23%	$10
Letter Notification	Questionnaire	Postcard Notification/Reminder	Reminder Letter and Another Copy of the Questionnaire	28%	$7

Letter Notification   Postcard Notification/Reminder   Questionnaire   Reminder Letter and Another Copy of the Questionnaire

Costs include postage, printing, and survey distribution labor.

Source: Robert A. Peterson, Gerald Albaum, and Roger A. Kerin, *A Note on Alternative Contact Strategies in Mail Surveys*, Journal of the Marketing Research Society, Volume 31, No. 3, 1989.

Table 6.8 Cost Comparison of a Household Travel Survey With and Without Survey Follow-Up

	Pre-Notification	First Mailing	First Follow-Up	Second Follow-Up	Third Follow-Up	Fourth Follow-Up	Total
Survey with No Follow-Up							
Number of Items Sent Out	20,000	19,400	0	0	0	0	
Marginal Direct Cost	$ 1.00	$ 7.00	0	0	0	0	
Marginal Labor Cost	1.00	2.00	0	0	0	0	
Total Marginal Cost	**$ 2.00**	**$ 9.00**	**0**	**0**	**0**	**0**	
Cost	$40,000	$174,600	0	0	0	0	$214,600
Percent Valid Responses	0%	30%	0%	0%	0%	0%	30%
Cumulative Responses	0	6,000	6,000	6,000	6,000	6,000	6,000
Survey with Follow-Up							
Number of Items Sent Out	10,000	9,700	9,700	5,300	4,500	3,500	
Marginal Direct Cost	$ 1.00	$ 7.00	$ 0.50	$ 0.60	$ 7.00	$ 0.50	
Marginal Labor Cost	1.00	2.00	1.00	1.20	2.00	1.00	
Total Marginal Cost	**$ 2.00**	**$ 9.00**	**$ 1.50**	**$ 1.80**	**$ 9.00**	**$ 1.50**	
Cost	$20,000	$87,300	$14,500	$9,540	$40,500	$5,250	$177,140
Percent Valid Responses	0%	30%	11%	6%	9%	4%	60%
Cumulative Responses	0	3,000	4,100	4,700	5,600	6,000	6,000

Source: A.J. Richardson, E.S. Ampt, and A.H. Meyburg, *Non-Response Issues in Household Travel Surveys*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995).

household mail survey. The top of the table shows the costs of a non-follow-up survey design which yields a total of 6,000 returns. The bottom half of the table shows the costs for the survey design the authors recommend that also yields 6,000 returns. The survey with the extensive follow-up is estimated to actually cost less. The survey with follow-up also has a higher response rate, perhaps reducing the amount of bias.

Survey Follow-Up for Telephone and Telephone-Mail-Telephone Surveys

For telephone and in-home surveys, overall non-response occurs because of the surveyors inability to contact potential respondents, or because potential respondents refuse to participate in the survey. Therefore, non-response-reducing strategies have been designed primarily for the recruitment stage of the survey, rather than for the retrieval follow-up stage.

While item non-response is as much or more of a problem with interview surveys as it is for mailback surveys, for the most part it is dealt with during the actual interview. If a respondent is unable or unwilling to answer a specific question, an interviewer probes for an answer or further explains the question. Follow-up contacts are not likely to improve the quality of the responses that the initial interviewer is able to get. This is particularly true if the interviewer is well-trained and the CAPI or CATI software is designed well to trap inconsistencies, illogical answers, and errors.

Still, it is relatively easy and common to recontact respondents by telephone to correct problems discovered after the interview. Since the respondent has already invested a great deal of his or her time into the interview, clarifying a few questions is generally not a problem. On the other hand, respondents are likely to get tired of re-answering questions so follow-up contacts need to be short. If a response has so many questions or problems that it would require more than a few follow-up questions, the surveyor should probably classify the response as unusable.

Survey Follow-up Considerations for Diary Surveys

Travel and activity diaries usually ask respondents to record their travel or activities over a pre-specified period. If a respondent fails to complete the diary during that period or immediately following the period, she or he is more likely to forget about certain travel or travel details. Consequently, in follow-up contracts, most survey teams ask respondents to consider a different upcoming day (or days) when completing the diary. While this method is probably preferable to asking respondents to remember travel and activities a day or a week or even more in the past, it is still not optimal. In expanding the data, the survey team may need to consider the differences in travel conditions between the desired and actual diary periods.

In addition, when reassigning diary periods for respondents, the survey team should consider potential inconsistencies between the original and new periods. For instance, if schools are in session during the original diary period, they should also be in session on the new date. Usually, the follow-up contact asks respondents to use the same day or days of the week as the original period as soon as possible after the original period.

The Use of Survey Follow-Up to Measure and Correct for Non-response Bias

The primary goal of using survey follow-up techniques in household travel/activity surveys is to reduce the level of non-response in the survey effort. Another possible advantage of conducting the follow-up is that it provides the survey team with a means to infer the characteristics of non-respondents and perhaps to even make corrections. Methods for performing these procedures are discussed in Section 6.12.

Incentives for Survey Methods

Surveyors often provide respondents with incentives of one type or another to motivate them to participate in their survey efforts. The most common incentives that are employed are:

- **Prepaid Cash** – some denomination sent to the potential respondents with the survey materials;
- **Promised Cash** – an offer in which a specified amount of money would be provided upon completion of the survey;
- **Provided Gifts** – a gift, such as a pen, key ring, or refrigerator magnet, enclosed with the survey materials;
- **Promised Gifts** – an offer to provide the potential respondent with a specified gift upon completion of the survey;
- **Lottery** – the inclusion of the potential respondent in a lottery drawing;
- **Study Results** – respondent is promised survey results upon completion of the study;
- **Charitable Contribution** – prepaid or promised donation of a specified dollar amount to a charity in the name of the potential respondent.

Travel survey specialists, like their general marketing research colleagues, have mixed views on the cost-effectiveness of incentives. Their usefulness is probably related to the population of the region under study, so broad generalizations about their effectiveness are difficult to make. However, it is apparent that incentives do improve response rates and speeds in many cases. The remaining question for the survey designer is whether the benefits of incentives outweigh the investment in providing them and the potential biases that they may cause.

Based on the recent literature, the prepaid cash incentive is the most consistent incentive method for improving response rates. It is also considered the least biasing of available incentives as well as easiest to use. This conclusion is supported by evidence from household travel/activity surveys, such as the Puget Sound Transportation Panel Survey. In this effort, three incentive approaches were used; 1) no incentive, 2) $1.00 per household member prepaid, and 3) $10.00 per household promised incentive. The two groups that received incentives each had diary rates of slightly more than 60 percent, compared to a return rate of 49 percent for the group not receiving the incentive.[22] [23] [24] [25]

Experience with monetary incentives has revealed that incentives need not be substantial. The incentive should be a small token of appreciation for the respondents' efforts. Ideally, it should build rapport between surveyors and respondents, and it should motivate respondents to try to please the survey sponsors. Larger incentives, especially in the promised form, take on the feeling of payment for one's time, and for complex household travel/activity surveys, even relatively high payments are not likely to be adequate compensation for many respondents.

Despite the advantages of the prepaid monetary incentive, there are conditions when another incentive type is more reasonable. Agencies may be able to provide other types of incentives more cost-effectively, or may have reasons for not wanting to provide the pre-paid incentive. Sometimes agencies can obtain suitable gifts, such as pens, maps, or refrigerator magnets, at no cost or reduced cost. Gift incentives would probably be more cost-effective in these cases. A recent household activity survey in the Boston region (an area with a high rate of state lottery participation) offered vouchers for a $1.00 state lottery ticket, in part because it did not require the agency sponsoring the survey to send cash incentives to people at a time of state government cutbacks.

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[22] David H. Furse and David W. Stewart. *Monetary Incentives Versus Promised Contribution to Charity: New Evidence on Mail Survey Response.* Journal of Marketing Research, Volume XIX (August 1982): p. 375.

[23] A.H. Church. *Estimating the Effect of Incentives on Mail Survey Response Rates: A Meta Analysis.* Public Opinion Quarterly, Volume 57 (Spring 1993): pp. 62-79.

[24] Ananda M. Gajraj, A.J. Faria, and John R. Dickinson. *A comparison of the effect of promised and provided lotteries, monetary and gift incentives on mail survey response rate, speed and cost.* Journal of the Market Research Society. Volume 32, No. 1: pp. 150-151.

[25] Melissa Tooley. *Incentives and Rate of Return for Travel Surveys,* presented at 5th Conference on Transportation Planning Applications, Seattle, April 1995.

Although incentives of all types are used to increase survey response, evidence suggests that incentives do not have the same appeal for all respondents. Biases can be created when incentives are used. No known studies relate incentive conditions to survey measures of respondent travel, but incentives are known to have different appeals based on the respondent's sex, marital status, employment status, property ownership, and religion.[26] Therefore it is reasonable to assume that trip generation estimates could be affected by the use of incentives, as well. Some travel survey experts do not recommend the use of incentives because they feel the risk of bias outweighs the potential improvement in response.

Response Facilitators

Although the use of incentives is the most well-known mechanism for increasing survey response, it is likely that other survey considerations will have as large or larger effects on survey response and quality. Based on their experiences and intuitions, survey researchers have developed a number of survey response facilitators that they believe increase the likelihood of survey participation. It is not clear how much these facilitators affect response rates, because researchers have difficulty isolating them from other aspects of the survey. However, most survey designers stand by one or more of them.

During the survey design, the household survey team should decide which facilitators are most likely to be important for their survey population, and they should estimate the costs of providing them.

As Dillman points out:[27]

> Non-response is a serious problem under any circumstances. Thus each element that might help prevent it – no matter how trivial – is worthy of design considerations.

Response facilitators include the following:

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[26]David H. Furse and David W. Stewart. *Monetary Incentives Versus Promised Contribution to Charity: New Evidence on Mail Survey Response.* Journal of Marketing Research, Volume XIX (August 1982): p. 363.

[27]Dan Dillman, *Mail and Telephone Surveys: The Total Design Method,* John Wiley & Sons, New York, 1978, p. 161.

Mail Survey Response Facilitators

- Include a cover letter signed by a high-ranking and popular elected official.
- Personalize the survey materials for each respondent, where possible.
- Use postage stamps on any packages sent to respondents, rather than prepaid or machine stamped mailings, so the mailing stands out from direct mail.
- Send materials in distinctive envelopes.
- Provide a toll-free telephone number for respondents to call in case they have questions or complaints.
- Have the return address(es) be within the region under study.
- Have the return address(es) be for the agency or another public organization, rather than for a private firm.
- Provide the respondent with a deadline for replying to the survey.
- Provide brief reassurances of anonymity on the survey materials.
- Provide descriptions on the survey materials of the importance of the survey and of the specific respondent's role in the survey.

Telephone Survey Response Facilitators

- Make sure interviewers have local accents or are relatively accent-free.
- Provide reassurances of anonymity at the beginning of the call.
- Provide descriptions of the importance of the survey and of the specific respondent's role in the survey.
- Provide a toll-free telephone number for respondents to call in case they have questions or complaints.

In-Person Survey Response Facilitators

- Select interviewers that are of the same age groups, races, ethnic backgrounds, and social classes of potential respondents.
- Provide reassurances of anonymity at the beginning of the interview.
- Provide descriptions of the importance of the survey and of the specific respondent's role in the survey.

- Provide a toll-free telephone number for respondents to call in case they have questions or complaints.

These mechanisms are all likely to help improve response rates marginally, but the survey team needs to consider the facilitators as a package. Simply selecting a few facilitators to improve response will not be as effective as developing an integrated strategy, using pre-notification, follow-up, incentives and facilitators that work well together and complement one another.

Output of the Survey Design Task

By the time the survey team completes the survey design task, they will have analyzed the output data needs from the household travel/activity survey, and made decisions about the survey method, data collection techniques, and the inclusion of different design elements to improve the quality of the survey results. The survey team will have a clear idea of the approach (or approaches) that will need to be pretested.

The survey design task outputs will feed directly into the sampling, survey organization, and survey materials development tasks, but, in reality, the survey design task will guide all the work conducted on the rest of the tasks.

It can be helpful at this state of the survey implementation process to prepare a detailed plan for the household travel/activity survey. The survey team will be in a position to define detailed survey procedures and to layout more accurate schedules and budgets. The detailed survey plan is a useful document for involving outside agencies and/or technical advisory committees in the development of the household travel/activity survey. In addition, the plan organizes the survey team's tasks, and can be an effective tool for allocating responsibilities.

By the time the survey design task is winding down, it is likely that the survey team will already have gotten underway on the organization and sampling tasks, which are discussed next.

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6.4 Organizing the Household Travel/Activity Survey

■ Key Issues in Organizing the Household Travel/Activity Survey

1. What are the staffing needs (numbers of people, required skills) of the household travel/activity survey?
2. How should contractors be selected and used in the survey effort?
3. How should the survey be coordinated with other transportation planning activities and other agencies' ongoing work?
4. What citizens' participation and advance publicity efforts should be undertaken?

■ Section Summary

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■ 6.4 Organizing the Household Travel/Activity Survey

Closely related to the design of the survey is the need to organize and manage the effort. The section summary page shows the key issues associated with the organization of the household travel/activity survey. The four issues are described in this section.

Management of the Survey Effort

The management structure of travel survey development efforts is discussed briefly in Section 4.3 of this manual. For household travel and activity surveys, the survey team managers must provide:

- Overall management and leadership of the effort;
- Day-to-day management of survey fieldwork; and
- Continuing assessment of the effects of different decisions on the final analyses to be performed with the survey data.

In almost all cases, the overall leadership role is provided by the sponsoring agency's project manager. Increasingly, the day-to-day management of survey fieldwork is being left to survey subcontractors who are able to provide trained fieldwork staff and specialized facilities. The final management function is often provided by a combination of in-house staff and travel demand consultants.

The use of a peer review panel, as described in Section 4.3, is highly recommended for household travel and activity surveys. If nothing else, these panels provide an extra set of eyes to catch problems before they happen, and they are likely to provide much more, including expertise and experience with most of the challenging issues facing an agency.

Staffing Needs for the Household Travel/Activity Survey

In the early stages of the survey design process, the survey team should scope out the most likely approach to the household survey, and then make a preliminary estimate of the labor and skill requirements of the study. When staff members' pre-existing schedules are considered, almost all agencies that perform household surveys find the need to temporarily increase staffing. This is generally done in one of two ways:

- By bringing relatively low level temporary professionals or students on to the agency staff for key points of the survey; and/or

- Hiring survey research contractors and other consultants to provide specialty services that agency staff members would have to learn to do.

Hiring Temporary Professionals for a Household Travel/Activity Survey

In most regions, temporary agencies can provide the necessary additional office support people for the survey effort. In addition, many regions have one or more universities whose students could be recruited for temporary work.

These sources may also be able to supply survey fieldworkers for conducting telephone and in-home interviews. However, these people will need to be carefully screened, trained, and briefed on survey interview techniques prior to conducting any interviews. This means that the temporary employee fieldworkers will need to be lined up well in advance of the survey effort, probably three to four months at a minimum.

Once the temporary staff have been hired, it is essential that they receive as much on-the-job-training as possible. Household travel/activity survey workers' strengths and weaknesses should be well-understood by survey managers prior to the beginning of the survey effort.

Hiring Survey Contractors for a Household Travel/Activity Survey

An easier but sometimes more costly approach to organizing the work force for a household survey is to hire a consultant to perform the survey. Usually, the consultant would be a survey research firm, or a team including such a firm. It may also be advantageous to include a transportation modeling consultant as part of the consultant team, or to have such a consultant available to the agency through a separate contract.

In most cases, the sponsoring agency will not have access to great numbers of trained fieldworkers or to special facilities for centralized telephone interviewing. Survey research firms usually have trained interviewers on their staffs and may maintain telephone interviewing facilities that provide toll-free calling throughout the survey area, CATI capability, and the opportunity for monitoring (either by in-house supervisors or from outside phones that can be used by agency personnel). Because of the need for high quality data for travel modeling purposes and for high response rates to minimize costs, it can be highly efficient to use a survey research firm.

Survey designers can identify potential survey research firms through directories maintained by a number of organizations.[28] Two such directories are:

- *GreenBook International Directory of Marketing Research Companies and Services.* (American Marketing Association/New York Chapter, Inc., New York, NY). Annual. A listing of market research companies arranged alphabetically, with brief paragraphs that describe the companies' services. Additional sections list the companies by type of service offered, by market/industry specialty, by computer programs used, by company trademarks/service marks, by geographical area, and by principal personnel.

- *MRA Blue Book Research Services Directory.* (Marketing Research Association, Inc., Rocky Hill, CT). Annual. More limited in scope than the GreenBook, this guide focuses on services and facilities of data collection companies, research companies and suppliers of related services (data processing, questionnaire coding, field management, etc.) who are members of MRA. Company listings are alphabetical within each geographic area, cross-referenced by the type of service or facility available.

These directories are usually available at business school libraries. In addition, the survey designer can contact other planning agencies that have recently completed similar household travel/activity survey efforts for lists of potential contractors.

The survey sponsoring agency should consider the following factors in selecting a survey research contractor:

- Marketing research experience and qualifications of key staff members;

- Transportation research experience and qualifications of key staff members;

- Household travel survey experience and qualifications of key staff members;

- Range of services offered, including capabilities in research design, sampling statistics, data collection, and statistical analysis;

- Size and quality of interview and other fieldwork staff;

- Interviewer experience levels and pay;

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[28] These and other sources are described by Jane Lappin, Paula Figoni, and Suzanne Sloan in *A Primer on Consumer Marketing Research: Procedures, Methods and Tools* (March 1994).

- Interviewer training standards;
- Available facilities, including telephone survey centers and mail processing centers;
- Use of in-house facilities versus contract interviewing facilities (many survey firms contract to other firms to perform telephone and/or in-person interviews);
- CATI and CAPI capabilities and equipment;
- Foreign language interviewing capabilities;
- Coding, editing, and geocoding procedures and capabilities; and
- Quality control procedures and client communications procedures.

Consulting firms with expertise in travel modeling can also provide valuable insights in the survey development process. Such consultants are able to provide an understanding of the data needs and problems associated with model development. In many cases, a consulting team with both market research and transportation firms will be hired to conduct a household survey. In others, an agency may have transportation modeling consultants available through separate arrangements. Some agencies may have sufficient transportation modeling expertise in-house, but unless they have very experienced modelers, there is no way to guarantee that the survey will be appropriate for use in developing model datasets. This has been a substantial problem in several recent surveys.

There are advantages to using qualified local consultants if they exist in the survey area. Surveyors who know the local geography will make fewer errors in recording and spelling local place names. Survey times can be shorter if location information is known to the interviewer, and respondents would be less likely to be exasperated by having to give what to them is obvious information about well known locations. In some cases, respondents may feel more comfortable speaking to interviewers with local accents and knowledge.

The main problem with using local firms is that in many areas, especially small and mid-size areas, there are few if any local firms with sufficient transportation survey knowledge and experience. If a non-local firm is performing the survey, the question then becomes how to provide the necessary local knowledge. In some cases this local knowledge can be provided by agency personnel; in others, it may have to be provided through other consultants. There have been many recent successful survey efforts conducted by non-local firms.

Survey teams have hired survey subcontractors at several different point in the household travel/activity survey implementation process. Sometimes, the contractors are brought into the process early in the survey design phase, so that the survey team can benefit from the market research experience of the survey contractor's key staff during the evaluation and selection of the survey method, survey techniques, and quality-enhancing procedures. Other times, when the survey sponsor is comfortable with making the design decisions alone, or with the help of independent consultants, the survey subcontracting firm is not brought into the project until the final phases of questionnaire design, just before pretesting.

In either case, it is important that the sponsoring agency recognize the need to carefully delineate the responsibilities of any contractors in the Request for Proposal (RFP) and in the services contract. In preparing the RFP, agency staff should remember that any responsibilities and tasks not explicitly assigned to the contractor will most likely need to be completed by themselves. Therefore, spending extra effort on the RFP is usually worthwhile.

Because RFPs need to be tailored to individual conditions, little specific guidance can be offered on their development. In general, in developing RFPs it is helpful to review recent similar RFPs from other agencies. A list of agencies recently completing household travel/activity surveys is available in the forthcoming "FHWA Scan of Recent Travel Surveys." The scopes-of-work from recent household travel/activity survey RFPs are shown in Appendix D of this manual.

Because of the nature of survey work, survey firms are not accustomed to establishing a final fixed contract price for a pre-selected number of "complete" households. Estimating contact rates, response rates, interview times, and even the number of surveys needed for specific analyses are usually very difficult prior to the completion of a high-quality pretest. Setting a fixed price prior to that point, while beneficial from a resources planning perspective and an agency procurement perspective, can lead to problems later in the survey. For instance, pretests tend to become pro-forma tasks, rather than opportunities for careful review of procedures and for trying innovative procedures, because if the survey cost is fixed, there is no incentive to look very hard for potential problems.

To avoid these potential problems, it is recommended that agencies consider one or more of the following approaches:

- Select survey contractors primarily on the basis of qualifications and experience, rather than cost.

- Provide detailed surveying parameters with which contractor prices can be compared – if detailed assumptions are not provided in the RFP, proposers may offer cost proposals that are not directly comparable.

Agency Coordination

The need for coordinating travel survey and demand modeling efforts with other local agencies is described in Chapter 4.0. Because the household survey is likely to be the most important survey effort performed in a region, and because household surveys are not (or at least have not been) done on a regular basis, it is essential that agencies work cooperatively on the design and implementation issues.

As soon as possible in the household travel/activity survey development process, the sponsoring agency should contact:

- All affected state agencies;
- Local and regional planning officials;
- Local and regional elected officials;
- Local and state police;
- Federal agencies that may be involved;
- Local transit providers;
- Active public interest groups; and
- Chambers of commerce/business groups (for workplace/establishment surveys).

These agencies should be briefed on the survey plans, and should be provided with the Statement of Goals for the survey. Representatives of these agencies should be invited to participate in the survey development process, and to identify ways in which the survey data could help their organizations' planning efforts. Many household travel/activity surveys can be easily adapted to provide useful data to many different agencies. However, it is essential that potential data coordination activities be identified early in the survey design effort to minimize the disruption and amount of necessary re-design.

Advance Publicity

The survey designer needs to decide whether and how to publicize the household survey. Generally, telephone-based survey methods are helped by advance publicity. Potential respondents are more likely to believe that a telephone interviewer is legitimate if they have heard that the study would be going on. In addition, respondents are likely to attach a higher level of importance to a survey effort that has been publicized, and therefore consider participating to be more important. A few recent telephone-mail-telephone household survey efforts ran into some criticism in part because the efforts were not well-publicized before they began.

If, for some reason, a survey team is using an in-home interview survey method, they may not want to consider publicizing the effort. The 1973 Travel Survey Manual counsels:[29]

> "Especially in large urban areas where there is the problem of individuals posing as interviewers to gain entrance into households for other purposes, it is often best not to notify the public at large."

In fact, the potential for this type of abuse is one good reason to avoid in-home methods.

Despite the fact that there are documented reports of thieves posing as household travel/activity survey telephone and in-person interviewers, most agencies sponsoring recent household travel/activity surveys have chosen to use some advance publicity. If advance publicity is determined to be necessary or appropriate, the following efforts could be included:

- An agency press conference explaining how the survey data will be used to improve regional planning or an agency's planning efforts;
- Press releases for each major survey design milestone;
- Informational meetings with local citizens' groups and public service organizations, such as the Lions' Club or the Rotary;
- A project specific newsletter or prominent display within an agency's regular newsletter; and
- An informational telephone number that respondents can call to contact the agency if they have questions about the survey effort or are concerned about the veracity of the survey effort.

[29]U.S. Department of Transportation, Federal Highway Administration, *Urban Origin-Destination Surveys*, Washington, D.C., 1973 (reprinted 1975), p. 26.

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6.5 Sampling for Household Travel and Activity Surveys

■ Key Issues

1. What variables are of the greatest interest in designing future analyses?
2. How are the study population, sampling frame, and sampling unit defined?
3. Which sampling method should be used to meet the precision requirements?
4. What sample size is required to satisfy these precision requirements?

■ Section Summary

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■ 6.5 Sampling for Household Travel and Activity Surveys

The statistical computations needed to determine sample sizes for travel surveys are described in Chapter 5.0. For household travel surveys used to develop travel demand models such as those maintained by metropolitan planning organizations, the study population is usually known. The sampling unit is the household, and the sampling frame a list of households by telephone number or address.

Urban travel demand model systems include a number of components to be estimated for which the survey data are needed. These include:

- Trip generation;
- Trip distribution; and
- Mode choice.

The variables of interest are different for each of theses models. The sampling requirements for each are discussed below.

Trip Generation

The main variable of interest for trip generation models is the number of trips generated by households for each trip purpose. The household variables generally used in trip production models include number of persons, income, auto ownership, number of workers (for work trips), and number of students (for school trips). Most variables of this type have distributions that can be obtained from census data, providing a good basis for computing sample size requirements. The census, however, provides no information on the number of trips generated (and no information at all on non-work trips).

If information on the mean and variance (or coefficient of variation) of the number of trips generated per household were available from another source – say a previous survey – the required sample size could be computed from Equation 5.7:

$$n' = \frac{\sigma^2}{(SE(m))^2}$$

where:

σ = represents the standard deviation of the population; and

SE(m) = the standard error for the mean for a given confidence level and precision level.

Smith used values from some older (1960s) household surveys to determine the coefficient of variation and computed a typical sample size requirement of about 900-1,200 households at the 90 percent confidence level and a precision level of +/-5 percent.[30] The higher number resulted from an assumed cross-classification in the trip production model by income and auto ownership.

This analysis, however, did not take into consideration different trip purposes; ideally one would compute the required sample size for each purpose in the model and use the largest. With smaller means for the number of trips by purpose, the standard error may be smaller, resulting in larger required sample sizes.

In planning for the 1990 Bay Area household survey effort, the MTC estimated necessary sample sizes by trip purpose using data from their 1981 survey effort. Table 6.9 shows the conversion of trip rate information into sample size estimates for this effort.

Some recent household survey efforts intended for use in developing trip production models have used smaller sample sizes of around 500 households, including surveys in the Portland, Maine and Pittsburgh areas. While information on statistical levels of accuracy and precision have not been reported, it can be assumed that lower levels of one or both were found to be acceptable in these areas.

It is common practice to use a stratified sampling plan for collection of trip generation data. Since trip production models are often cross-classification models, the survey sample can be stratified according to variables in the model such as those described above. Information on existing distributions of the variables is usually available from census data, so required sample sizes can be computed. This is a good strategy for ensuring sufficient sampling of relatively small but important markets such as households without autos.

The main difficulty with such a procedure is that it is impossible to tell which stratum a household is part of until it is recruited. This can be addressed by collecting a larger sample than necessary to account for the expected number of responses in the critical cell or by screening households prior to having them complete the entire survey – basically creating cell quotas.

[30] M. E. Smith, "Design of Small-Sample Household-Interview Travel Surveys." Transportation Research Board. Transportation Research Record 701, 1979, pp. 29-35.

Table 6.9 Calculation of Necessary Sample Sizes from Previous Trip Rate Information

Trip Purpose	1981 Mean Trip Rate	Standard Deviation	Coefficient of Variation	Sample Size (95% Confidence, ± 5%
Total Trips	8.713	7.399	0.849	1,108
Vehicle Trips	5.231	5.009	0.958	1,409
Transit Trips	0.558	1.409	2.525	9,798
HBW	1.890	1.883	0.996	1,525
HBSH	2.274	2.778	1.222	2,293
HBSR	1.262	2.034	1.612	3,992
HBSK	0.952	1.883	1.978	6,012
NHB	2.335	3.351	1.435	3,165

Source: C.L. Purvis, Sample Design for the 1990 Bay Area Household Travel Survey: Working Paper #1 – 1990 MTC Travel Survey, April 1989.

Trip Distribution

It is now generally recognized that household travel surveys are not appropriate means of generating acceptable estimates of zone-to-zone trips.[31] While household surveys taken in the 1960s were generally used for this purpose, they usually had much larger sample sizes, and models had fewer zones. Presently, travel demand modelers use household survey data to estimate parameters of trip distribution models rather than attempt to develop zone-to-zone trip tables directly from the survey data.

Most trip distribution models in U.S. urban areas are gravity models based on travel times. Some areas use generalized cost instead of travel time, but generally gravity models are based on one variable. With that in mind, the variable of interest is the trip length frequency distribution. Again, Equation 5.7 can be used to estimate the required sample size if the coefficient of variation and mean are known. Pearson reported in 1974 coefficients of variation of 0.53 for home-based work trips, 0.58 for home-based non-work trips, and 0.63 for non-home-based trips.[32] Using these numbers, samples sizes of about 600-700 trips per purpose would be required at the 90 percent confidence level for the +/-5 percent error level. Since households make several trips per day on average, only a few hundred households would be required to obtain a statistically significant estimate of the mean trip length. Even if travel time estimates are desired for different times of day, as long as there are not a large number of different time periods (most models use one or two, some three or four), there should be enough trips to estimate travel time distributions.

The above discussion leads to the conclusion that any survey which is sufficient for the development of trip generation models is likely also sufficient for the estimation of gravity model parameters.

Some agencies have been developing destination choice (or more accurately attraction choice) models for the purposes of estimating trip tables. These are generally logit models which are similar in function, and often variables, to gravity models. If travel time is the only parameter of these models, then the same analysis as described above for gravity models holds. However, if other variables are used in the model, the problem becomes similar to that of mode choice models, as discussed below.

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[31] M. E. Smith, "Design of Small-Sample Household-Interview Travel Surveys." Transportation Research Board. Transportation Research Record 701, 1979, pp. 29-35.

[32] D.F. Pearson et al. *A Procedure for Estimation of Trip Length Frequency Distributions. Texas Transportation Institute Report No. TTI-2-10-74-17-1, prepared for the Federal Highway Administration, April 1974.*

Mode Choice

In most urban areas, the use of household travel surveys for the estimation of mode choice models is problematic for the following reasons:

- In many areas, there are simply too few transit trips to get an accurate estimate of the distribution of important variables among transit users.
- Unless households are recruited at transit stops or on transit vehicles, it is difficult to determine in advance whether or not there are transit trips made by the household. Therefore, a stratified sampling approach with respect to mode would be difficult to implement.
- It is unlikely to have information about the means, standard deviations, or coefficients of variation of most of the variables in mode choice models unless another survey had collected them. These variables include fares, parking and other auto-related costs, and wait and access times. In addition, data on other variables such as demographic or area type measures are unlikely to be available weighted by trip (as opposed to by household).
- The logit model formulation does not lend itself to simple derivation of statistical computation of sample size.

Given these problems, it is rare that a household travel survey sample size would be based on mode choice model requirements. However, in some large cities where mode choice models can be developed from survey data, it is likely that the sample size would have to be much larger than what would be required for trip generation.

It is possible to develop simple estimates of the required sample size to get a statistically significant sample of users for each mode using Equation 5.7. This is done using the sample variance s^2 in the equation based on the estimated mode share. For work trips, this is generally available from census data; for non-work trips, a conservative (high) estimate of transit (or other rarely used mode) share can be used to develop a conservative estimate of the sample size requirement. Of course, if there are a large number of modes to be examined, the computation must be repeated for each one.

Stratification of the sample can be an efficient means of increasing the accuracy of the survey data for mode choice purposes. Obviously, if one could identify transit users before recruitment, better information about critical variables for transit users could be obtained. Even though this pre-selection would be very difficult, it is possible to target specific markets that are easier to define. For example, in Portland, Oregon[33] the household

[33]NuStats, Inc. "Sample Productivity Plan," Technical Memorandum, 1994.

survey was stratified to include areas near transit lines and with favorable land use characteristics for non-auto modes. Such geographic stratification is not difficult to determine using readily available data such as census data for planners familiar with transportation in the local area. In addition, the Portland survey employed choice-based sampling for one stratum, recruiting park-and-ride users at parking lots.

6.6 Drafting and Constructing Household Travel/Activity Surveys

1. What data elements are needed from the Household Travel/Activity Survey and what limitations are there in obtaining the data?
2. What survey instruments are needed for the survey? How should they be designed?
3. How can the required data elements be developed into questions and response categories?

■ Section Summary

6.6 Drafting and Constructing Household Travel/Activity Surveys (continued)

■ 6.6 Drafting and Constructing Household Travel/Activity Surveys

The household survey is probably the best travel survey for obtaining the most detailed data on respondents and their travel patterns. As discussed in Chapter 3.0, the household survey can include almost any type of survey question. In addition, the survey may include either interviews or self-administered questionnaires, or both. Household survey interviews can either be computer-assisted or manual.

The key issues related to drafting household survey questions and constructing the survey instruments for a household travel/activity survey are listed on the section summary page. The first challenge for the survey team is to determine what data elements are needed from the household travel/activity survey. This determination must be based on the anticipated analyses and the survey goals, but the data elements of other recent household travel/activity surveys will help the survey team narrow its selection. Once the data elements are identified, they need to be developed into survey questions and response categories. At the same time, the survey team needs to identify the different survey instruments and materials that will be needed for the survey effort. The final product of this task will be the survey materials, which will be a combination of the products of the three steps.

The three key steps of drafting and constructing household travel/activity surveys are described below.

Data Elements For Household Travel/Activity Surveys

In most household survey designs, the survey team is in the position to obtain information on a great number of relevant topics. The analysis and travel demand modeling plans for the survey results and the survey's overall goals will dictate what specific data elements need to be included, which data elements should be included, and which data elements could be included, if possible.

Unfortunately, in general, the surveyor does not have the luxury of including as many data items as possible in a household travel/activity survey because the length of the survey will affect the quality of responses and the level of non-response. The tradeoff between survey length and response quality is discussed below in the section describing the development of survey questions, but because it is almost always true that users of survey data would like more questions than can be asked, the survey team needs to determine the data elements of the most interest for the survey effort, and prioritize their inclusion in the final surveys.

The remainder of this data elements section describes the most common information sought in household travel/activity surveys. Each survey team will have different data needs from their surveys, but most household travel/activity survey efforts have common concerns. Therefore, reviewing data elements that are frequently collected is a productive exercise.

Two recent research papers provide excellent taxonomies of the recent content of household travel/activity surveys. Axhausen provides a detailed catalog of many recent household travel/activity surveys, including many examples of North American, European, and Australian surveys.[34] Stecher, Bricka, and Goldenberg provide a breakdown of household survey data categories and elements from recent North American efforts.[35]

Applying these taxonomies, household travel and activity survey data elements can be categorized into the following five categories:

- **Household Data** – Information on the characteristics of the household and on the actual physical property in which the household resides.
- **Person Data** – Demographic, socioeconomic, and employment information for one or more members of the household.
- **Vehicle Data** – Information on the type, ownership, and usage of private vehicles available to household members.
- **Travel and Activity Data** – Diary or recall information about the travel and activities of one or more household members.
- **Attitudinal, Opinion, Knowledge and Stated Preference Data** – Information from respondents that provide surveyors and modelers with the respondents' views, tastes, and concerns.

Household Data Elements

Table 6.10 lists common household data items for household travel/activity surveys. These data elements are used to classify respondent households as independent variables in travel demand models, and to compare the sampled households with actual study area households for

[34]K.W. Axhausen, *Travel Diaries: An Annotated Catalogue*, University of London Centre for Transport Studies Working Paper, November 1994.

[35]Cheryl C. Stecher, Stacey Bricka, and Leslie Goldenberg, *Travel Behavior Survey Data Collection Instruments*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995).

Table 6.10 Household Travel/Activity Survey Household Data Elements

Data Elements	Information Typically Obtained
Number of people living in the household	Actual number of people.
Number of full-time, part-time workers, students, and small children in household	Actual numbers of people, or assemble data from person-based questions (see below)
Household income	Income categories based on Census definitions or the agency's standard categories.
Language(s) spoken in the household	Aggregation of Census categories.
Number of vehicles available to the household	Actual numbers of vehicles available (see vehicle questions below).
Location of the residence	Street address, as accurately as needed for anticipated geographic analyses.
Type of dwelling unit.	U.S. Census categories or surveying agency's land-use categories.
Own or rent status.	Dummy variable (check one).
Size of the dwelling unit.	Square footage (used in lieu of, or in addition to, income questions, particularly in Europe).
Time at the residence.	Number of years; number of months if less than a year.
Location of previous residence.	Street address or neighborhood.
Number of telephone lines in the household, and the number shared with other households.	Actual numbers; data element is used primarily for sample expansion.
Number of computers, fax machines, modems, etc.	Actual numbers; data elements are used for sample expansion and are sometimes used for analyzing telecommuting issues.
Number of visitors staying at household during the travel or activity diary period.	Actual number of people.
Seasonal usage of the dwelling unit.	Months of the year that the respondent lives at the sampled dwelling unit.

Sources: Cheryl C. Stecher, Stacey Bricka, and Leslie Goldenberg, *Travel Behavior Survey Data Collection Instruments*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995). and K.W. Axhausen, *Travel Diaries: An Annotated Catalogue* Working Paper of the University of London Centre for Transport Studies (November 1994).

which Census data are available. Three household data items are particularly important for most travel survey efforts: household size, household location, and household income.

The number of people in the household is a key consideration in estimating household level trip generation rates. The primary challenge for the household travel/activity survey with regard to this data element is to define to the respondent what is meant by the term household. In general, travel survey teams define a household as the total group of people who usually reside at the sample address, regardless of whether they are related to each other. Travel survey teams need to consider how they will account for college students and others whose legal address is at the sample household, but who live elsewhere. In addition, the travel survey team must decide how to handle visitors to sample households, particularly for survey efforts with travel or activity diaries.

The geographic location of the household is usually an essential data element. Any survey effort that will rely on geographic analyses of some type needs to accurately and precisely define the household location. If the location cannot be coded in sufficient detail, the data record usually cannot be used. Hence, the travel survey team needs to determine the level of geographic detail necessary for future analyses (are neighborhood definitions sufficient? are exact addresses needed, or can nearest intersections and landmarks be used?). In addition, if interview methods are employed, the travel survey team should determine ways to test the sufficiency of the geographic data as soon as it is collected, and before continuing on with other parts of the survey. If the collected data are unusable, then the interviewer can attempt to clarify the response.

Household income information is commonly used in travel demand models and other survey-related analyses, but the collection of household income data is among the more challenging aspects of household travel/activity survey instrument design. Household income questions almost always have significant levels of item non-response and refusals. In addition, many travel surveyors have questioned the validity of the self-reported income information, based on comparisons with Census income data and other sources.

The question design issues for this data element are discussed below, but a more basic decision related to household income is how the survey data, which is likely to have problems even with the best designs, may be used for analyses. The non-response workshop of the recent TRB Household Travel Survey Conference recommended that travel modelers recognize the inherent limitations of this data element, and that, at a minimum, they consider combining response categories into a few large categories in an attempt to improve the data reliability.

Person Data Elements

Common person-based data elements are shown in Table 6.11. The person-based data elements for household travel/activity surveys are often used as explanatory variables in trip distribution and mode choice models. In addition, these data are commonly used to compare the survey respondents to the U.S. Census population for the study area. The data items for person-based data are generally straightforward, and often include questions about jobs and workplaces.

Vehicle Data Elements

The recent focus on the interaction between travel demand models and air quality models has led a number of travel surveyors to ask for detailed vehicle information in household travel/activity surveys. It remains to be seen which of the very detailed data elements will prove to have significance in travel demand models, so recent surveys have sought many different elements. Table 6.12 shows some of the data elements that have recently been sought. Because a number of the listed data elements require respondents to record information from the vehicles, not all of the data elements are appropriate for all survey methods. For instance, a simple telephone survey could not be used to obtain these data elements.

It is often a challenge to define for respondents the vehicles of interest for the survey. In general, survey teams are interested only in vehicles that are registered and operable. The survey team needs to determine whether only vehicles kept by household members should be reported, or whether all vehicles that respondents could use should be reported. Since informal car-sharing and borrowing are common in the U.S., it is important that survey teams define before the survey effort what they will need for their analyses.

Often, vehicle availability data are used in conjunction with U.S. Census data to expand the survey sample. If this is the case, it is imperative that the survey question be consistent with the Census vehicle availability question:

> "How many automobiles, vans, and trucks of one-ton capacity or less are kept at home for use by your household?"

An easier, but usually more costly approach to organizing the workforce for travel surveys is to hire a consultant to conduct the survey. Consulting firms who may be qualified to conduct travel surveys include transportation consultants, survey research firms, and engineering firms. Often a team combining two or more of these types of firms will be selected.

Table 6.11 Household Travel/Activity Survey: Person Data Elements

Data Elements	Information Typically Obtained
Sex	Dummy Variable (check one).
Age or year of birth	Actual number or year is usually considered to be preferable to categories with ranges of ages or birth years.
Race, ethnicity, or nationality	Census standardized definitions.
Relationship of the person within the household.	Typically only the relationship to the person completing the survey for the household is queried; relationship to others in the household could also be sought.
Marital status.	dummy variable (check one).
Holds a current driver's license.	dummy variable (check yes or no).
Highest level of education attained	Aggregation of Census standardized definitions.
Employment status	Variations on categories like full-time, part-time, retired, unemployed and looking for work, unemployed and not looking for work, full-time homemaker, and student. Need to be prepared for multiple responses and for combined employment and student status (a full-time student with a part-time job).
Student status	Variations on categories like full-time student, part-time student, not a student.
Paid/unpaid Employment.	dummy variable (check one).
Location of place(s) of employment.	Street address, as accurately as possible without incurring item nonresponse.
Time at the place(s) of employment.	number of years; number of months if less than one year or month and year employment began.
Previous job location.	Street address or neighborhood.
Occupation(s)	Aggregation of U.S. Census categories for each job.
Industry(ies)	Aggregation of S.I.C. industry categories for each job.
Work Load	Hours of work per week.
Work schedule.	Usual start and end times.

Table 6.11 Household Travel/Activity Survey: Person Data Elements (continued)

Data Elements	Information Typically Obtained
Schedule flexibility.	Variation on categories like rigid schedule, formal flextime policy, and informal flextime policy, and core business hours for those with flexibility.
Ability to work at home.	Days per week or month that person works at home.
Shift rotations.	Frequency of shift changes, and start and end times for other shifts.
Usual transportation mode(s) to work.	Complex data element for respondents who use multiple modes, or different modes on different days (see travel questions below).
Employer (or school) provision of parking.	dummy variable (check yes or no).
Employer parking subsidies.	amount per month, if any.
Cost of parking at work or school.	amount per month, excluding subsidies.
Employer transit subsidies.	amount per month, if any.

Sources: Cheryl C. Stecher, Stacey Bricka, and Leslie Goldenberg, *Travel Behavior Survey Data Collection Instruments*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995), and K.W. Axhausen, *Travel Diaries: An Annotated Catalogue* Working Paper of the University of London Centre for Transport Studies (November 1994).

Table 6.12 Household Travel/Activity Survey: Vehicle Data Elements

Data Elements	Information Typically Obtained
Make, model, and year of each vehicle available to household members.	Usually collected in open-ended questions, with interviewer probing, as necessary.
Body type of the vehicle.	Variations on NPTS categories.
Fuel used by the vehicle.	Variations on categories like gasoline, diesel, other.
Vehicle identification number (VIN).	The alphanumeric codes found behind vehicle windshields can be translated to detailed make, model, body type, engine type, etc.
Odometer reading	Actual reading at the beginning and/or end of the travel diary period. Collecting data both at the beginning and end allows surveyor to check completeness of diaries.
Vehicle-miles traveled during the last year	Respondent estimate of level of usage.
Vehicle owner/leaseholder	Specific household members, as well as employer, rental agency, or other.
Primary driver of the vehicle	Specific household members, and possibly non-household members, as well.
Percent usage of vehicle by each household member.	Respondent estimates based on usage over the last week/month/year.

Sources: Cheryl C. Stecher, Stacey Bricka, and Leslie Goldenberg, *Travel Behavior Survey Data Collection Instruments*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995). and K.W. Axhausen, *Travel Diaries: An Annotated Catalogue* Working Paper of the University of London Centre for Transport Studies (November 1994).

Travel and Activity Data Elements

Household travel/activity surveys commonly collect a great deal of highly detailed data on people's activities and trips. Table 6.13 summarizes many of the most common data elements. Usually, these detailed data are collected by means of diaries that either record all respondent trips over a pre-specified time period or record all the activities that respondents engage in over a pre-specified period. It is likely that all activity-based modeling systems will require the use of activity diaries, but conventional travel demand models can utilize either activity diary data or travel diary data. As discussed above, the trend among recent household travel/activity surveys has been toward the use of activity diaries.

If the survey team chooses to use an activity diary to record respondent activities, a fundamental question that needs to be addressed is whether and how to categorize activities. As discussed previously in Section 6.3, the first choice for the survey team is whether to include only activities that are performed outside the home, or to include both in-home and out-of-home activities. Recent household surveys have used both techniques.

The next question for the survey team is how to record people's activities. Because of the wide range of potential responses, the most accurate approach for obtaining the information probably involves the use of open-ended questions, with interviewer probing as necessary. However, this approach increases the burden both on respondents and interviewers. Therefore, survey teams have generally defined activity classification schemes, and have asked respondents to categorize their activities on the basis of those schemes. Table 6.14 shows some of the activity categories that have been recently used in household surveys. More classifications of people's activities are obtainable from the many time-use surveys conducted since the 1970s. These studies tend to have extremely detailed classification schemes (some with more than 100 categories) for how people spend their time.[36]

Because of the large number of activities that people perform in a typical travel diary period, many household activity survey teams have asked respondents to record only activities that last for more than 30 minutes or activities that require travel (regardless of how long the activity takes). This decision rule limits the reportable activities to a manageable number, but may also dilute the usefulness of the time-use data because many activities may not be reported. Certain types of activities – like meals – that often take less than 30 minutes and do not involve travel are likely to be under-reported.

[36]See A. Szalai (ed.) *The Use of Time.* Mouton (The Hague), 1972

Table 6.13 Household Survey: Travel and Activity Data Elements

Data Elements	Information Typically Obtained
Activity or travel purpose	Activity or trip purpose categories of sufficient detail to characterize the trip in the travel demand models.
Start and end time of activities	In an activity-based approach, activity start and end times are recorded. Travel times are derived from the start and end time data.
Arrival and departure times or travel time	In a trip-based approach, trip start and end times are recorded. Activity times are derived from the trip start and end time data.
Name of place where trip started or ended or where activity took place.	Name of location in respondent's words.
Type of place or land-use of trip end or activity place.	Variations on categories like private home, place of business, hotel/motel, other.
Address of trip end or activity place.	Street address or nearest intersection.
Travel group size and make-up.	Number of people traveling together; identification of other household members in travel group.
Travel mode.	Categories designed to exhaust the mode possibilities for the region, plus an "other" category.
Chosen private vehicle for the trip (for those using private auto).	Linked to vehicles described in the vehicle section of the survey.
Private vehicles available for the trip (for private auto users and others).	Linked to vehicles described in the vehicle section of the survey.
Driver or passenger (for those using private auto).	Dummy variables (check one).
Type of parking (for those who use or could use private auto).	Variations on categories, like: garage, free lot, paid lot, on-street parking.
Parking cost (for those who use or could use private auto).	Actual (or expected) cost to park, with and without subsidy.
Parking payment method (for those who use or could use private auto).	Variations on categories, like: meters, cash, parking stickers or passes.
Private vehicle routing (for those who use private auto).	List of major highways used or tracing of travel route on a map.

Sources: Cheryl C. Stecher, Stacey Bricka, and Leslie Goldenberg, *Travel Behavior Survey Data Collection Instruments*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995). and K.W. Axhausen, *Travel Diaries: An Annotated Catalogue* Working Paper of the University of London Centre for Transport Studies (November 1994).

Table 6.14 Household Activity Categories for Respondents

Los Angeles Household Activity Survey (1993) 12 Categories (Variant of Boston Activities) No Detail on In-Home Activities	Portland, Oregon Household Activity Survey (1994) 28 Categories All Activities; In-Home and Out-of-Home Activities Not Separated	New Hampshire Household Activity Survey (1995) 11 Categories Separate In-Home and Out-of-Home Activities	A Proposal for a New York Household Activity Survey 33 Categories Separate Home, Work, and Other Place Activities
At-Home Activities	**Household Sustaining Activities**	**In-Home Activities**	**At-Home Activities**
Out-of-Home Activities	Meals	Household Activities	Sleep/Napping
Picking Up or Dropping Someone Off	Work	Paid Work	Meals
Work	Work-Related	**Out-of-Home Activities**	Personal Care
Working at Home	Shopping (General)	Errands	Dependent Care
Work-Related	Shopping (Major)	Meals	In-Home Amusements
School	Personal Services	Recreation	Household Business
Shopping	Medical Care	School	Household Maintenance
Social Activities	Professional Services	Paid Work	School/School-Related
Recreation	Household Business	Shopping (General)	Working at Home
Eat Out	Household Maintenance	Shopping (Major)	At-Home Exercise
Banking/Personal Business	Household Obligations	Chauffeuring Family, Friends	Telephone
Other	Pick Up/Drop Off Passengers	Cruising for Travel's Sake	Computer
	Social Activities		**At-Work Activities**
	Visiting		Work
	Casual Entertaining		Meals
	Formal Entertaining		**Other Place Activities**
	Personal Enrichment Activities		Drop Off or Pick Up Someone
	School		Meals
	Culture		School/School-Related
	Religion/Civil Services		Shopping (General)
	Civic		Shopping (Major Purchases)
	Recreation and Other Diversions		Medical Care
	Amusements (At-Home)		Household Business
	Amusements (Out-of-Home)		Culture/Entertainment
	Hobbies		Formal Entertaining
	Exercise/Athletics		Religious
	Rest and Relaxation		Civic
	Spectator Athletic Events		Spectator Sports
	Other		Exercise/Athletics
	Incidental Travel		Personal Care
	Tag-Along Travel		Household Care
	Out-of-Area Travel		Visiting
			Work-Related/Outside Work
			Professional Services
			Buying Gasoline

The level of under-reporting can be limited by having interviewers probe for any at-home activities that could be substituted with activities that take place outside the home, such as eating out/catalog shopping. High quality interviewers are essential for an approach like this, because the probing could greatly increase the data retrieval time if it is not performed efficiently. Another circumstance that time-use and activity-based survey designs must consider is when activities occur simultaneously or when an activity (like eating, reading, or paperwork) is completed in the course of travel.

When trip-based methods are employed, rather than activity-based methods, a key issue in the design of diaries is the definition of a trip. Respondents are likely to define the word, 'trip' differently than the survey team members. Therefore, the interviewer or the survey instruments need to explain the term to respondents so that they will answer the question as accurately as possible. In most studies, trips are defined as one-way travel between an origin and a destination other than the origin. This issue is discussed in more detail later in the section on question wording.

Attitudinal, Opinion, Knowledge, and Stated Preference Data Elements

The final data elements that are commonly collected in household travel/activity surveys are the attitude, opinion, knowledge, and stated preference data, including the data elements shown in Table 6.15. These data are not discussed extensively in either the Stecher, Bricka, and Goldenberg paper or the Axhausen paper, because of their focus on household surveys that are used for regional travel model development. Because of their length and complexity, household travel and activity surveys that are conducted for purposes of model building should be limited to the collection of data that will be (or could be) used as model inputs. Survey teams should resist the temptation to collect "nice-to-know" information without first understanding exactly how it will be used.

Other types of household travel/activity surveys, such as those performed for transit agencies, are more likely to employ the types of data elements listed in the table.

Stated response data have been collected in many different types of household surveys, including those that are used for regional model development. The issues related to these data elements are discussed in Chapter 13.0.

Table 6.15 Household Travel/Activity Survey Attitudinal, Opinion, Knowledge and Stated Preference Data Elements

Data Elements	Information Typically Obtained
Assessment of one or more existing transportation facilities or services.	Rankings or ratings of a facility or service, as a whole, or of different components or attributes of the facility or service.
Assessment of a proposed transportation facility or service.	Rankings or ratings of a proposed facility or service, based on descriptions provided by the interviewer or in the survey materials.
Suggestions for improvements to transportation facilities or services.	Open-ended opinion questions.
Level of familiarity with transportation facility or service.	Knowledge questions about the facility or service.
Source of knowledge about facilities or services.	Variations on categories, like: personal experience, word-of-mouth, print advertising, radio advertising, other.
Advertising awareness and recall.	Open-ended questions about which agency advertisements that respondents remember.
Hypothetical choices.	Respondent choices, rankings, or ratings of a set of choices offered in a stated-response exercise.

Translating Required Data Elements Into Questions and Response Categories

Once the survey team and travel demand modeling staff have established the essential and optional data items to be included in the household travel/activity survey, survey questions need to be developed that will produce the data elements accurately and reliably.

A survey question should be included in a household travel/activity survey interview or questionnaire if the following are true:[37]

- The information obtained from the question is relevant to the models being developed or refined, or to other anticipated analytical efforts.
- The question and response categories are expected to be valid measures of the modeling variables.
- The responses can be coded meaningfully for modeling analyses.
- Analysts, interviewers (if any), and respondents agree unambiguously on the meaning of the question and response categories.
- The question and response categories have no wording problems.
- The wording of questions and responses is the same or equivalent to any measure from other surveys that will be used in the modeling work.
- Response categories exhaust all meaningful answers that can be anticipated.
- Response categories are meaningful and understandable to respondents.
- (For interviews) the questions and response categories are easily learned by interviewers.

In addition, each survey question should be reviewed in terms of its effect on the overall survey quality. The following should also be true:

- The benefits in the survey analysis from the question outweigh its costs in terms of survey length, respondent burden, and increased non-response.

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[37]Based on Charles Backstrom and Gerald Hursh-Cesar, *Survey Research*, 2nd edition, John Wiley & Sons, 1981, pp. 119-122.

- The information gained from the question is more useful than the information that would be gained from other questions that will not be on the survey.

- The question does not provoke respondents to be hostile to the survey effort or to question the goals of the surveying agency.

In short, a question and its response categories should provide unambiguous, accurate, reliable, and usable information without affecting the overall validity of the survey effort.

To meet these requirements, the survey team must successfully perform three tasks in translating data elements into actual survey questions:

1. Determine exact question content and the forms of the questions;

2. Develop the wording for questions and response categories; and

3. Determine how questions should be sequenced.

These tasks are described below.

Determining the Form and Content of the Questions

The survey team needs to operationalize the survey's required data elements by defining in more detail what data are needed and by determining the appropriate question forms to obtain the data.

The list of needed data elements that the survey team assembles while analyzing the proposed analyses based on the survey data will include a number of items that will lead directly and logically to the development of one or more survey questions without much effort. For instance, if one of the identified needed data elements is whether a person has a valid drivers' license, the data could be collected by simply asking her or him.

On the other hand, for some data elements there will not be a clear set of survey questions. These data elements require that the survey team improve its data definitions and more carefully consider what survey information is required.

For instance, one data element that is often sought in household travel/activity surveys is whether an individual had a vehicle available for a particular trip from home to work. The most straightforward and commonly employed approach to obtaining this data element is to ask, "did you have a vehicle available for this trip?," or some variation. However, as Axhausen points out, this simple question is riddled with ambiguity.[38] Does answering yes to the question mean that there was a vehicle at home that the person could have driven, or does it mean that, if necessary and with advance planning, the person could have arranged to take a vehicle, perhaps by changing how other household members travel, or does it mean something else?

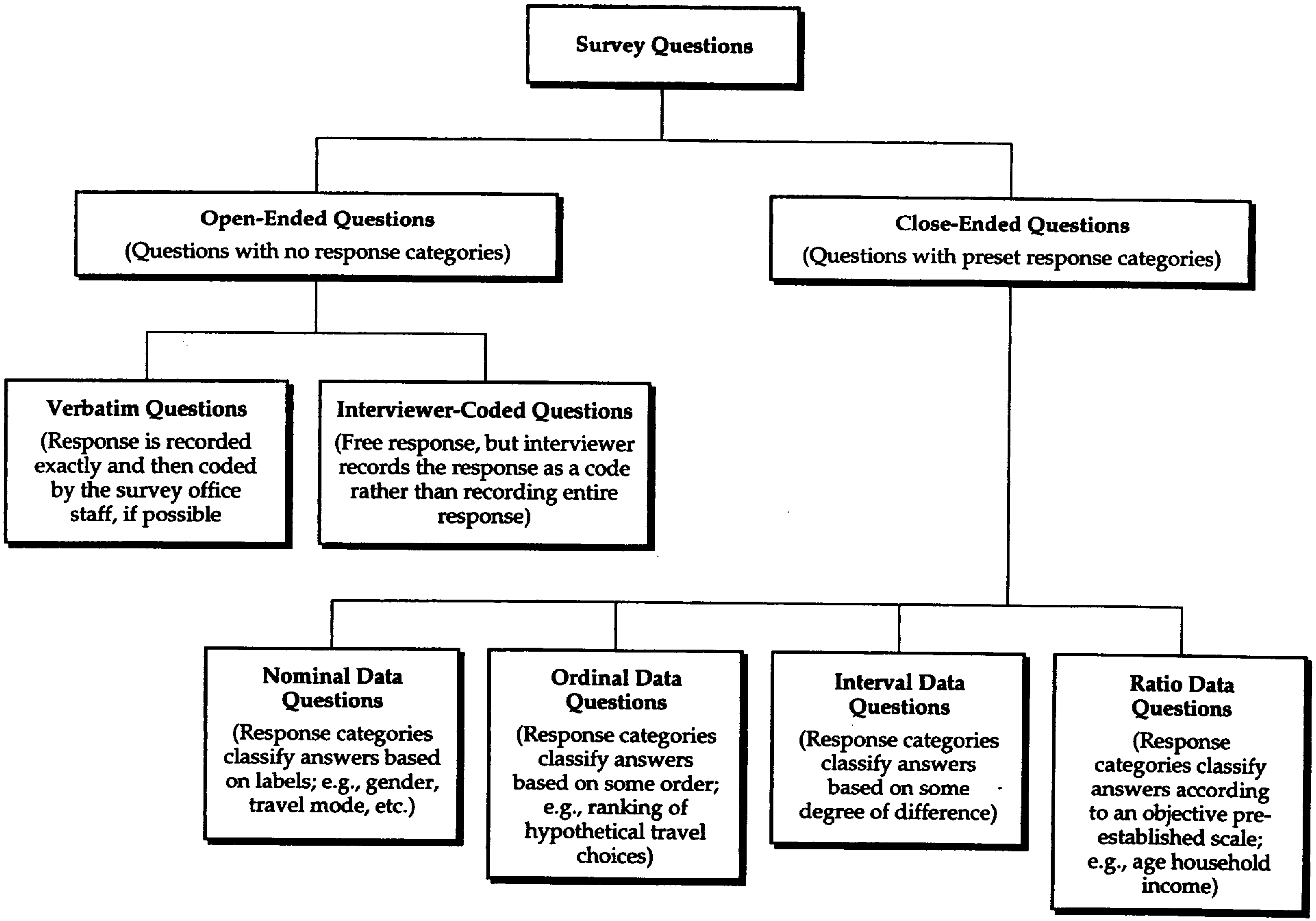
Given this problem, the survey team might want to consider the development of a series of questions to determine how the household allocates vehicle usage and how mode choice decisions are made, or they might want to consider asking questions that would allow them to trace the usage of all household vehicles throughout the travel period in question. Before deciding how best to proceed the survey team should re-examine the expected analyses that will rely on these data elements to find out the best approach.

As the survey team evaluates the household travel/activity survey's needed data elements, they should also consider the types of survey questions with which the data elements are best matched with. In Chapter 3.0, different kinds of survey questions, including factual, behavioral, test-of-knowledge, attitudinal, opinion, and stated response questions, were defined. However, in developing the survey questions it is useful to classify questions differently, according to the question form. Figure 6.3 shows a classification scheme for the forms of survey questions. As the top of the figure shows, survey questions can be either open-ended, which allow respondents to reply to the questions freely, or closed-ended, which provide respondents with preset response categories. Open-ended questions are sometimes useful, particularly when:

- The survey team is uncertain about the possible range of responses to a question;
- The question has so many potential responses that providing categories would be infeasible;
- The survey team needs to have precise information on how respondents think about something;
- The survey team would like to provide respondents with the opportunity to sound off about the survey topic(s); or
- The survey team is seeking verbatim remarks to complement the statistical analyses.

[38] KW Axhausen, *Travel Diaries: An Annotated Catalogue*, University of London Centre for Transport Studies Working Paper, November 1994.

Figure 6.3 Survey Question Forms



Geographic questions are almost always open-ended, because locations that individual respondents refer to cannot be foreseen by the survey team. In addition, questions that ask for respondents' opinions are generally open-ended.

However, almost all household travel/activity surveys rely to a large degree on closed-ended questions for most data elements, because both data collection and survey processing are greatly facilitated by forcing responses into a small number of categories. Closed-ended questions allow respondents to simply pick a reply, rather than to form one from scratch. In addition, the possibility of respondents providing inappropriate answers or of misinterpreting questions is limited by providing preset responses. Finally, closed-ended questions are much easier to code than verbatim respondent replies.

Because of these advantages, many interview questions that appear to be open-ended are actually made closed-ended by having interviewers categorize respondents' remarks into preset divisions.

Closed-ended questions are generally of one of four types, nominal, ordinal, interval, or ratio. This classification is useful in question design, because it is usually easy to determine which of the four categories best addresses particular needed data elements. Because there are relatively few ways to phrase survey questions in each of the four categories, the question construction of other survey questions in the category can often be used as a guide in converting the data element to a useful survey question.

The Wording of Questions and Response Categories

Before developing the wording for any questions, the survey team should understand how the survey process and specific questionnaire wording can bring inaccuracies and biases into the survey results. Two basic survey question problems can harm the survey effort:

- Item non-response; and
- Inaccurate replies (response errors).

To minimize the effects of these problems, it is first important to understand what possible motivations respondents might have to be less than forthcoming or to mislead the surveyor. There are four general reasons why respondents can provide incomplete or inaccurate information in surveys:

1. The respondent does not know the answer to a question or questions;
2. The respondent cannot remember the answer to a question or questions;

3. The respondent misunderstands the question; and

4. The respondent has some motivation not to be totally forthcoming.

While it is not possible for survey teams to eliminate these issues, it is clear from recent household travel/activity survey efforts that good question design can certainly reduce the number of response errors significantly.

The remainder of this section discusses common survey question wording problems, and then discusses question wording issues for particular household travel/activity survey questions, including diaries.

Survey Wording Problems

Each question should be tested by the designer for the potential problems listed above. To minimize the chances that a respondent will not know, remember, understand, or be willing to answer survey questions, the survey team should seek to avoid questions that fall into three broad categories:

- Confusing questions;
- Ambiguous questions; and
- Loaded questions.

Confusing questions are questions that mix up respondents in some way. Ambiguous questions are questions which not everyone would agree mean the same thing. Loaded questions are questions that suggest to respondents that certain responses are preferable to others. Loaded questions are usually of the most concern on attitude, opinion, and stated response questions. Since household/activity questions use these types of questions infrequently, they are probably less of an issue than misperceived or ambiguous questions.

Tables 6.16, 6.17, and 6.18 provide examples of survey questions that have these problems. Although these examples are contrived, they illustrate the many ways question wording can lead to response errors. It is fairly easy to identify questions that could be potential problems in many recent household travel/activity survey materials. In most of these cases, the survey teams probably considered alternative wording but found that the alternatives introduced wording problems of other types. Ultimately, the household travel/activity survey team needs to use its judgment, experience, and the results of carefully-designed pretests to make final decisions about survey wording.

Table 6.16 Examples of Confusing Survey Questions

Outside Respondent's Experience

- **Problem** – *In a description for a stated preference survey, "The agency is considering building a rail transit system similar to the one in Washington, DC."*
- **Improvement** – *"The agency is considering building a rail transit system."*

Technical Terms

- **Problem** – *"Did you use an HOV lane for any part of your work trip?"*
- **Improvement** – *"For any part of your trip from home to work, did you use a carpool lane that requires autos to have more than two people in them?"*

Overfamiliarity

- **Problem** – *"Did you make any trips on Thursday?"*
- **Improvement** – *"Did you go any place for any reason on Thursday?"*

Note – The common word "trip" may imply long distance travel to some respondents. The term should either be defined for respondents at the beginning of the survey or should be avoided.

Uncommon Idiom

- **Problem** – *"With which mode did you make the trip?"*
- **Improvement** – *"How did you get there?" List of modes provided by interviewer or questionnaire.*

Table 6.17 Examples of Ambiguous Survey Questions

Incomplete Questions

- **Problem** – *"Household Income?"*
- **Improvement** – *"Combined 1994 Household Income from all sources, before taxes?"*

Imprecise

- **Problem** – *"Did you have a vehicle available for this trip?"*
- **Improvement** – *"At the time of the trip, was there a vehicle at the starting point of the trip?" and then, if yes, "Could you have taken this vehicle without causing others to change their travel plans?"*

Indefinite in Time

- **Problem** – *"Do you regularly drive to work?"*
- **Improvement** – *"Did you drive to work yesterday?"*

Assumes Knowledge

- **Problem** – *"If you had made the trip by driving, how much would you have paid to park?"*
- **Improvement** – *"Do you know how much it would have cost to park if you had driven?" and then, if so, "How much would you have had to pay?"*

Confusing Two-part Questions

- **Problem** –*"Do you think the bus system has improved in the last year, or do you think it still needs to be upgraded?"*
- **Improvement** – *"Did you think the bus system has gotten better or worse in the last year?" and then "On a 0 to 10 scale, how would you rate the current bus system?"*

Indefinite Comparisons

- **Problem** – *"Do you think the fare for the current inner-city bus routes is fair?"*
- **Improvement** – *"Compared to other transportation services, do you think the fare for the current bus routes is fair or unfair?"*

Indefinite Persons or Places

- **Problem** – *"Does public transit serve your neighborhood?"*
- **Improvement** – *"Are there any bus stops or transit stations within five blocks of your home?"*

Table 6.18 Examples of Loaded Questions

Provide Unfair Alternatives

- **Problem** – *"Some people say that Route 66 needs to be widened. Do you agree or disagree?"*
- **Improvement** – *"Some people say that Route 66 needs to be widened. Others say it doesn't. Which opinion do you agree with?"*

Omit Names of Alternatives

- **Problem** – *In a stated preference question, "Under these circumstances, would you choose to take the maglev system described above or would you choose to take the other alternative?"*
- **Improvement** – *"Under these circumstances, would you choose to take choice A or choice B?"*

Vary Descriptions of Alternatives

- **Problem** – *A stated preference question refers to a two-page description of a proposed new mode developed by the equipment manufacturer, and asks respondents to select between it and the mode they use now for different combinations of travel times and costs.*
- **Improvement** – *The description of the new mode should be minimized and well-balanced with positive and negative attributes. All alternatives should receive similar descriptions.*

Link Personalities to Questions

- **Problem** – *"Governor Williamson has proposed increases in transit service in the Mudville area. How do you feel about this proposal? Do you strongly agree, agree, disagree, or strongly disagree with it?"*
- **Improvement** – *"How do you feel about the proposal to increase transit service in the Mudville are? Do you strongly agree, agree, disagree, or strongly disagree with it?"*

Link Institutions to Questions

- **Problem** – *"Please rate the bus service offered by the public transit agency, City Transit: excellent, good, fair, or poor?"*
- **Improvement** – *"Please rate the bus service in your area. Is it excellent, good, fair or poor?"*

As a general rule, the wording of questions and response categories on surveys should be aimed at the respondent audience. For household travel/activity surveys, this means that the wording needs to be designed for a broad audience with a wide-range of reading and comprehension abilities, and with differing levels of interest in transportation. The challenge for the survey team is to word the survey as simply as possible without boring more advanced respondents.

The following question-writing principles are suggested to achieve this goal:

- The household travel/activity survey should be understandable by the average fourth grader. Once a preliminary set of survey questions is developed, the survey team may want to try administering the questions to some children to see whether any questions are confusing for them.

- The household travel/activity survey should hold the interest of intelligent adults who are not involved in transportation planning or market research. The travel survey team may also want to test this principle by administering the survey to non-technical friends and acquaintances. These people can indicate where the survey is tedious and whether certain questions feel condescending.

- Almost none of the household travel/activity survey respondents will have a background in transportation planning or surveys, and many will have little or no interest in the subjects. Survey team members need to be extremely careful about projecting their level of knowledge and interest onto potential respondents. In particular, the transportation planning field is full of jargon and expressions that are not obvious to non-planners. The survey team needs to be very careful with the use of many words, including:

  - "Trip"
  - "Journey"
  - "Travel"
  - "Activity"
  - "Origin"
  - "Destination"
  - "Mode"
  - "Trip purpose"
  - "Bus"
  - "Shuttle"
  - "Transit"
  - "Transfer"

  This is not to say that such terms should not be used. Rather, the terms are often central to the information that is being sought, and can be absolutely necessary in many cases. The survey team needs to be aware, however, that these and other terms do not always mean the same thing to everyone, and for some people, they will mean nothing. The survey team needs to make sure that the terms are either defined for respondents, or that the context in which they are being used does not allow for ambiguity in their meaning.

- In addition, marketing research and survey analysis terms and jargon should be avoided in surveys, because some respondents will resent being part of an experiment. Among the words to watch for in this regard are:
  - "Questionnaire"
  - "Research"
  - "Data"

Question Wording Issues for the Household Travel/Activity Survey

In household travel/activity surveys, a few question types are known to be problematic. Three particular question types are discussed here:

- Questions about household income;
- Questions about personal property; and
- Activity and travel diary questions.

Questions About Household Income

Household income questions usually have the highest levels of non-response of all the survey questions. Recent survey efforts have reported item non-response rates for household income questions of more than 10 percent. Unfortunately, the people who refuse to answer income questions are usually not representative of the whole population. Research indicates that those who refuse to answer income questions are more likely than the population as a whole to have higher income levels.[39] In addition, some recent U.S. survey efforts, such as a recent statewide effort in New Hampshire, have found that households in the lowest income categories are less likely to complete these surveys. This may be due to either a higher income non-response rate for this group or to an overall higher unit non-response. Therefore, analyses of income data with significant non-response are likely to be biased.

Many surveyors believe that the income question has a high response error level, as well. Many respondents who are unwilling to provide accurate income information sometimes make up an answer, rather than

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[39]A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg. *Survey Methods for Transport Planning,* Eucalyptus Press, Melbourne 1995, p. 303.

simply refusing to answer it. Also, some respondents will not know their total household income or will be confused about which types of income to include in their estimates. It is difficult to determine the magnitude of the response error, because it is impossible to tell valid responses from invalid ones.

Because of the perception of response error, some surveyors believe that there is a practical maximum number of income categories beyond which the data are probably too inaccurate and the question either takes too long in an interview or takes up too much space on the mail survey form. These practitioners believe the survey team should limit the number of income categories to between 8 and 12.

It is generally accepted by travel surveyors and market researchers that the household income question should, if possible, be the last question on the survey. If the question is asked earlier in the survey, the likelihood of the respondent not completing the survey is increased. In addition, once a respondent refuses to answer a question, the likelihood that he or she will refuse to answer others, as well, increases. For some survey efforts, such as those where more than one household member are interviewed, asking income as the very last question is not always feasible. In these cases, survey teams should attempt to sequence the income question after other demographic questions and after the collection of any other descriptive information that may be used in survey expansion.

A number of wording and questionnaire design techniques have been tried to reduce the level of non-response and improve the quality of data from income questions on household travel/activity surveys. Unfortunately, many of the techniques contradict each other, and their success may be specific to certain survey populations. Since careful comparisons are not usually made, it is impossible to say how effective each is.

If the survey team identifies the need for a survey question about household income, they should consider evaluating alternative wording and questionnaire designs as part of the survey pretest to identify the best solution for their area. The form of the income question can be varied, so that pretest respondents receive different questions. The preliminary pretest results may indicate that one question form is superior to others. Alternatively, if a survey team is using one or more focus groups for developing the questionnaire, the focus group participants can be asked to assess the relative invasiveness of different question forms.

Some recent household travel/activity survey teams using telephone data retrieval have reported some success with asking for household income information in a series of choices, rather than by listing all the categories.

The question is structured, as follows:

> *For 1992, will your household's total income from all sources, before taxes and any other deductions from pay be less than $35,000, or $35,000 or more?*
>
> *Ask all with household income less than $35,000: Will it be under $20,000, or $20,000 to 35,000?*
>
> *Ask all with household income $35,000 or more: Will it be more than $35,000 and less than $60,000, or $60,000 or more?*

The simple choice questions continue until the desired level of categorization is achieved. In this type of question structure, the first query ($35,000 in the example) is usually set near the median household income, or a little lower.

This approach can be useful, because in some cases, partial data can be collected from people who would not have responded to the usual income question. On the other hand, the question lengthens the interview at a point where most respondents really would like the interview to be over.

Travel surveyors have tried different approaches of leading into the income question. Some surveys have re-stressed confidentiality and the study goals before asking the question. The household income question on the 1994 Boise survey is worded:

> *Now a question just for statistical and travel forecasting purposes, we need to know your total household income before taxes. I will read several ranges to you. Please stop me when we reach the right one (interviewer then reads categories in ascending order).*

Other travel surveyors believe the best approach to asking income is to include the question at the end of a series of short factual demographic questions. The income question is asked in the same quick way as the other demographic questions. The hope is that the respondent will sense that the income question is just another question that will be used to differentiate groups of people, and that the respondent will simply fall into the rhythm of answering questions.

In telephone-mail-telephone surveys, some surveyors believe that difficult questions, like income, should always be deferred until the retrieval call. On the other hand, some telephone-mail-telephone surveys have asked the income question at the end of both the recruitment interview and the data retrieval interview. Surveyors have found that some people who refuse to supply the information in the recruitment (which is a "cold call") will answer the question during the data retrieval (presumably, they have been convinced of the survey's legitimacy).

Similarly, some household travel surveys have asked all adult members of the household to answer the question, in the hopes that if one household member is reluctant to give out the information, others may not be. Of course, methods that seek the information more than once may lead to consistency questions if the survey team ends up with more than one household income estimate for a household.

Questions about People's Property

Usually the only questions on the household travel/activity survey that have significant non-response problems are those that ask about household income. However, as household travel/activity surveys become more detailed, a few other questions need to be carefully worded and presented. In particular, questions about people's property that might interest enterprising thieves are likely to be a problem for an increasing number of respondents.

It has become fairly common to collect detailed household vehicle information on household travel/activity surveys. While most respondents will recognize a question about the number of vehicles available to the household as having valid transportation planning use, most will not be familiar enough with air quality analyses to understand the need to know the make, model, and year of the vehicle. Untrusting respondents, who question the legitimacy of the survey effort, may feel that they are contributing to some car thief's shopping list. Some recent survey efforts have asked respondents to record the vehicle identification number (VIN) of all their vehicles. Because the most widely-known use of this serial number is to track stolen vehicles, this question may raise the suspicions of respondents even more.

As issues involving telecommuting become more important in transportation planning, it is likely that more and more household travel/activity surveys will also seek information about people's ownership of computers, fax machines, and other equipment. Combined with travel and activity diary data and detailed addresses, this dataset would be ideal for thieves, and it is likely that respondents will recognize this fact.

To limit the non-response on questions of these types, survey teams should:

- Put the questions near the end of survey instruments;
- Explain to respondents what the data are to be used for; and
- If possible, ask only in the second or third contact with the respondents, so that they are more comfortable with the survey's legitimacy.

Activity and Travel Diaries

Diary design is an extremely important element of questionnaire development because response errors in the form of unreported trips are common, and are almost always a serious problem for those who analyze the survey data.

Types of Diaries

Over the past 20 years, household travel/activity surveys have used several types of diaries for which Axhausen has developed the following typology:

- **Stage-Based Diaries** – Treat the travel on a single mode (and the associated wait time) as a building block to construct the whole trip (data are gathered on the basis of each trip segment);

- **Trip-Based Diaries** – Establish the trip as a whole and then disaggregate them into stages, if necessary (data are gathered on the basis of the whole trip);

- **Activity-Based Diaries** – Focus on activities and then collect trip details to and from the activities (data are gathered on the basis of trip-end activities); and

- **Half Tour-Based Diaries** – Collect information for travel between home and the farthest point of a trip chain, and then fill in information on individual trips in the chain (data are gathered on the basis of the key stop in a trip chain).

Stage-based diaries have recently been used in a 1991 mail survey in Chicago, in a 1990 telephone-mail-telephone household survey in the Bay Area, and in a 1993 telephone-mail-telephone survey in Tucson. Figure 3.2 shows the example page from the Chicago survey. In this diary, information on each trip stage is recorded in one column. The Chicago survey is stage-based, because one of the valid answers for the question, "Why did you go to this destination?" is to "change type of transportation." Several columns of information might be needed to describe a single trip.

Figure 6.4 shows the Bay Area's stage-based diary design. Actually, the diary instrument used for this survey was a simple memory jogger. Respondents recorded a minimum amount of information about the stages of the trips they made in the memory jogger, and then the telephone retrieval call was used to obtain details about the trip stages. Again, the respondent is asked to record information about each stage of his or her trips.

Figure 6.5 shows the Tucson survey diary's example, which illustrates yet another diary format for stage-based reporting. In this diary, the trip stages are recorded in the numbered rows, labeled with "Then I went to."

The stage-based design is most useful for survey efforts where the survey team has identified the need for path choice and sub-mode choice information. These diaries readily provide information both on the number of

Figure 6.4 The Bay Area's Stage-Based Diary

1990 MTC AREA TRANSPORTATION STUDY
YOUR TRIP RECORD FOR ONE DAY

Please carry this trip card with you and write down each trip you make on TRAVEL DAY ____________
When you go from one place to another for <u>any reason</u>, this is a trip.
When you change your travel mode (car, bus, BART, bicycle, walk, etc.) this is a new trip.
Please record an address if possible, or an easily identifiable location, where each trip begins and ends, as well as the times for each trip beginning and ending.

PERSON: ____________________

TRIP BEGINNING		TRIP DESTINATION		DESTINATION PURPOSE	TRAVEL MODE (car, bus, BART, walk, etc.)	PARKING COST or TRANSIT FARE (and how paid)	NUM IN CAR
START TIME	ADDRESS AND CITY	ADDRESS AND CITY	END TIME				

Please turn card over and continue

TRIP BEGINNING		TRIP DESTINATION		DESTINATION PURPOSE	TRAVEL MODE (car, bus, BART, walk, etc.)	PARKING COST or TRANSIT FARE (and how paid)	NUM IN CAR
START TIME	ADDRESS AND CITY	ADDRESS AND CITY	END TIME				

All information will be kept completely confidential and used for transportation planning purposes only.

Source: MTC Area Transportation Survey, 1990.

Figure 6.5 Tucson's Stage-Based Diary

PERSON TRAVEL DIARY

PERSON NUMBER:______
(use person number from household data form)

NAME:______________________SEX:______ AGE: _____

TRAVEL DAY: ____________________

- Record trips in the order you make them.
- Include the specific information requested for each trip.
- Record every trip even if made with another household member.
- Include ALL walking or bicycle trips.
- At the end of your travel day, leave all completed diaries in a convenient place at home so they will be available when the interviewer calls.
- Use the back of this card and an extra card, if necessary.
- If you have any questions about completing this travel diary, please call our toll-free number: 1-800-447-8287

0

My first trip today began at:
☐ Home ☐ If not home, show location below:

Name of Place ____________________

Address or Intersecting Streets ____________________

City ____________ Zip Code ____________

KIND OF PLACE

	WHERE did this trip end?	KIND OF PLACE (Restaurant, doctor's office, grocery store)	PURPOSE of trip (Circle one)	TIME of trip (Circle AM or PM)	MODE of travel (Circle one)	If Driver, Which vehicle was used as listed on household data form	If Driver, Number of persons in vehicle (include self)
1 First I Went To:	Name of Place Address or Intersecting Streets City Zip Code		1 Home 2 Work 3 School 4 Shopping 5 Medical 6 Social/ Recreation 7 Other Personal Business 8 Work Related 9 Pick up/Drop off Passenger 10 Change Mode of Travel 11 Other	BEGIN ___:___ AM PM END ___:___ AM PM	1 Driver (Auto/Van/Pickup/Motorcycle) 2 Passenger (Auto/Van/Pickup/Motorcycle) 3 Carpool 4 Vanpool 5 SunTran Public Transit Bus 6 School Bus 7 Bike 8 Walk/Jog 9 Taxi/Social Service/Special Bus 0 Other ______	1 2 3 4 (other)	
2 Then I Went To:	Name of Place Address or Intersecting Streets City Zip Code		1 Home 2 Work 3 School 4 Shopping 5 Medical 6 Social/ Recreation 7 Other Personal Business 8 Work Related 9 Pick up/Drop off Passenger 10 Change Mode of Travel 11 Other	BEGIN ___:___ AM PM END ___:___ AM PM	1 Driver (Auto/Van/Pickup/Motorcycle) 2 Passenger (Auto/Van/Pickup/Motorcycle) 3 Carpool 4 Vanpool 5 SunTran Public Transit Bus 6 School Bus 7 Bike 8 Walk/Jog 9 Taxi/Social Service/Special Bus 0 Other ______	1 2 3 4 (other)	
3 Then I Went To:	Name of Place Address or Intersecting Streets City Zip Code		1 Home 2 Work 3 School 4 Shopping 5 Medical 6 Social/ Recreation 7 Other Personal Business 8 Work Related 9 Pick up/Drop off Passenger 10 Change Mode of Travel 11 Other	BEGIN ___:___ AM PM END ___:___ AM PM	1 Driver (Auto/Van/Pickup/Motorcycle) 2 Passenger (Auto/Van/Pickup/Motorcycle) 3 Carpool 4 Vanpool 5 SunTran Public Transit Bus 6 School Bus 7 Bike 8 Walk/Jog 9 Taxi/Social Service/Special Bus 0 Other ______	1 2 3 4 (other)	

OVER

Source: PAG Household Survey, 1993

modal transfers and their locations. Because respondents record each stage of a trip, the stage-based designs tend to require more from respondents, and therefore, more space on the questionnaires than the other designs.

Figure 6.6 shows a trip-based diary used in a 1990/1991 British survey, the Sainsbury's Swindon Survey. Trip-based diaries, like this one, rely on respondents to characterize their main mode of travel or provide respondents with more exhaustive mode lists which incorporate sub-modes.

A recent U.S. example of a trip-based diary is the ongoing panel mail survey being conducted by New York MTA. The instruction page for this diary survey is shown in Figure 6.7. In this diary, respondents are asked to provide the origin and final destination of trips and to record the travel modes that they used in order of usage. This panel survey effort is being used primarily to track people's travel choices with respect to MTA services and to measure the MTA's market share in different markets, not for the development of regional travel models. Therefore, stage-based information are not considered to be necessary.

In the past few years, the activity-based diary has become the predominant form of diary in the United States. Recent telephone-mail-telephone household travel/activity surveys in Portland, Detroit, and New Hampshire (to name a few) have used activity-based diaries. Figure 6.8 shows a portion of the activity diary for the 1994 Research Triangle Activity and Travel Survey.

Figure 6.9 shows the diary for a 1994 Detroit survey, and Figure 6.10 shows the activity diary for the 1994 Portland survey. Respondents in the Detroit survey were instructed to treat travel mode changes as destination activities. This is the activity-based counterpart to stage-based diary design. All the trip stage information is collected for detailed modeling analyses, but at the cost of asking respondents to record more details and of needing much thicker diary booklets. The Portland diary was used to record all activities, both at-home and outside-the-home. The question "Where did your activity take place?" is needed to identify multiple activities at the same location. Note that the activity-based diaries collect as much, or more, travel data than the other "Travel diaries." The survey team is not limited to activity-based analyses by selecting to use activity-based diaries.

The final type of diary, the half-tour based approach has not been widely applied in the U.S., but might be useful for certain special types of analyses. This diary approach seeks detailed information on the primary trip within a trip chain, and then asks for less-detailed information about the other stops on the trip chain (usually limited to the number of stops). This type of diary might be particularly useful in the analysis of intercity and long-distance trips. As an example of this diary approach, Axhausen provides the diary from a recent Canadian fuel-usage survey, shown in Figure 6.11.

Figure 6.6 An Example of a Trip-Based Diary from the United Kingdom

Journey 16

PLEASE FILL IN A SEPARATE PAGE FOR EACH PART OF YOUR JOURNEY

	START	FINISH
Place		
Road & Number		
Area/Town		
Postcode		
TIME	Hour / Minute	Hour / Minute
(please tick)	AM ☐ PM ☐	AM ☐ PM ☐

What day was it?

- Monday ☐
- Tuesday ☐
- Wednesday ☐
- Thursday ☐
- Friday ☐
- Saturday ☐
- Sunday ☐

What was the main reason for this part of your journey?

(Tick main one only)

- To go to work/education/ for work ☐
- To go home ☐
- To take a passenger somewhere (incl. kids to school) ☐
- Social/entertainment ☐
- Shopping or personal business (eg. doctor, bank) ☐
- Other ☐

IF SHOPPING OR PERSONAL BUSINESS

Which of these were you doing? (Tick all that apply)

- Food/grocery shopping ☐
- Other shopping (incl. Petrol) ☐
- Personal Business ☐

What was your method of travel? (tick one)

- Car/van driver ☐
- Motorcycle or moped ☐
- Car/van passenger ☐
- Goods vehicle ☐
- Pedal Cycle ☐
- Walk ☐
- Bus ☐
- Taxi ☐
- Train ☐
- Other ☐

IF DRIVER/PASSENGER OF CAR/VAN/MOTORCYCLE

Which vehicle were you in? ☐
(see page 10 of diary for code)

Were you delayed by traffic congestion? Yes ☐ No ☐

Did you park (please tick) On-street ☐ Off-street ☐

Was the parking (please tick) Free ☐ Paid ☐

How long did you spend searching/queuing for parking? Minutes ☐

How many adults travelled? (include self) ☐

How many children were with you? ☐

Source: Sainsbury's Swindon Survey by Taylor-Nelson Research, 1990-1991. (Example is from K.W. Axhausen's Travel Diaries: An Annotated Catalogue, 1994.)

Figure 6.7 An Example of a Recent U.S. Trip-Based Diary

INSTRUCTIONS

- Record all the trips you make each day.
- Record all the trips that you make in the 5 boroughs of New York City as well as trips you make in the tristate area (New York, New Jersey, and Connecticut).
- If you made no trips during a particular day check off the box in the top left hand corner.

DATE OF TRAVEL?

- For DAY 1, and DAY 2 fill out the top section by completing the exact date.

WHERE DID YOUR TRIP BEGIN (OR END)?

- If you are not sure of your exact location just fill in as much information as you can. If you started or ended a trip at home it's okay to write down "Home".

TIME TRIP STARTED (OR ENDED)?

- If you don't know the exact time your best estimate is fine. Please remember to fill in am or pm.

TRIP PURPOSE CATEGORIES

- Work or Business ....WORK
- Visiting Friends/Family ..VISIT
- Recreation or Entertain ...REC
- Returning Home ....HOME
- Medical ...MED
- School ....SCHOOL
- Shopping ..SHOP
- Religious ..RELIG
- Other .....OTHER

TRANSPORTATION TYPES USE CODES

- Auto (yours or someone else's) .... AUTO
- Bicycle.......................... BIKE
- Car Service....................... CAR
- Express Bus .... EXBUS
- Ferry (any service).................. FERRY
- Local bus (includes limited) .... LBUS
- Long Island Railroad................ LIRR
- MetroNorth Railroad................ MNRR
- Paratransit or Access-a-Ride.......... PARA
- PATH............................ PATH
- Staten Island Rapid Transit........... SIRT
- Subway........................... SUBWAY
- Taxi (yellow cab) .... TAXI
- Van Service....................... VAN
- Walking.......................... WALK
- Other............................ OTHER

Questions? Please Call 1(800) 772-9288

Moisten, fold, and seal before mailing.

Record All Your Trips For S A M P L E the 24th of June
Fill In Date and Month

If no trips this day check here ☐

	WHERE DID YOUR TRIP ORIGINALLY BEGIN? Write down Borough & Street Intersection. If it was outside NYC, write down the Town or County and State (if not NY)	TIME TRIP STARTED? Please enter time and circle am or pm.	WHAT WAS THE MAIN PURPOSE OF YOUR TRIP? Please use list under "Instructions" at left.	WHAT TYPES OF TRANSPORTATION DID YOU USE? Please use list under "Instructions" at left and list as many as apply in the order you used them.	WHERE DID YOUR TRIP FINALLY END? Write down Borough & Street Intersection. If it was outside NYC, write down the Town or County and State (if not NY).	TIME TRIP ENDED? Please enter time and circle am or pm.
1ST TRIP	Brooklyn Pacific Street and 4th Ave	8:00 am pm	Work	1st: SUBWAY 2nd: 3rd: 4th:	Manhattan 32nd and Lex	8:45 am pm
2ND TRIP	Manhattan 32nd and Lex	10:00 am pm	Work	1st: WALK 2nd: MNRR 3rd: TAXI 4th:	White Plains	11:15 am pm
3RD TRIP	White Plains	3:15 am pm	Work	1st: TAXI 2nd: MNRR 3rd: SUBWAY 4th:	Manhattan 32nd and Lex	4:30 am pm
4TH TRIP	Manhattan 32nd and Lex	5:30 am pm		1st: TAXI 2nd: 3rd: 4th:	Manhattan 7th Ave and Christopher St.	5:50 am pm
5TH TRIP	Manhattan 7th Ave and Christopher St.	10:[illegible] am pm		1st: SUBWAY 2nd: 3rd: 4th:	Brooklyn Pacific Street and 4th Ave	11:00 am pm
6TH TRIP		: am pm		1st: 2nd: 3rd: 4th:		: am pm
7TH TRIP		: am pm		1st: 2nd: 3rd: 4th:		: am pm
8TH TRIP		: am pm		1st: 2nd: 3rd: 4th:		: am pm

If more than 8 trips show total number here ___

Please print as clearly as possible

SAM

Source: MTA Transportation Panel Survey, 1995.

Figure 6.8 An Activity Diary from a Recent North Carolina Research Triangle Survey

Continue Recording All Your Activities for **DAY 1** Here

ACTIVITY	PLACE	TIMES Start	TIMES End	If your activity was a TRIP, please answer the following: What TYPES of transportation did you use?	Where did you go using this TRANSPORTATION TYPE? (record nearest intersection)	Times Used Start	Times Used End
3 ☐ Work ☐ School	☐ Home ☐ Work ☐ School			1st		am pm	am pm
☐ Meals ☐ Trip	☐ Other: (specify address below)					am pm	am pm
Other: (specify)	Place ____ Address ____			2nd		am pm	am pm
____	City ____					am pm	am pm
4 ☐ Work ☐ School	☐ Home ☐ Work ☐ School			1st		am pm	am pm
☐ Meals ☐ Trip	☐ Other: (specify address below)					am pm	am pm
Other: (specify)	Place ____ Address ____			2nd		am pm	am pm
____	City ____					am pm	am pm
5 ☐ Work ☐ School	☐ Home ☐ Work ☐ School			1st		am pm	am pm
☐ Meals ☐ Trip	☐ Other: (specify address below)					am pm	am pm
Other: (specify)	Place ____ Address ____			2nd		am pm	am pm
____	City ____					am pm	am pm
6 ☐ Work ☐ School	☐ Home ☐ Work ☐ School			1st		am pm	am pm
☐ Meals ☐ Trip	☐ Other: (specify address below)					am pm	am pm
Other: (specify)	Place ____ Address ____			2nd		am pm	am pm
____	City ____					am pm	am pm

Figure 6.9 Activity Diary from a Recent Detroit Survey

7th Activity

1. What was the next thing you did? (Check ONE only)

At Home Activities (including sleeping, working at home)		☐
Pick Up or Drop Off a Person(s)	At Work	☐
	At School/Child Care	☐
	Other	☐
Work		☐
Work-Related		☐
School/College/University		☐
Child Care (Day Care/After-School Care)		☐
Shopping		☐
Social Activities/Recreation/Church/Eating Out		☐
Banking/Personal Business		☐
Bus Stop/Carpool/Vanpool/Park N Ride Activities		☐
Other (Please Specify) ______		

2. What time did you ARRIVE there? [:] ☐ a.m. ☐ p.m.

What time did you LEAVE there? [:] ☐ a.m. ☐ p.m.

3. WHERE were you?

______
Business/Store/Place Name

______
Address or Nearest Cross-streets

______
City/Town

4. How did you get there? (Please check)

Walk (5 minutes or more)		☐	
Automobile/Minivan:	Driver	☐	Including yourself, how many persons were in the vehicle? [ ]
	Passenger	☐	
Van/Light Truck:	Driver	☐	Including yourself, how many persons were in the vehicle? [ ]
	Passenger	☐	
Carpool/Vanpool:	Driver	☐	Including yourself, how many persons were in the vehicle? [ ]
	Passenger	☐	
Bus (SMART, DDOT, AATA)		☐	
Shuttle/Campus Bus		☐	
School Bus (K-12)		☐	
Taxi		☐	
Bicycle		☐	
Motorcycle/moped		☐	
Other		☐	

5. If you checked Automobile/Minivan, Van/Light Truck or Carpool/Vanpool and you were the driver:

Did you pay to park your vehicle? ☐ Yes ☐ No

How much did you pay? [$]

Is this an
☐ Hourly Rate? ☐ Daily Rate?
☐ Weekly Rate? ☐ Monthly Rate?
☐ Other ______

6. If you checked bus or taxi:

How much was your fare? [$]

7. Was this the last activity you did today?

Yes ☐ STOP! Please turn to the inside back cover

No ☐ Please turn to next page ➡

Source: Southeast Michigan Council of Governments Household Travel Survey, 1994.

Figure 6.10 Portland's Activity-Based Diary

Day One: Activity Three

1 What was your activity?

2 Where did your activity take place?

Name of place: ____________
Address: ____________
City: ____________

3 What time did your activity start?
________ am / pm

4 What time did your activity end?
________ am / pm

5 Did you have to travel to get to this activity?
❑ Yes → Continue with Question 6
❑ No → Go to Next Activity

6 What time did your travel start?
________ am / pm

7 What time did your travel end?
________ am / pm

8 How did you travel to the activity? (Circle one and follow instructions)

Private Vehicle → Answer Questions 9-16
Public Bus / Max → Answer Questions 17-28
Walk / Bicycle / School Bus / Other → Answer Questions 29-32

If you traveled by private vehicle, answer Questions 9-16, then 33-34

9 Which vehicle did you use? (Make/Model)
Household ____________
Other ____________

10 Were you the
❑ Driver ❑ Passenger

11 How many people were in the vehicle? (including driver)

12 Where did you park? ❑ Did not park
❑ Street ❑ Drive-through ❑ Driveway
❑ Parking lot/garage ❑ Other

13 How did you pay for parking?
❑ Did not pay
❑ Hourly ❑ Weekly ❑ Semesterly
❑ Daily ❑ Monthly ❑ Other

14 How much did you pay for parking?
$ ________

15 Who subsidized your parking?
❑ No one ❑ Employer
❑ Business/store ❑ Other

16 What was the full unsubsidized price to park? $ ________

If you traveled by public bus or Max, answer Questions 17-28, then 33-34

17 Did you have a vehicle available?
❑ Yes ❑ No

18 How would you have paid for parking if you went by car?
❑ Would not pay
❑ Hourly ❑ Weekly ❑ Semesterly
❑ Daily ❑ Monthly ❑ Other

19 How much would you have had to pay for parking if you went by car?
$ ________

20 What was the first transit route taken?

21 Where did you board?
Address/place: ____________
Cross streets: ____________
City: ____________

22 How did you get to the stop?
❑ Drove & parked ❑ Dropped off
❑ Carpooled ❑ Walked ❑ Other

23 How did you get from the stop to your destination?
❑ Drove & parked ❑ Picked up
❑ Carpooled ❑ Walked ❑ Other

24 How did you pay for the trip?
❑ Cash ❑ Fareless square
❑ Ticket ❑ Transfer
❑ Pass ❑ Other

25 Who subsidized your transit fare?
❑ No one ❑ Employer
❑ Business/store ❑ Other

26 Did you transfer to another bus or Max?
❑ Yes ❑ No

27 To what line did you transfer?

28 How many people were in your party?

If you traveled by walking, biking, school bus or other non-private vehicle, answer Questions 29-22, then 33-34

29 Did you have a vehicle available?
❑ Yes ❑ No

30 How would you have paid for parking if you went by car?
❑ Would not pay
❑ Hourly ❑ Weekly ❑ Semesterly
❑ Daily ❑ Monthly ❑ Other

31 How much would you have had to pay for parking if you went by car?
$ ________

32 How many people were in your party?

If your travel mode changed during this trip (even to walking), answer Questions 33-34

33 To what did you change?
❑ Walk ❑ Public bus
❑ Max ❑ Private vehicle
❑ Bicycle ❑ School bus
❑ Other

34 Where did you change travel modes?
Address/place: ____________
Cross streets: ____________
City: ____________

Source: Portland, OR Transportation Survey, 1994.

Figure 6.11 An Example of a Half-Tour Based Diary

FIRST DAY **DAY 1** **Reminder: the label on the front cover tells you which are "your" days. Please use the log for those three consecutive days, no matter how much or how little you drive.** **Please complete:** **The FIRST DAY on which I used used this log was: ________ , ________** Day of the week Date	**1st Trip** Vehicle used: Make ________ Model ________ Year ________	**2nd Trip** Vehicle used: Make ________ Model ________ Year ________ ☐ Same as previous trip
1. *What time did the trip START?*	*1. Time trip started:* ___ : ___ ☐ am ☐ pm	*1. Time trip started:* ___ : ___ ☐ am ☐ pm
2. *Odometer reading at START of trip?*	*2. Odometer at start:* ☐miles ☐Km	*2. Odometer at start:* ☐miles ☐Km
3. *Where did the trip start?*	*3. The trip started at:* ☐ Your home ☐ Work or School ☐ Somewhere else	*3. The trip started at:* ☐ Your home ☐ Work or School ☐ Somewhere else
4. *What time did the trip END?*	*4. Time trip ended:* ___ : ___ ☐ am ☐ pm	*4. Time trip ended:* ___ : ___ ☐ am ☐ pm
5. *Odometer reading at END of trip?*	*5. Odometer at end:*	*5. Odometer at end:*
5. *Where did the trip end?*	*6. The trip ended at:* ☐ Your home ☐ Work or School ☐ Somewhere else	*6. The trip ended at:* ☐ Your home ☐ Work or School ☐ Somewhere else
7. *IF YOU MADE STOPS ALONG THE WAY, about how many minutes in total did you spend OUT OF THE CAR?*	*7. Total time out of the car in stops en route:* ___ minutes.	*7. Total time out of the car in stops en route:* ___ minutes.
8. *Why are you making this trip?* (Check only most important)	*8. Main reason for trip:* ☐ To or from work/school ☐ Driving as part of job ☐ Personal/family errands or shopping ☐ Recreational, social ☐ Other ________	*8. Main reason for trip:* ☐ To or from work/school ☐ Driving as part of job ☐ Personal/family errands or shopping ☐ Recreational, social ☐ Other ________
9. *How many passengers did you carry (NOT including yourself)*	*9. Number of passengers:* (EXcluding driver)	*9. Number of passengers:* (EXcluding driver)
10. *What SPEED LIMITS applied to all, most or some of the roads you used during this trip?*	*10. Speed limits:* ALL: MOST: SOME: 100 kmh ☐ ☐ ☐ 70-90 kmh ☐ ☐ ☐ 60 kmh or less ☐ ☐ ☐	*10. Speed limits:* ALL: MOST: SOME: 100 kmh ☐ ☐ ☐ 70-90 kmh ☐ ☐ ☐ 60 kmh or less ☐ ☐ ☐
Was all, most or some of the distance driven in urban (built-up), or rural areas?	*11. Urban/rural driving:* ALL: MOST: SOME: Urban ☐ ☐ ☐ Rural ☐ ☐ ☐	*11. Urban/rural driving:* ALL: MOST: SOME: Urban ☐ ☐ ☐ Rural ☐ ☐ ☐
Did any of the following bother you on this trip? If you drove more than 6 trips on "your" day, please estimate how many miles or kilometres you drove IN ADDITION to the trips you have recorded. ☐ miles ☐ kilometres	*12. Bothered by:* ☐ Slippery roads ☐ Heavy traffic ☐ Unexpected delay ☐ Poor visibility ☐ Other drivers ☐ Other ________ ☐ Nothing unusual	*12. Bothered by:* ☐ Slippery roads ☐ Heavy traffic ☐ Unexpected delay ☐ Poor visibility ☐ Other drivers ☐ Other ________ ☐ Nothing unusual

Source: Ontario Fuel-Usage Survey, 1988 (Example is from K.W. Axhausen's *Travel Diaries: An Annotated Catalogue*, 1994.)

Selecting the Best Type of Diary

There are good reasons to use each type of diary, so survey teams need to decide which approach to follow based on their data needs. An increasing number of survey teams are choosing to ask people to record activities, rather than trips, primarily because there is strong evidence to suggest that diaries that focus on activities, rather than trips, measure travel more completely than travel diaries. Based on analysis of the recent Boston Household Survey, Stopher concludes that: 1) activity diaries appear able to capture non-home-based trips better than travel diaries; and 2) overall trip rates per person and per household from the activity diary are significantly higher than most travel diaries measure.[40] Jones found that asking about activities, rather than trips on either diary surveys or recall surveys results in improved trip-rate estimates, compared to trip-based approaches.[41]

Researchers and surveyors also seem to be selecting stage-based designs more frequently, whether the diary is travel-based or activity-based. This is probably a function of two things:

- Data analyses are increasingly requiring more detailed information; and
- Asking respondents to remember each part of their trips can sometimes help them remember brief stops that they would have otherwise forgotten.

Level of Detail for Diary Questions

As the example forms show, most household travel and activity surveys seek detailed information about people's travel. This means that surveys that are to be mailed back must be carefully designed to obtain all the necessary information. However, if the diary data are to be retrieved by telephone, the survey team has two options:

- Provide complete diary forms, similar to those used in mailback surveys, from which respondents can simply read their answers; or
- Provide simplified diary forms with which respondents record key information about trips or activities, and then are asked to provide more detailed facts during the retrieval call.

With the first option, respondents are not surprised in the data retrieval call by questions that they were not expecting. In the second option, they

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[40]Peter R. Stopher, Use of an Activity-Based Diary to Collect Household Travel Data, Transportation Vol. 19 (1992), pp. 159-176.

[41]Peter Jones, *Summary of the Diary Surveys Workshop* in Ampt, E.S., Richardson, A.J., and Brög, W. (1985) New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pp. 36-39.

are, to some extent. This is important because of the extreme length of diary retrieval call. If respondents are already dreading having to supply a large amount of trip or activity information, suddenly being asked "additional" questions may cause them to refuse to complete the survey. For instance, respondents to a recent NPTS pretest objected to the additional questions.

Another advantage of providing the complete diary forms is that they are in a form that can be used if they are mailed back. If a respondent is unwilling to complete the data retrieval telephone call, the survey team may want to ask them to mail the completed diary instead. If a shortened, or abridged, diary form is used, this is not an option. In addition, with a complete diary, the quality of information collected by proxy (where one household member provides another household member's diary information) is improved.

On the other hand, complete diary forms are more likely to appear complex or confusing, and may discourage respondents before they even begin to complete them. A complete diary form will usually have questions that will not be answered by a particular respondent. For example, questions about transit trips would not be answered by someone who never used transit. In addition, with the complete diaries, it is less likely that respondents will be willing to complete the diaries as they perform the activities and make the trips throughout the period, as requested. Instead, they may try to complete the form at one or a few times only, raising the likelihood that trips will be forgotten.

To alleviate this problem, some survey teams have provided memory joggers, similar to the Bay Area form shown in Figure 6.4, as well as diaries, so that the respondents could record less detailed information with the memory joggers throughout the diary period, and then fill-in the more detailed diaries from them. The memory joggers are much easier for respondents to carry with them, and so it is believed that respondents are more likely to record trips as they occur, but respondents have found the duplication of effort required with this method to be burdensome. Focus group participants in the recent Research Triangle study said that the two forms were unnecessarily redundant. To address this, the simplified "checkbook-style" diary form shown in Figure 6.8 was developed so that respondents would complete the form throughout the diary period, but would not have to complete more than one form.

Both the complete diary form approach and the simplified diary approach are currently being used in the U.S. The relative importance of the different advantages and disadvantages cited above do not seem to support the recommendation of one approach over the other. The survey team can select the best approach for the particular survey population under-study through pretesting or through focus groups with potential respondent groups.

Additional Diary Question Design Issues

Often, one or more household member is unavailable or unwilling to complete the survey diaries, so survey teams must develop a set of procedures for accepting or not accepting proxy reports. Usually, proxy reports for children under age 14 are deemed acceptable. However, surveyors have differed on how to address the potential need for proxies for older household members. Most surveyors try to avoid proxy reports for adults. Survey teams have specified that interviewers attempt to reach these respondents as many as four times. If these individuals are still not reached or persuaded to provide the information, some surveyors have sought proxies from within the household. Others have deemed the household contact as incomplete, because proxies consistently report lower numbers of trips.

One final diary design consideration is that some travel surveyors have found that CATI data retrieval can enhance the completeness and accuracy of the diary data. CATI systems can identify missing links in people's trip patterns (indicating a mis-recorded or forgotten trip or activity) and check for data anomalies, such as a person not ending up at home by the end of the period. A common diary completion error is to not record the final trip to home on a day. The CATI system can look for such curiosities, and instruct the interviewer to confirm that the data are correct.

Sequence of Survey Questions

In conjunction with developing the wording for the survey questions, the survey team needs to determine where and when each question will be asked. The survey team must decide:

- In which survey instrument each question will be asked;
- The order of the questions; and
- The length of the survey.

For the simple mail and simple telephone survey, the first choice is easy. There is only one place the survey question can be – in the mailed survey, or in the telephone interview. However, for the more complicated survey methods, the survey team has the choice of placing questions in the recruitment call, or in the mailed survey, or (for the telephone – mail – telephone) the data retrieval call, or in some combination of the instruments.

Usually, the recruitment call is designated to be short. The call needs to achieve the following:

1. Screen potential respondents to ensure they are in the survey population of interest;

2. Gain the cooperation of potential respondents;

3. Obtain information necessary for the next phases of the survey (mailing address, number of diary instruments needed, best time for data retrieval call, etc.); and

4. Obtain respondent information, so that the survey team can weight the survey results to account for people who were recruited, but who do not complete the survey.

For the recruitment interview, the general order of the questions should be close to this sequence. The recruitment call should pique the interest of respondents, and make them look forward to the mailing, so if time permits, interesting attitudinal and opinion questions could be included. For the most part, the recruitment call should avoid questions that will make respondents uncomfortable. As noted above, it is generally not a good idea to ask about people's property in these calls. Asking household income questions on the recruitment call has both positive and negative points. By asking the question, the survey team can gain an important variable for non-response weighting, but they do so at the risk of alienating respondents before they have completed their tasks.

For survey methods with mailed data retrieval, the mailed survey instrument usually contains most (or all) of the key survey questions, plus the diary (if one is being used). As discussed below, the travel/activity diary and associated materials are generally separate documents from the rest of the survey questions, and usually do not need to be sequenced with the other questions. The other questions should be ordered according to the following principles:[42]

- Order the questions in descending order of how important respondents are likely to perceive them. Begin with questions that are clearly related to the survey topic (recent travel information) and then move on to questions which are only tangentially related (demographics).

- On printed survey materials, organize the questions into related groupings, perhaps separated with titles, "About your travel choices," or "about your household."

- Within each group, sort the questions by the tasks they ask of respondents. For instance, all "yes" or "no" questions in one sequence and all the scale questions in another.

[42]Don Dillman, *Mail and Telephone Surveys: The Total Design Method,* John Wiley & Sons, New York (1978), pp. 123-125.

- Build ties between the question groupings, so that one flows into the next. If a mail survey has several question groupings which do not seem to relate to one another, the respondents are more likely to feel burdened, and will more easily become confused.

- Put questions that are possibly objectionable to respondents at the end of each grouping of questions.

- Always put demographic questions last, with household income questions at the very end.

If the survey team has special concerns about how two different questions will interact with each other, it makes the most sense to remove one from the mail survey and ask it in the recruitment or data retrieval interview. There is no way to prevent respondents in a mail survey from using (or misusing) information from one question in another, regardless of whether the two questions are near each other, or in which order they appear.

The sequence of the data retrieval call will depend on how much data are to be retrieved directly from mailed materials, and how much will be from new questions to respondents. Most data retrieval calls are designed simply to obtain the information that the respondent has recorded. These calls will follow the mail survey and diary questions precisely, perhaps asking a question or two along the way to clarify or probe responses. It is usually a good idea for the survey team to ask for a few details about the information collected from the mailing, simply to keep respondents actively involved in the interview.

Since both survey cost and non-response levels are related to the length of the interviews and the size of the mail survey, questionnaire length is very important. In general, recruitment calls are brief, between eight and 15 minutes. Recruitment call times for recent household travel/activity surveys have been:

• Portland, 1995	8-9 minutes
• Beaumont, TX, 1993	7 minutes
• North Carolina Research Triangle, 1994	10 minutes
• Baltimore, 1993	9 minutes
• NPTS, Pretest 1994	12 minutes

Interviewers and respondents exchange information during this call, so it is more likely to be interesting for respondents.

Data retrieval calls are substantially longer. Retrieval calls for one-day diary surveys usually average 30 to 50 minutes per household. Two-day diary survey retrieval average times range from 40 to 75 minutes per household. Since these figures represent averages, larger households have had to have been on the phone for very long periods of time. In some recent surveys, data retrieval has been spread over two or three calls. Data retrieval calls are also less interesting for respondents than recruitment calls since they usually are simply being asked to read their written response. The effect of survey length on non-response is highly variable, depending on the level of interest the respondent has in the survey topic, but most household travel/activity surveys are well into the range of being too long for a substantial number of people. Beside the obvious approach of cutting survey questions out, two procedures have been used to shorten data retrieval calls:

- Move questions from the retrieval interview into the recruitment interview; and

- Split the sample so that respondents are only asked a subset of questions. Different respondents are asked different questions so all the questions are asked of at least some of the sample.

Both of these approaches have clear limitations, however. Recent survey efforts that have tried to ask too much of respondents in the recruitment interview had lower respondent cooperation rates, and one effort ran into public relations problems because respondents were uncomfortable with the level of detail they were being asked to provide in the initial call. Splitting the sample is usually very difficult for household travel activity surveys, because almost all the retrieval time is spent on the diary information, which cannot be split practically.

The survey team must ensure that every effort has been made to keep the respondents interested in the survey, and to provide an organized interview as soon as possible.

Survey Instruments and Materials

Because household travel/activity surveys are generally used to collect a wide range of detailed data, the survey team is likely to need to develop a number of different survey instruments and materials. Table 6.19 summarizes the most common survey materials. As the table indicates, the key questions in designing any of these materials are:

- Simply put, what is the purpose of the survey material or instrument?

- Who are the "users" of the survey material or instrument?

It is important to remember that the answer to the latter question usually includes more than one group, who sometimes require very different design decisions. Designing survey materials with only respondents in mind can lead to interviewer errors and coding, editing, and cleaning problems. These problems will almost certainly show up in the survey cost and scheduling.

The following sections describe the development of the survey materials used in the most common household travel/activity survey methods.

Table 6.19 Survey Materials Commonly Used in Household Travel/Activity Surveys

Survey Materials	Purpose	User Group toDesign Materials For	Required/ Optional
Materials for Any Survey Method			
Pre-notification letters and postcards	To inform potential respondents of the upcoming survey and to persuade them to participate	Potential respondents	Optional
Pre-notification telephone interview script	To inform potential respondents of the upcoming survey, and to persuade them to participate	Potential respondents, interviewers	Optional
Thank you letter or card	To thank respondents for completing the survey	Respondents	Optional;
Follow-up letters and postcards	To remind or persuade non-respondents to participate in the survey	Non-respondents	Optional
Materials for Surveys with a Mail Component			
Envelope	To deliver materials, and to get potential respondents to look at materials	Potential respondents	Required
Cover letters	To introduce the study and to persuade potential respondents that their replies are needed	Potential respondents	Required
Information on the survey effort	To provide additional information about the study to potential respondents	Potential respondents	Optional
Main survey	To ask respondents the basic survey questions	Respondents, coders, data entry staff	Required
Household forms	To ask respondents about their households, using tables and graphics making it easier to supply the information	Respondents, coders, data entry staff	Usually Required
Vehicle forms	To ask respondents about their vehicles, using tables and graphics making it easier to supply the information	Respondents, coders, data entry staff	Depends on Survey
Travel or activity diaries	To collect household travel and activities over some pre-specified time period	Respondents, coders, data entry staff	Depends on Survey
Memory joggers	To allow respondents to record trips and activities without having to carry the diary forms with them	Respondents	Optional

Table 6.19 Survey Materials Commonly Used in Household Travel/Activity Surveys (continued)

Survey Materials	Purpose	User Group toDesign Materials For	Required/ Optional
Forms for special questions and exercises	To provide respondents with extra information, in order to answer certain questions, like stated preference exercises	Respondents, coders, data entry staff	Depends on Survey
Reminder cards	To remind household members of the survey tasks, such as diary completion	Respondents	Optional
Cover letters for follow-up surveys	To remind or persuade non-respondents to participate in the survey, and to re-introduce the survey materials	Potential respondents	Optional
Materials for Surveys with an Interview Component			
Recruitment interview script	To introduce the study and to persuade potential respondents to participate, and to screen respondents and ask questions	Potential respondents, interviewers, coders, and data entry staff	Required
Reminder call interview script	To remind respondents that their diary time period is approaching	Respondents, interviewers	Optional
Retrieval interview script	To ask respondents survey questions, and to collect diary and other specialized data	Respondents, interviewers, coders, data entry staff	Required
Interviewer instruction reminders	To provide interviewers with a quick-reference card to help them with some aspects of the survey, and help them get assistance	Interviewers	Optional
Interviewer progress forms	To provide a means for interviewers to record attempted and successful respondent contacts	Interviewers, survey supervisors	Required

Materials for Any Survey Method

Pre-Notification Letter, Brochure, Postcard, or Interview Script

The primary purpose of pre-notification is to inform potential respondents of the upcoming survey and to persuade them to participate. Pre-notification is in effect a sales effort. The survey team wants to convince a potential respondent that the household travel/activity survey effort is:

- Legitimate;
- Important;
- Worth looking for in their mail; and
- Worth their time and effort to complete.

To convince respondents of these facts, the following design guidelines are suggested:

- The pre-notification phone call should be made, or the letter, brochure, or postcard should be sent so that it arrives three or four days before the survey materials.
- If pre-notification is by mail, the document needs to be short and to the point. It should convey its message to the reader in less than a minute.
- The document should look official. If possible, it should be printed on letterhead or have the name of the sponsoring agency or agencies prominently displayed.
- The document can either be from the agency sponsor or another interested agency that might be more recognizable to respondents.
- If possible, the document should be signed by a recognizable public figure or an elected official.
- The document should explain the reasons for the survey in plain language, and stress the confidentiality of the survey effort.
- The document should provide the name and telephone number of someone who can answer questions about the survey and confirm its validity. In most cases, almost no one will call the number, but if potential respondents see that it is offered, it will help them believe in the validity of the survey.
- For those people who do call the number, it is best if the number is for someone at the sponsoring agency, rather than at a private market

research firm. Some survey contractors can provide a phone number that can be covered by an answering machine with the name of the agency on the message. Representatives of either the survey firm or the sponsoring agency can return the few calls that will come in. It is useful to draft a list of the most frequently asked questions with the response for use by the sponsoring agency and/or the contractor. Whoever receives the call will answer respondent questions in a consistent manner.

A secondary use of the pre-notification material is to use it to identify bad addresses for which mail is undeliverable. To do this, the pre-notification letter must be sent by first-class mail with a return address (many surveyors believe all materials should be sent by first-class mail to separate the materials from junk mail). Mailing the pre-notification material by this method helps the survey team to identify the percentage of bad addresses in the sampling frame, and allows the team to save some postage costs by sending the survey materials only to valid addresses.

Figure 6.12 shows an example pre-notification letter from the 1996 Oregon (statewide) Travel Behavior Survey.

Thank You Card

From a myopic data collection point-of-view, once the survey team has been able to retrieve complete and seemingly valid data from a respondent, further contact with that respondent is superfluous. However, in some instances, it is politically advantageous for an agency to send a postcard thanking the respondent households for their efforts. These cards build a sense of good will between the respondents and the agency, which might be valuable in future planning efforts that are increasingly relying on citizen participation.

The cards also help to confirm for respondents that the survey effort was legitimate and that their information was valuable. A survey team that is considering the possibility of using the household travel/activity survey as part of an ongoing panel design should certainly consider the use of thank you cards.

Follow-Up Letters and Postcards

Usually, if a potential respondent household fails to respond to the initial mail survey, they are sent one or more reminder letters or postcards. These materials are designed to:

- Remind the respondent households who have completed the survey, but not yet returned it to mail it back;

- Re-stress the importance of the survey effort and the importance of the particular household receiving the letter or card; and

- Provide potential respondents with another opportunity to complete the survey by assigning new diary periods, and/or by inviting them to contact the survey team by phone.

The first set of follow-up letters or cards stress the reminder message. Often, a simple postcard is sent that states that the respondent household's survey has not yet been received, and asks the household please make sure that they do not forget to send it.

With each successive follow-up round, the content of the letters and/or cards shifts away from the reminder message toward a more persuasive message. Later follow-up mailings tend to be either letters stressing the importance of the household's participation or letters combined with a new set of survey materials.

Richardson, Ampt, and Meyburg suggest that each successive follow-up mailing be sent in different color and style of envelope so that they are less easily dismissed by potential respondents.

Figure 6.13 shows an example follow-up letter from the 1991 CATS household travel mail survey.

Materials for Surveys with a Mail Component

Envelope for the Survey Mailing

The first challenge in getting households to respond to the survey is to get one of the household members to open and read the survey package. A very high percentage of direct mail is thrown away without ever having anyone open it. Unfortunately, mailed household travel/activity surveys generally look very much like direct mail when they show up in people's mailboxes.

The travel survey team needs to take steps to get their envelope opened. One simple step for survey efforts with pre-notification or where the mailing is taking place after the respondent has been contacted by phone is to describe the envelope to the respondent before it is mailed to them, "You will be receiving the mail survey in a large blue envelope with our return address on it."

In addition, Dillman suggests the following steps to separate the mailing from junk mail:[43]

- Use as small an envelope as possible to limit postage costs and to avoid the "bulk" image;
- Type the name (use specific people's names, rather than only the family name whenever possible) and address directly on the envelope, rather than on address labels;
- Do <u>not</u> embellish the envelope with messages, like "dated materials inside" or "immediate reply requested"; and
- Use actual stamps, rather than metered or bulk rate mail, even though postage costs will be higher (not all surveyors see this as a justified expense, particularly if respondents have been pre-notified of the effort).

The design of return envelopes for mailback questionnaires is less important than the survey package envelope, because the respondent would use it only if she or he has decided to complete the survey. The important design considerations for these letters include the following:

- The envelopes should be provided;
- The envelopes should be prepaid through the use of business reply mail; and
- The return address should be for the sponsoring agency, if possible. If the replies are going to be sent to a survey contractor, respondents should already be aware of the name of the firm from the cover letter and other survey materials or interview contacts. Unless it is absolutely necessary, envelopes should not be sent to addresses outside the study region.

Cover Letter for the Survey Mailing

The cover letter for the survey mailing has been shown to be an important survey element. It must perform the same functions as the pre-notification letter, plus introduce the attached survey materials. The cover letter should be no more than one page, and should be both motivational and informative.

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[43]Don Dillman, *Mail and Telephone Surveys: The Total Design Method,* John Wiley & Sons, New York (1978), p. 175.

Figure 6.12 Example Pre-Notification Letter for the Oregon Statewide Activity Survey

Oregon

DEPARTMENT OF TRANSPORTATION

Planning Sectio:
File Code: TRA :

Are you concerned about increasing traffic congestion and growth management in your area? The Oregon Department of Transportation (ODOT) invites you to help us find solutions by participating in the 1996 **Travel Behavior Survey.** Your household's commitment is vital for creating a better transportation future.

ODOT will use the study results to forecast future travel patterns and develop transportation solutions. To do this we need detailed information, such as:

- What activities cause you to travel most?
- What activities cause you to travel least?
- How often you do these activities?
- Where are you traveling?
- When you are traveling and not traveling?

You are important to the success of this study -- no matter how much or how little you travel. You may be the only household in your immediate neighborhood that has been randomly selected for participation in this study! A member of the project team will telephone you in the next few days to answer questions and to explain how you can help us in this important study. By agreeing to participate, your household will keep activity diaries for two days.

All information your household shares with us is strictly confidential. NuStats is the name of the survey research company who will conduct the study under strict privacy and confidentiality standards. If you have any other questions or concerns about the project, please contact one of the project team members listed below. We look forward to your participation in the study. The results could improve your quality of life and the future of <u>city</u>.

Sincerely,

Mike Gillett
ODOT Project Manager
(503) 986-4113

Johanna Zmud
NuStats Project Manager
1-800-619-3601

Transportation
Development Branch
Mill Creek Office Buildi
555 13th Street NE
Salem, OR 97310

Form 731-0384 (6-95)

Cover letters should have the following general outline:[44]

- **Top of Page** – Official letterhead of the sponsoring agency;
- **Date** – Exact (and correct) date of transmittal;
- **Address** – Name and address, similar to any business letter;
- **Salutation** – Specific salutation (e.g., Dear Ms. Thompson:), if possible (sometimes not possible because only the family name is known or because the person's sex is not obvious from his or her name), otherwise no salutation at all;
- **Paragraph 1** – 1) topic of the study; and 2) social usefulness of the study;
- **Paragraph 2** – 1) why recipient is important to the study; and 2) who in the household should participate;
- **Paragraph 3** – 1) promise of confidentiality; and 2) explanation of privacy procedures and serial numbers on survey forms;
- **Paragraph 4** – 1) usefulness of the study results; and 2) explanation of incentive (if one is being employed);
- **Paragraph 5** – What to do if questions arise;
- **Closure** – Thank you;
- **Signature** – Business letter-type signature block, with typed name and title under the signature, and with an original handwritten signature in blue ink.[45]

If possible, the signature should be from a well-known elected official. Recent household surveys have had cover letters signed by Governors and U.S. Senators. Of course, when higher profile people are used for the signature, the ability to provide an actual handwritten signature is eliminated.

Figure 6.14 provides an example of a recent household travel/activity survey cover letter. While this letter does not follow the suggested format with precision, it covers the main points that need to be included, and appears to be an effective communication tool.

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[44]Don Dillman, *Mail and Telephone Surveys: The Total Design Method,* John Wiley & Sons, New York (1978), pp. 165-174.

[45]For large survey efforts, a signature stamp would be required to provide an "original-like" signature.

With address-based sampling, it is possible to individualize the cover letters so that the study's benefits can be defined specifically for the individual receiving the letter. In an ongoing Bay Area survey, this individualization is being done as follows:

*"Dear **<<respondent name>>**:*

*Do traffic conditions on **<<main corridor near respondent's home>>** sometimes concern you? What about the number of parking spaces at the **<<nearest transit station>>** station?"*

Individualization can also take place later in the cover letter.

*"You are important to the success of this study – no matter how much or how little you travel. You may be the only household on **<<street>>** that has been randomly selected for participation in the study."*

Survey Fact Sheet

The design of the cover letter involves a tradeoff between supplying more information and the need to keep the letter short and punchy so that it gets read, instead of just skimmed. Sometimes, when survey teams feel it is necessary to provide additional information about the survey, they include a one-page fact sheet or pamphlet. Figure 6.15 shows the survey fact sheet from a recent household activity survey.

Survey Questionnaire

The development of mail survey questionnaires and the mail component of telephone-mailout-mailback surveys requires the survey team to consider both the extremely difficult wording issues discussed above and issues of survey layout, as well. The quality of the layout of self-administered survey will affect:

- Overall non-response rates;
- Item non-response rates;
- Response quality;
- Survey coding quality; and
- Data entry and editing efficiency.

Figure 6.13 Cover Letter for the Mailing of a Boston Area Household Activity Survey

The Commonwealth of Massachusetts

Executive Office of Transportation & Construction

Office of the Secretary

William F. Weld
Governor

Argeo Paul Cellucci
Lieutenant Governor

Richard L. Taylor
Secretary

10 Park Plaza, Room 3510

Boston, MA 02116-3969

Telephone 973-7000

TDD (617) 973-7306

Telefax (617) 523-6454

Dear Fellow Citizen:

Thank you very much for agreeing to participate in the Boston Region Household Travel Survey. On behalf of the Commonwealth of Massachusetts, I thank you and all members of your household for taking part in this important study. As a token of our gratitude, we have enclosed coupons that you may redeem for complimentary Massachusetts State Lottery Megabucks game tickets — thanks to State Treasurer Joe Malone. Good Luck!

By completing the One Day Diaries and Household Summary Form included with this letter, you and the members of your household will provide vitally important information helping us to learn about how often people travel, where people travel, and what kinds of transportation they use. This information will assist us in planning and designing transportation improvements throughout Eastern Massachusetts, ranging from upgrading local highways to expanding commuter rail services.

HOW YOU WERE CHOSEN TO PARTICIPATE

Ideally, we would like to be able to ask everyone in the region about their travel patterns. Because of time and money constraints, such a survey is impossible. Instead, we randomly selected a small number of Boston area households to participate in this survey. Your household was one of those selected.

CONFIDENTIALITY

Your answers to the survey are completely confidential. When the results of the survey are released, they will be reported for groups of people, NOT for individuals or households.

Instructions on how to provide the information are included on the One Day Diaries and Household Summary Form, which accompany this letter. If you have any questions about the purpose of the survey or about the One Day Diary or Household Form, please call "Survey Help" toll-free from within the 617 and 508 area codes at (508) 371-4255.

Sincerely,

Richard L. Taylor
Secretary of Transportation

Source: Boston Region Household Travel Survey, 1991.

The importance of questionnaire layout on self-administered survey materials is illustrated by the results of an actual household products panel survey effort in 1980.[46] Figure 6.16 shows two mail survey questions that were asked of the same 4,000 respondents about the same products within a year of each other. The only difference between the surveys in which the two questions were offered was the questionnaire layout.

The question on the left produced results which were consistent with the expectations of the study sponsor. The question on the right produced the dramatically different results shown in the figure. These results were found to be invalid in clarification telephone calls. After discovering the problem, the survey team theorized that the line on which the other brand was to be entered was too close to the box around the question, and that respondents counted from the bottom to check their brand.

It is fortunate (or perhaps unfortunate) for the survey team that the study sponsor happened to be the manufacturer of one of the two products in question. The survey team had a strong sense of the relative market shares of the two products from previous waves of the panel, so the problem was discovered and rectified. For travel surveys, there are generally no recent survey data to test the validity of questions, and so survey teams need to be as careful as possible in designing the layout of questionnaires.

Fowler provides the following guiding principles for developing self-administered questionnaires:[47]

1. A self-administered questionnaire should be self-explanatory. Reading instructions should not be necessary, because they will not be read consistently.

2. Self-administered questionnaires should be restricted to closed-end answers whenever possible. Checking a box or circling a number should be the only task required. When respondents are asked to answer in their own words, the answers are usually incomplete, vague, or difficult to code, and therefore are of only limited value as measurements.

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[46]Charles S. Mayer and Cindy Piper, *A Note on the Importance of Layout in Self-Administered Questionnaires,* Journal of Marketing Research, Vol. XIX (August 1982), pp. 390-391.

[47]Floyd J. Fowler, Jr., *Survey Research Methods* Revised Edition, Sage Publications (1988) p. 102.

Figure 6.14 An Example of a Form to Provide Additional Information on the Survey to Respondents

What is TravelCount?

This folder gives you some information about TravelCount. We hope that it answers any questions you may have, but, if you have more questions, call the TravelCount hotline, **1-800-496-9616.** It's a free call!

Question **What is TravelCount?**

Answer TravelCount is a very important project by the North Central Texas Council of Governments (NCTCOG) to help plan for better highways and transit throughout the Dallas-Fort Worth Metroplex. The work is being done with the help of local agencies, with technical support and funding provided by the Texas Department of Transportation and the U.S. Department of Transportation.

Question **Who is doing the actual work on TravelCount?**

Answer The project to ask households and people about their activities is being done by NCTCOG. The Council of Governments chose a team of consultants to carry out the travel surveys.

Question **How can my information make a difference in a region with 4 million people?**

Answer Choosing 16,000 people has been shown scientifically to be enough to tell us about the things people in the region do, in much the same way that a blood sample tells a doctor about all of a person's blood. The same principle is used to find out about what TV programs people watch, and about how people are likely to vote in an election.

Question **What is the North Central Texas Council of Governments?**

Answer The North Central Texas Council of Governments is an organization of 219 local governments within a 16-county region which, among other things, directs regional transportation planning.

Question **Why is TravelCount happening?**

Answer TravelCount is a project that will help make sure that the billions of dollars to be spent in the Metroplex on highways and transit over the next 20 years will be spent wisely.

Question **How was I chosen?**

Answer By random choice. That *random choice* is the key to the way we select people — it does not pick out any special type of people or households and it doesn't exclude any particular types of people or households. In fact, everyone has a chance to be selected.

Question **Will we ever know the results?**

Answer Yes. While the main reason for collecting this information is to help NCTCOG and other government agencies plan transportation improvements, highlights of the results will be published by NCTCOG. The highlights will not have any information about specific households — only summary information about everyone who took part.

Question **How many people are being asked to take part in TravelCount?**

Answer There are 1.8 million households in the Metroplex. Of those, 6,000 households (with about 16,000 people) have been chosen to help us in this project.

Question **Why does everyone in my household, even the kids, have to tell you what we do for a whole day?**

Answer Because it is all important information. What each of you does in a day helps us to know more about why you travel, where you travel, and how you travel. These facts will help us figure out how to improve the ways travel can take place in the region. It also helps us know how other changes, like new shopping centers and office buildings, might change the way

What is TravelCount?

* *Information for the Future*

North Central Texas Council Of Governments

Source: NCTOG, 1995. (Actual document is a 81/2 X 11 two-fold pamphlet, printed on orange paper).

Figure 6.15 An Example of the Importance of Layout on Self-Administered Questionnaires

QUESTION VERSION I

What make or brand is the newest one?

	Product X	*Product Y*	*Product Z*
• Brand A	☐ 1	☐ 1	☐ 1
• Brand B	☐ 2	☐ 2	☐ 2
• Brand C	☐ 3	☐ 3	☐ 3
• Brand D	☐ 4	☐ 4	☐ 4
• Brand E	☐ 5	☐ 5	☐ 5
• Brand F	☐ 6	☐ 6	☐ 6
• Brand G	☐ 7	☐ 7	☐ 7
• Other Brand	☐ 8	☐ 8	☐ 8

QUESTION VERSION II

What make or brand is the newest one?

	Product X	*Product Y*	*Product Z*
• Brand A	☐ 1	☐ 1	☐ 1
• Brand B	☐ 2	☐ 2	☐ 2
• Brand C	☐ 3	☐ 3	☐ 3
• Brand D	☐ 4	☐ 4	☐ 4
• Brand E	☐ 5	☐ 5	☐ 5
• Brand F	☐ 6	☐ 6	☐ 6
• Brand G	☐ 7	☐ 7	☐ 7
• Other Brand (Specify)	______	______	______

PARTIAL RESULTS

Product	Version I Brand Market Share	Version II Brand Market Share	Expected Results Based on Previous Survey Brand Market Share
• Product X			
Brand F	3	30	5
Brand G	71	47	67
• Product Y			
Brand F	2	18	1
Brand G	41	27	39
• Product Z			
Brand F	3	27	8
Brand G	58	35	55

Source: Charles Mayer and Cindy Piper, *A Note on the Importance of Layout in Self-Administered Questionnaires*, Journal of Marketing Research, Vol. XIX (August 1982), pp. 390-391.

3. The question forms in a self-administered questionnaire should be few in number. The more the questionnaire can be set up so that the respondent has the same kinds of tasks and questions to answer, the less likely it is that respondents will become confused; also, the easier the task will be for the respondents.

4. A questionnaire should be typed and laid out in a way that seems clear and uncluttered. Photoreduction, or other strategies for putting many questions on a page, actually reduces the response rate compared with when the same number of questions are spaced more attractively over more pages.

5. Skip patterns should be kept to a minimum. If some respondents must skip some questions, arrows and boxes that communicate skips without verbal instructions are best.

6. Provide redundant information to respondents. If people can be confused about what they are supposed to do, they will be.

Since household travel/activity surveys often collect very detailed information from all household members, they can become quite repetitive and boring for respondents. Survey designers have sought ways to use graphical and tabular formatting to both improve the presentation of the survey materials and to ease the burden on respondents.

The tabular and graphical formats are used both on mailed survey instruments and on interviewer scripts. The formats improve the appearance and user-friendliness of the survey forms for respondents and interviewers, because they help organize the information logically and unambiguously. On the other hand, the formats tend to require shortened forms of questions and the informal wording of questions. The survey team needs to be especially careful when using tables or graphics that they do not introduce any of the wording problems discussed above.

Still, if the tables and graphics are carefully-designed, their advantages far outweigh their potential disadvantages. Survey teams should seek opportunities to present the survey questions in clear, logical, and visually interesting formats. The widespread availability of desktop-publishing and graphics software greatly enhances the ability of survey teams to use special formats.

Survey teams should consider the use of colored paper and different ink colors to enhance the attractiveness of the survey materials, to improve the organization of the different survey materials in the survey packet, and to aid in data entry. Using different colored paper for each survey form makes it easier for respondents to keep them straight, and provides a useful mechanism for simplifying written instructions or data retrieval calls. For instance, an interviewer could say, "Now I would like you to read me the answers you filled out on the pink form."

Using ink colors other than black has a few advantages, as well. First, the forms can be made more visually interesting for respondents. In addition, since many respondents will fill out the forms in black ink, or pencil using some other color for questions will make it easier for data entry specialists to pick up the answer, or for the respondents, themselves, who could be asked to read what they wrote. The recent Research Triangle survey used green ink to improve the data entry.

Household and Vehicle Forms

One common approach for improving the layout of survey questionnaires in household travel/activity surveys is to separate out groups of related questions into stand-alone survey forms. Travel diary data are almost always recorded in separate diary booklets, and, increasingly, survey teams are using household and/or vehicle forms, that seek the same type of information for all members of the household and all the vehicles available to the household.

Figures 6.17 and 6.18 show examples of different formats used to collect household and vehicle data from respondents. Each form is designed to be a separate one- or two-page instrument. In surveys that use such forms, respondents are generally asked to complete several different forms. For instance, a household survey might include a household form, a vehicle form, a travel diary, and a stated response exercise, which are all separate forms. This design is appealing to respondents, because it logically categorizes the questions, it improves the visual layout of the questions, and it allows them to feel a sense of accomplishment as they finish off individual forms.

Travel or Activity Diary

Virtually all recent household travel/activity surveys seeking diary information have presented the diary questions in an easy-to-complete tabular format, rather than as a series of unformatted questions. Diaries are usually organized in booklets, one per household member, that record trips or activities, one (or a few) per page.

The several diary pages shown in Figure 3.2 and in Figures 6.4 through 6.11 illustrate the many different diary layouts. The Chicago (Figure 3.2), and Ontario (Figure 6.11) surveys collect information about each activity or trip in a single column. This columnar format was first developed for a 1973 West German trip-based diary survey. The design has come to be known as the "KONTIV" format, and has been used in many surveys since.

Figure 6.16 Household Form from a Recent Boston Survey

4. Please answer the following questions for all people in the household who are 5 years of age or older.

	PERSON NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
	YEAR OF BIRTH	19 __	19 __	19 __	19 __	19 __	19 __	19 __	19 __	19 __	19 __	19 __	19 __
RELATIONSHIP OF THIS PERSON TO YOU	*Self*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Spouse	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Son/Daughter	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Father/Mother	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Brother/Sister	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Grandparent	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Other Relation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Not Related	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
SEX	*Male*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Female	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
HAVE A VALID DRIVER'S LICENSE?	*Yes*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	No	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
EMPLOYMENT STATUS *Check as many boxes as apply*	*Employed Full Time*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Employed Part Time	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Homemaker	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Retired	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Seeking Employment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Unemployed/Not Looking	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Other	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
ENROLLED IN SCHOOL?	*No*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Full Time Student	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Part Time Student	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
DOES THIS PERSON GET ANY PART OF HIS/HER COMMUTE EXPENSES PAID BY HIS/HER EMPLOYER?	*No*	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Yes, Company Car	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Yes, Auto Mileage Expense	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Yes, Preferred Parking	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Yes, Transit Pass	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Yes, Other	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Source: CTPS Boston Region Household Survey, 1991.

Figure 6.17 An Example Vehicle Information Form

Vehicle Information

Please list all vehicles, including cars, pickups, trucks, vans, minivans or motorcycles that are available for use by your household. Be sure to include any company vehicles or leased vehicles available for personal use and kept at your home. Also include any vehicles that are normally available to your household, but are under repair today. Please provide the mileage (odometer) reading of each vehicle at the start of the diary period, and again at the end of the diary period. Please include information for any vehicle(s) that you borrow or rent to make trips during your diary period.

Make	Model	Body Type	Model Year and Year Acquired	When acquired, did this vehicle replace an existing one or was it an additional vehicle?	Fuel Type	Vehicle Owner or Leaseholder	Primary Driver (relationship of driver to you)	Beginning Odometer Reading (whole miles)	Ending Odometer Reading (whole miles)
1		☐ Auto ☐ Pick-up Truck ☐ Van ☐ Other Truck ☐ RV ☐ Motorcycle ☐ Utility Vehicle ☐ Other	Model Year 19__ __ Year Acquired 19__ __	☐ Replacement ☐ Additional vehicle	☐ Gas ☐ Diesel ☐ Other *(specify)*	☐ Household Member ☐ Employer ☐ Rental ☐ Other *(specify)*	☐ Self ☐ Other Related ☐ Spouse ☐ Live-in Help ☐ Son/Daughter ☐ Not Related ☐ Father/Mother ☐ No Primary Driver		
2		☐ Auto ☐ Pick-up Truck ☐ Van ☐ Other Truck ☐ RV ☐ Motorcycle ☐ Utility Vehicle ☐ Other	Model Year 19__ __ Year Acquired 19__ __	☐ Replacement ☐ Additional vehicle	☐ Gas ☐ Diesel ☐ Other *(specify)*	☐ Household Member ☐ Employer ☐ Rental ☐ Other *(specify)*	☐ Self ☐ Other Related ☐ Spouse ☐ Live-in Help ☐ Son/Daughter ☐ Not Related ☐ Father/Mother ☐ No Primary Driver		
3		☐ Auto ☐ Pick-up Truck ☐ Van ☐ Other Truck ☐ RV ☐ Motorcycle ☐ Utility Vehicle ☐ Other	Model Year 19__ __ Year Acquired 19__ __	☐ Replacement ☐ Additional vehicle	☐ Gas ☐ Diesel ☐ Other *(specify)*	☐ Household Member ☐ Employer ☐ Rental ☐ Other *(specify)*	☐ Self ☐ Other Related ☐ Spouse ☐ Live-in Help ☐ Son/Daughter ☐ Not Related ☐ Father/Mother ☐ No Primary Driver		
4		☐ Auto ☐ Pick-up Truck ☐ Van ☐ Other Truck ☐ RV ☐ Motorcycle ☐ Utility Vehicle ☐ Other	Model Year 19__ __ Year Acquired 19__ __	☐ Replacement ☐ Additional vehicle	☐ Gas ☐ Diesel ☐ Other *(specify)*	☐ Household Member ☐ Employer ☐ Rental ☐ Other *(specify)*	☐ Self ☐ Other Related ☐ Spouse ☐ Live-in Help ☐ Son/Daughter ☐ Not Related ☐ Father/Mother ☐ No Primary Driver		
5		☐ Auto ☐ Pick-up Truck ☐ Van ☐ Other Truck ☐ RV ☐ Motorcycle ☐ Utility Vehicle ☐ Other	Model Year 19__ __ Year Acquired 19__ __	☐ Replacement ☐ Additional vehicle	☐ Gas ☐ Diesel ☐ Other *(specify)*	☐ Household Member ☐ Employer ☐ Rental ☐ Other *(specify)*	☐ Self ☐ Other Related ☐ Spouse ☐ Live-in Help ☐ Son/Daughter ☐ Not Related ☐ Father/Mother ☐ No Primary Driver		
6		☐ Auto ☐ Pick-up Truck ☐ Van ☐ Other Truck ☐ RV ☐ Motorcycle ☐ Utility Vehicle ☐ Other	Model Year 19__ __ Year Acquired 19__ __	☐ Replacement ☐ Additional vehicle	☐ Gas ☐ Diesel ☐ Other *(specify)*	☐ Household Member ☐ Employer ☐ Rental ☐ Other *(specify)*	☐ Self ☐ Other Related ☐ Spouse ☐ Live-in Help ☐ Son/Daughter ☐ Not Related ☐ Father/Mother ☐ No Primary Driver		

Please turn over and complete HOUSEHOLD INFORMATION!

Source: Cheryl C. Stecher, Stacey Bricka, and Leslie Goldenberg, *Travel Behavior Survey Data Collection Instruments*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995).

The Bay Area (Figure 6.4), Tucson (Figure 6.5), and New York MTA (Figure 6.7) diaries collect trip information in rows. This format is easy for respondents to follow, but it is limited in the amount of data it can collect. The Bay Area format is actually a memory jogger, in which only the key trip details are collected. The telephone data retrieval call collected the more detailed information.

The row-wise format uses space efficiently. The MTA diary questionnaire was produced in a small booklet measuring only 8.5 inches by 3.5 inches. This convenient size makes it easier for respondents to carry the questionnaire with them as they travel.

The other diary pages shown, the British diary (Figure 6.6), the Research Triangle diary (Figure 6-8), the Detroit diary (Figure 6.9), and the Portland diary (Figure 6.10) use a diary format for which each activity or trip is recorded on a single page of the diary booklet. This format is the most graphical and readable of the three. It is especially well-suited for surveys relying on mailback data retrieval. The British survey was a self-completion instrument and, therefore, required the added clarity of the format. In addition, although the Detroit survey used telephone data retrieval, the form used for this survey was based on an earlier activity-based diary that appeared in a telephone-mailout-mailback survey in Boston.

Memory Jogger

Because of the level of detail to be reported, household travel/activity survey diaries usually need to be several pages. Although survey designers have produced the diaries in attractive booklets, it is not generally convenient for respondents to carry the booklets with them during the diary period. Survey designers suspect that a high proportion of respondents complete their diaries at the end of the diary period, rather than during it as they asked to do. This can lead to recall problems and inaccurate trip or activity reports.

To reduce this problem, past survey teams sometimes included a memory jogger, a one page trip or activity record where only the most important details of travel are recorded. The memory joggers were designed to be more convenient for respondents to keep with them as they travel around, so it was believed that respondents would be more likely to use them.

For most of these studies, at the end of the diary period, the respondent was asked to copy the information from the memory jogger into the diary and to supply the missing details that the diary required. Unfortunately, it has been found that in many cases, respondents complete either the memory jogger or the diary, but not both. Therefore, it is recommended that memory joggers not be combined with complete diaries.

As discussed previously, for some studies with telephone data retrieval, a simplified diary is the only travel information the respondent is asked to complete. Details of the trips and activities on the simplified diaries are obtained directly through the telephone interview. In these designs, past examples of memory joggers are likely to be more useful in terms of instrument design than complete diaries.

Figure 6.19 shows an example memory jogger from the recent Boston survey.

Forms for Special Questions and Exercises

Some special survey questions, such as stated response questions, often require respondents to examine certain information, to sort printed cards, or to perform some other similar task. This requires the survey team to include even more materials in the survey mailing. Frequently, the materials for these questions are purposely made to be visually interesting for respondents, which enhances respondent willingness to perform the exercises. But, when respondents first receive the mailing, these materials can be distracting.

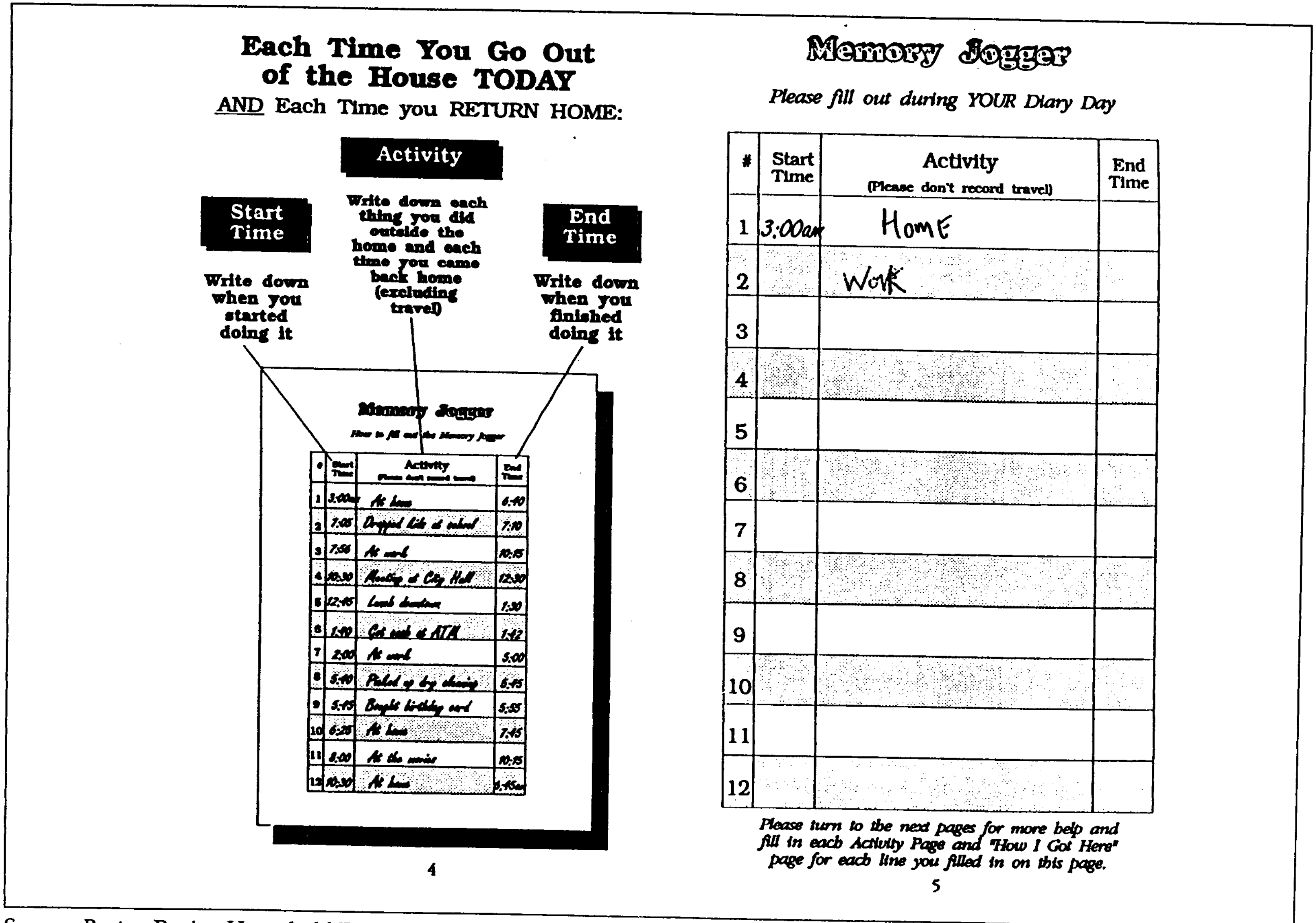
To limit the level of confusion and distraction that respondents will feel if they are bombarded with too many loose materials, it is recommended that such materials be placed in smaller envelopes within the main mailing. The envelopes can be labeled with a simple message, such as "Survey Materials for Question 13. Please see survey instructions."

Reminder Card

Survey teams that ask respondents to complete diaries or to record certain information on particular days often include a card reminding respondents of their day-of-record. The respondent is encouraged to hang the card in some central location, such as on the refrigerator, to remind themselves (and other household members if data are being sought from entire households) that they need to perform their survey duties that day.

Figure 6.20 shows a reminder card from a recent survey effort.

Figure 6.18 An Example Memory Jogger



Each Time You Go Out of the House TODAY
AND Each Time you RETURN HOME:

Start Time — Write down when you started doing it

Activity — Write down each thing you did outside the home and each time you came back home (excluding travel)

End Time — Write down when you finished doing it

Memory Jogger

How to fill out the Memory Jogger

#	Start Time	Activity (Please don't record travel)	End Time
1	3:00am	At home	6:40
2	7:05	Dropped kids at school	7:10
3	7:56	At work	10:15
4	10:30	Meeting at City Hall	12:30
5	12:45	Lunch downtown	1:30
6	1:40	Got cash at ATM	1:42
7	2:00	At work	5:00
8	5:40	Picked up dry cleaning	5:45
9	5:45	Bought birthday card	5:55
10	6:25	At home	7:45
11	8:00	At the movies	10:15
12	10:30	At home	5:45am

4

Memory Jogger

Please fill out during YOUR Diary Day

#	Start Time	Activity (Please don't record travel)	End Time
1	3:00am	HOME	
2		WORK	
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

Please turn to the next pages for more help and fill in each Activity Page and "How I Got Here" page for each line you filled in on this page.

5

Source: Boston Region Household Travel Survey, 1991.

Figure 6.19 An Example Diary Reminder Card

PLEASE DON'T FORGET

Refrigerator Magnet Here!

MAKE THE FUTURE BETTER

Your Activity/ Travel Days Are:

Thursday, October 27th
and
Friday, October 28th

THANKS AGAIN!

Source: CATS Household Survey, 1991.

Cover Letter for Follow-Up Survey

In general, the cover letter for a follow-up mailing of a household travel/activity survey needs to cover the same points as the cover letter for the original mailing. However, this letter should stress the motivational points made in the earlier letter, rather than the informational points. The key message of this letter is that the sponsoring agency needs this household's travel information.

Follow-Up Survey Materials

In general, the survey materials sent in follow-up mailings are the same as for the main mailing. However, the survey team needs to ensure that any dated materials in the original mailing are changed to reflect the follow-up mailing dates. Of particular importance in this regard are any dates associated with travel or activity diary periods. Usually, survey teams establish new diary periods for follow-up survey respondents. If this is the case, the survey team needs to ensure that none of the materials sent in the follow-up reference the old date.

Materials for Surveys with an Interview Component

Even though respondents never see any of the survey materials related to the telephone survey, the design of these materials can have a dramatic impact on the quality of the overall survey effort. Household travel/activity surveys often involve very long and involved telephone interviews. It is essential that these interviews go as smoothly as possible, and for this to happen, the interview forms need to be designed to relieve the interviewer of as much burden as possible.[48]

If a survey contractor is used on the survey, the manager will be able to convert the survey team's questionnaire into a usable interview script for either a PAPI or CATI technique. If no survey firm is involved, the survey team should work closely with the telephone interviewers prior to any

[48]Paul Lavrakas, *Telephone Survey Methods*, SAGE Publications, 1987, p. 142.

Figure 6.20 Example Follow-up Letter for a Chicago Mail Survey

CHICAGO AREA TRANSPORTATION STUDY 300 West Adams Street Chicago Illinois 60606

October, 1991

Dear Chicago Resident:

Late last month the Chicago Area Transportation Study sent you a letter stating that your household had been randomly selected to participate in a major travel survey of persons who live in the city of Chicago. By October 5, 1991 you should have received your survey materials. The survey asked for information about how you traveled on Thursday, October 10, 1991. To date, we have not received your completed questionnaire.

If you still have the survey, please fill it out using Thursday, October 17, 1991 or Thursday, October 24, 1991 as your reference travel day. If you no longer have the materials, but would like to participate, please call us and we will send you a new questionnaire.

Data from this challenging survey will provide valuable insight as to how travel patterns have changed in the city of Chicago. If you have any questions, or if you would like us to send you another questionnaire, please call Mr. Ed Christopher at 1-800-637-9125 (toll free) or 312-793-3467. If you have already mailed back your survey, please disregard this letter.

Very truly yours,

Aristide E. Biciunas
Executive Director

Source: CATS Household Survey, 1991.

data collection to establish the most useful presentations of questions and responses. In almost all cases, surveys that do not use survey contractors will use PAPI techniques, so issues that the survey team should decide on with the interviewers are:[49]

- Standard questionnaire typeset conventions (e.g., questions are typed in capital and lower case letters, instructions are in capital bold letters, etc.);
- Techniques for recording answers;
- Rules for recording open-ended items;
- Standard skip pattern conventions (e.g., color-coded responses and questions); and
- The use of tables and matrices to record data items.

[49]Paul Lavrakas, *Telephone Survey Methods*, SAGE Publications, 1987, pp. 142-146.

6.7 Pretesting Household Travel/Activity Surveys

1. What components of the survey design need to be tested?
2. What pretests are needed to adequately test the household travel/activity survey?
3. How should pretest results be evaluated?

■ Section Summary

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■ 6.7 Pretesting

The complexity and size of household travel/activity surveys makes careful and thorough pretesting an essential element of the survey implementation process. The pretest offers the survey team the opportunity to analyze the household travel/activity survey design elements before it is too late to change them. However, survey teams often fail to take full advantage of the pretests by failing to conduct them in earnest or by conducting them too late in the survey implementation process.

The section summary lists the three overriding questions with regard to pretesting. Essentially, the questions are: 1) what does one pretest?; 2) how does one conduct the pretests?; and 3) how does one analyze the results?.

Survey Design Components Analyzed in the Pretest

As discussed in Chapter 2.0 of this manual and reiterated below, one pretests as many aspects of the survey as possible by performing the exact same steps as the actual survey. Household travel/activity survey pretests provide the survey team with the opportunity to:

- Refine fieldworker, interviewer and office worker procedures and logistics;
- Test and revise question wording, sequencing, and formatting;
- Determine the range of potential responses to questions (such as how many trip or activity spaces are needed on diaries) and identify unexpected responses and respondent behavior;
- Identify problems with the sample population and the sampling frame;
- Develop preliminary estimates of the variance in key variables to help establish final sample sizes;
- Estimate response rates;
- Estimate the survey completion time and cost; and
- Compare alternative approaches to gathering certain data items.

The Pretesting Process

Despite the potential advantages of careful and exhaustive pretesting for household travel/activity surveys, all too often the pretest is the first part of the survey process that is cut back when time and cost pressures build.

The ideal approach for conducting pretests is outlined in Chapter 2.0. The process has three steps: the office pretest, the questionnaire pretest, and the survey dry-run.

In the office pretest, survey team members ask 10 to 12 colleagues and other experts who are not directly involved with the household travel/activity survey to review proposed procedures, and more importantly, to examine the survey questions and the questionnaire. The office pretest can be conducted formally or informally, and usually is a very effective way to identify problems with the questionnaire and with specific questions.

Based on the advice of this expert group, the survey team should revise the questionnaire content, wording, sequencing, length, and format. If the revisions are serious, the revised questionnaire should be brought back to the experts for another round of corrections.

Once the expert group is fairly comfortable with the questionnaire, the survey team should perform a questionnaire pretest. Household travel/ activity survey questionnaires, and particularly heavily-formatted question types like diaries, should be tested on non-experts because they are often confusing to people without knowledge of transportation planning or people who are unfamiliar with survey questionnaires, and because the surveys often rely upon respondents' understanding of technical (and sometimes ambiguous) terms and expressions. During the questionnaire pretest, respondents are administered the survey and are asked to describe any problems or areas of confusion that they encountered.

Often, these pretests are personally-administered even when the ultimate survey will not be. It is becoming increasingly popular to conduct this portion of the pretest as part of a formal or informal focus group of 10 to 15 participants. This allows the survey team to observe first-hand how respondents react to the survey; something which is usually impossible for mail surveys and only partially possible for telephone surveys.

Based on what the non-experts say about the questionnaire, the survey team may decide to revise the questionnaire, and to re-start the pretesting process. More likely, the revisions will be minor, and the survey team will be ready to take the survey instrument to the third phase of the pretest, the household travel/activity survey dry-run, or pilot survey.

In this part of the pretest, the survey team actually completes the survey on a small number of respondents, following all planned survey procedures as closely as possible. Survey teams for large household travel/activity surveys usually conduct pilot surveys with 100 to 300 respondents, often testing slight variations in design. Smaller survey efforts and most market research efforts have pretests with 30 to 50 respondents.

In the pilot survey, or dry-run pretest, all the field implementation and data processing tasks should be performed in an identical manner to the full survey effort. This effort should be "a cradle-to-grave" testing of the entire survey study, from drawing the sample, to conducting the survey, to geocoding responses, to analysis of responses (including perhaps trip linking, sample weighing and expansion, and imputation of missing data). The pretest will be unable to test issues that arise when the survey is applied to the high volume of final respondents, but ideally, the pretest can be used to ensure that all aspects of the survey effort are in place and are operating as expected prior to the beginning of any data collection. Note that if a full dry-run is performed, almost all of the final survey procedures and programs will be developed, improving the efficiency of analysis of the full survey.

Evaluation of the Pilot Test Results

The analysis of pilot study results is described in detail in two recent publications by E.S. Ampt et al.[50] [51] This section briefly describes the analysis of the eight survey design components listed above, but survey teams can expand upon these analyses whenever the pilot survey data permit.

Analysis of Survey Procedures and Logistics

Once the pilot survey is completed, the survey team should compare the actual amount of time and level of effort required to complete individual components of the survey effort to the levels that were predicted prior to the study. Those components that cost more or took longer than expected should be evaluated in detail. The survey team should determine whether the planned procedures had problems and/or whether the individuals responsible for completing the procedures did not complete them correctly.

The survey team should also consider whether inefficiencies in the survey implementation process are likely to be magnified by the much larger final survey effort. For instance, if preparing labels for a mail survey based on a recruitment call is a little slow with a pilot test of a few hundred

[50]A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg, *Survey Methods for Transport Planning*, Eucalyptus Press, Melbourne 1995, p. 216-221.

[51]E.S. Ampt and L. West, *The Role of the Pilot Survey in Travel Studies*, in Ampt, E.S., Richardson, A.J., and Brög, W. (1985), *New Survey Methods in Transport*, VNU Science Press: Utrecht, The Netherlands, pp. 77-78.

responses, it may be a major problem with a survey with thousands of responses. Some aspects of the pilot survey process will necessarily be different from the main survey effort, but many procedural and logistical survey components can be evaluated.

If problems are identified, the survey team will likely want to change training procedures or to re-design staff responsibilities. It is important that the actual survey staff work on the pretest. If interviewers are being used, the ones that are scheduled to conduct the survey should also conduct the pretest. If only experienced interviewers are used in the survey pretest, the pretest will not accurately reflect actual conditions.

Analysis of Survey Questions and Questionnaires

Richardson, Ampt, and Meyburg recommend the following analysis of the questionnaire:[52]

1. Do instructions appear to have been read and followed?

2. Are definitions clear? Are there any consistent misinterpretations on the part of either the respondent or the interviewers?

3. Are questions clear and unambiguous? Are there signs that respondents or interviewers have misunderstood the intent of the question?

4. Do the cover letters appear to have been read and understood? Was the survey information telephone number used by any respondents?

5. Do the answers to individual questions indicate any problems? Are special techniques such as attitude rating scales producing valid answers? Too much bunching of answers may indicate a leading question or badly chosen categories. Too many "Don't know" responses might indicate a vague question, a confusing question, or an unimportant question. Too many refusals to a question may indicate that it should be asked more delicately, the order of questions should change, or the question should be omitted.

6. Is there any evidence that the questionnaire is too long? Too many unanswered questions or hurried answers towards the end of the questionnaire indicate that perhaps the questionnaire is too long for the amount of interest shown in the subject matter.

7. Is the sequencing of questions clear? Are interviewers asking and/or respondents answering questions that do not pertain to them? Are more branching and skipping instructions needed? Is it clear what question should be answered next after a branching question?

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[52]A.J. Richardson, Elizabeth Ampt, and Arnim Meyburg, *Survey Methods for Transport Planning*, Eucalyptus Press, Melbourne 1995, pp. 216-221.

Questionnaire problems should be handled in the same way as for the earlier pretests. If major questionnaire revisions are needed, the questionnaire should be redesigned and the survey team should consider restarting the pretest task. Otherwise, minor questionnaire problems should simply be addressed.

Analysis of Responses

The survey team should evaluate completed questionnaires for layout problems. All responses should be easily read by coders and data entry specialists. The survey team should ensure that enough space is provided for potential responses, and that the questionnaires do not require interviewers or respondents to try to fit written responses in extremely small areas. A common problem on factual questions is that an "other" response requests a more detailed description, but the layout of the form makes it difficult or impossible for the respondent to comply. If a diary form is used, the survey team should ensure that the number of potential activities and trips on the diary is adequate for the diary period without being excessive (causing the survey to appear even more challenging).

The survey team should also determine whether any questions or parts of the survey forms have been systematically overlooked by respondents, and conversely whether sections of the questionnaire that should be skipped are being completed.

Analysis of the Adequacy of the Survey Population Definition and the Sampling Frame

Because the output of the pilot survey, like the output of the actual survey, will usually be the input datafiles for one or more travel models, the survey team can evaluate the pilot survey returns to determine whether the survey population and sampling frame have been defined properly for the likely analyses. The survey team should determine whether individuals outside of the scope of potential analyses are being asked to complete the survey. If they are, the survey team should consider ways to redefine the survey population, to improve the sampling frame, or perform better screening procedures. There is no sense in expending resources on individuals or households that will not factor into the final analyses.

Similarly, the survey team should attempt to identify segments of the survey population (geographic areas, income levels, household types, etc.) that did not seem to be getting contacted in the pilot survey. In most cases, missing population segments are caused by the small pilot survey sample sizes, but the survey team should ensure that these segments are, in fact, represented in the sampling frame. Usually, Census data sources can be used to identify missing segments of the population of interest.

Analysis of Sample Size Estimates

The pilot survey provides preliminary information on how precisely the actual survey sample sizes will measure certain parameters. As discussed in Chapter 5.0 and Section 6.5, the actual precision of survey-derived parameters can only be known after the final survey is complete and the data collection resources have been depleted. To estimate the necessary sample size that will provide adequate precision before the survey, the survey team must estimate the variance in key variables. The pilot survey represents one of the best sources of information on the likely final variances.

The survey team should calculate the variances and coefficients-of-variation for the key pretest results, and estimate the likely final survey precision levels. The survey team may determine the need for either more or less completed surveys based on this information. The necessary sample size to produce a desired confidence level and a maximum sampling error is given by Equation 5.8a:

$$n' = (CV)^2 \frac{Z^2}{d^2} = \frac{\sigma^2 Z^2}{m^2 d^2} \qquad \textbf{(Eq. 5 8a)}$$

where:

CV = Coefficient of Variation

Z = Z-Statistic

d = Relative precision level

σ^2 = Variance of the random variable in the population

m = Mean of the random variable in the population

The pilot test provides the survey team with reasonably accurate estimates of what the variance, σ^2, and the coefficient of variation, CV, will be in the final survey. By plugging in the pilot test derived coefficients of variation and the desired precision and confidence levels into the above equation, the survey team can determine the minimum final sample size. Based on this calculation, the survey team can increase or decrease the survey sample size target or adjust desired levels of precision and confidence.

Shiffler and Adams have found that for small sample pilot surveys, the variance and coefficient of variation estimates tend to systematically understate the final survey's actual variance and coefficient of variation.[53] The authors suggest applying the correction factors shown in Table 6.20 to calculated sample size estimates that are based on small sample pilot surveys. For a pilot survey with ten responses, Shiffler and Adams suggest that it is necessary to increase the sample size calculated with Equation 5.8a and the pilot survey's coefficient of variation by 7.1 percent.

It is recommended that survey teams perform pilot surveys with more responses than are shown in the table, but because household travel and activity survey samples are usually stratified, it is likely that individual strata will have pilot survey responses in the ranges shown.

Of course, whenever possible, the survey team should use more than the minimum calculated sample size because, even if the above correction factors are applied, there is no way to know if the final variance and coefficient of variation will be higher than for the pilot study. The above corrections simply equalize the probability that the calculated sample size will be sufficient.

Analysis of Response Rates

The survey teams should carefully track the levels and types of non-response encountered in the pilot survey. The biggest question in this regard is whether response levels are different than the survey team has anticipated. Depending on the survey method, variations in response rates can have a significant effect on the survey cost and completion schedule. In addition, higher than expected non-response levels may severely weaken the confidence one can have in survey-derived parameters.

With 30 to 50 completed questionnaires, the survey team can begin to get a picture of what the actual response rates and survey completion times are likely to be. This will allow the team to get a much more accurate estimate of the survey fieldwork costs and the amount of time the survey will take. If these actual measures are significantly different than had been estimated, the survey team will want to consider drastically changing the survey method and techniques. Of course, this will entail re-performing the survey design, sampling, and organization tasks, to some extent.

In addition to measuring non-response levels, the survey team should, to the extent possible, surmise the causes of the non-response. If any identifying information is available for both the pretest respondents and non-respondents (such as the location of their homes or type of housing unit),

[53]Ronald Schiffler and Arthur Adams, "A Correction for Biasing Effects of Pilot Sample Size on Sample Size Determination *Journal of Marketing Research,* Vol. 24 (August 1987), pp. 319-321.

Table 6.20 Shiffler's and Adam's Recommended Sample Size Correctional Factors

Pilot Survey Responses	Correction Factor
3	I.443
4	I.267
5	I.192
6	I.149
8	I.069
10	I.071
12	I.064
15	I.049
20	I.036
40	I.017
60	I.011

the survey team may be able to determine whether non-response bias is present. Some practitioners have used follow-up interviews with pilot survey non-respondents to develop strategies in the final survey design that address the potential biases.

Analysis of Survey Completion Time and Cost

If the pilot survey is carefully monitored, the survey team will be able to obtain fairly accurate estimates of the times and costs of each element of the survey fieldwork. Of particular interest, in this regard, is the time of any interviews that are conducted. Interview time is an important design parameter because interviewers are generally paid by the hour, and because as interview times increase, so do the rates of incompletions and non-responses.

If the final survey times and costs are estimated to be longer and/or higher than the sponsoring agency has available, the survey team can:

- Change survey procedures;
- Omit some questions to shorten the survey;
- Lower sample size targets;
- Increase the data collection budget; or
- Cancel or postpone the final survey work.

Note that if contractors and consultants are being used, the sponsoring agency should include in the contract an allowance for this decision to be made. Often, agreements are formulated in which it is to neither party's advantage to consider the full range of choices. Under these conditions, the usefulness of the survey pretest is diminished.

Analysis of Alternative Approaches and Methods

During the survey design effort, it is common for survey team members and/or other experts to disagree on the best approach to be used for certain elements of the survey design, or for the survey team to simply not be sure what is the best approach. The pilot survey is the ideal place to select between alternatives because slightly different procedures or instruments can be given to different groups of pretest respondents, and then can be compared somewhat objectively.

The recent NCTCOG household activity survey pretest involved comparing:

- Two different diary recording periods (24-hour versus 48-hour);

- Two different diary formats (complete diary versus simplified diary);
- Two different data retrieval methods (CATI versus mailback); and
- Three different types of incentives.

To perform these types of controlled experiments, the pilot survey sample size may need to be increased, especially if the different elements being compared are likely to interact with each other.

Pilot Survey Schedule

Usually, the pilot survey results do not imply the need for drastic changes in the survey design prior to the final survey, but because revisions of some type are to be expected, it is essential that the survey team complete the pretest well in advance of the planned fieldwork period. In addition, the survey team needs to allocate sufficient time and money resources to pretesting, so that they are prepared to make changes in the questionnaire and procedures based on the outcome of the pilot survey.

6.8 Training and Briefing for Household Travel/Activity Surveys

1. What topics need to be covered in fieldworker training and briefing sessions?
2. How should fieldworker training and briefing be conducted?

■ Section Summary

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6.8 Training and Briefing

Regardless of the level of effort that the survey team puts into the household travel/activity survey design, the success of the project is ultimately up to the interviewers and survey office staff who actually implement the effort. If survey workers are unprepared for the work, the survey will suffer in terms of schedule, budget, and quality. Following the convention established in Chapter 2.0, we define two tasks for the preparation task, training and briefing. Training involves teaching workers their jobs or refreshing their memories about the basic aspects of their jobs. Briefing involves teaching workers about the nature of the particular household travel/activity survey, and going over specific issues related to this job.

The two broad issues related to training and briefing workers to conduct household travel/activity surveys are listed in the section summary. This section briefly describes these issues.

Training and Briefing Topics

Since household travel/activity surveys generally involve mail surveys, telephone surveys, or most likely both, the survey workers who will need to be trained and briefed include telephone interviewers and survey office workers.

Training Topics for Telephone Interviews

The goal of the telephone interviewer training sessions are to bring the basic skill levels of interviewers up to the point where they can consistently perform their jobs well. For professional interviewers, the topics covered will be ones they have heard before. However, given the interviewers' importance in the survey process, it is most certainly worth reviewing good practices, and preventing the development of bad habits.

The following topics should be addressed:

- **Basic Survey Research Principles** – Why interviewing people is a useful and accurate way to obtain information;

- **Importance of Quality Interviewing** – How interviewers can contribute to survey bias, and the difficulty (impossibility) of correcting these problems;

- **Respondent Motives** – How and why respondents evade questions or fail to provide the truth, and how the interviewer can help to reduce these problems (and how interviewers can inadvertently make them worse);

- **The Importance of Consistency Between Interviewers** – How to be a "standardized" interviewer, not too detached, not too enthusiastic;
- **Ways for Handling Refusals** – How to be, and the importance of being both polite and persuasive;
- **Productivity Expectations** – Quality and quantity of interview data expected from them, and their refusal rate;
- **Supervision** – How they will be monitored, and where they can find help;
- **Interview Scripts** – Conventions used on the written or computerized questionnaire;
- **Recording Data** – Where and how to enter data;
- **CATI Procedures** – How to run a computerized system, and what to do if problems are encountered (CATI surveys);
- **Progress Forms** – Procedures for completing tally sheets (PAPI surveys); and
- **Employment Considerations** – Interviewer pay and benefits, as well as other administrative procedures, like timesheets.

Briefing Topics for Telephone Interviewers

The briefing session for telephone interviewers should address each of the topics listed in Chapter 2.0, as well as more specific telephone interviewing issues. The briefing should include:

- **Purpose of the Survey** – Including sponsorship, analysis goals, expected uses of the survey data;
- **Description of Sampling Approach** – Respondents sometimes ask about how they were selected;
- **Use of the Call Sheet or CATI Calling Procedures** – How interviewers will record which numbers have been tried, and which need to be tried;
- **Introductory Language and Screening Questions** – How interviewers begin the call;
- **Details About Specific Questions** – Why the questions are being asked, and why they are worded as they are;

- **"Fallback" Statements** – Standard replies for likely respondent questions;

- **Assurance of Confidentiality** – Specific steps being taken to assure respondent confidentiality; and

- **Editing Completed Interviews** – What to check and verify on the survey forms to ensure completeness.

Training and Briefing Topics for Mail Survey Office Workers

None of the tasks related to implementing mail surveys are likely to be very difficult for people with clerical or administrative experience, but the nature of the survey work requires that staff be particularly good planners. The mail survey office worker needs to consistently know what he or she needs to do next, and what to do after that, because deadlines of various types creep up quickly once the survey process is underway.

Therefore, the key training and briefing topic for mail survey office workers is to develop within each worker a detailed understanding of all the mail survey steps, and the amount of time and effort required in each task.

Conducting the Training and Briefing

Training and Briefing Session for Telephone Interviewers

Typically, for previously trained telephone interviewers, the training and briefing sessions can be combined. The sessions generally consist of four elements:

- Training lecture by survey manager;

- Review of the household travel/activity survey by a representative of the survey-sponsoring agency;

- Formal review of the questionnaire; and

- Role-playing and practice interviews.

Most training procedures are presented to interviewers by the survey manager. Next, the interviewers are told about the household travel/activity survey. It is usually very effective to have a survey team member or a staff member from the sponsoring agency lead this discussion because it demonstrates to interviewers how important the survey is to the sponsor, and the personal contact motivates the interviewer.

The third element of the training/briefing session is a detailed walk-through of the questionnaire. To perform this, many recent survey teams have prepared interviewer manuals which can be used as references by interviewers once the training/briefing session is completed. These recent documents are likely to be extremely useful to new survey teams. An example manual from a recent Tucson telephone-mail-telephone survey is presented in Appendix E of this manual. Survey teams should consider contacting the sponsors of previous household surveys that employed similar methods to the ones the team envisions for copies of their interviewer manuals.

The final part of the session is used to have interviewers practice with each other and/or with supervisors. All interviewers need to go through the entire survey two or three times before actually beginning the interviews. One way of helping interviewers is to record their "role play" interviews and to ask them to identify ways in whch they could improve.

Training and Briefing Session for Mail Survey Office Workers

The briefing session for office staff involves presenting them with detailed descriptions and schedules of tasks. Office workers should be shown the likely "deadline crunches," and the importance of the many identified deadlines.

6.9 Interviewing and Questionnaire Distribution for Household Travel/Activity Surveys

■ Key Issues

1. What are the processes for conducting the household travel/activity survey?
2. What techniques should be used to monitor and maintain data collection quality?

■ Section Summary

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■ 6.9 Interviewing and Questionnaire Distribution

Once the household travel/activity survey data collection is underway, the survey team's primary role is to monitor progress and quality, and to be prepared to correct problems as they (inevitably) arise.

Monitoring and Maintaining Data Collection Quality in Telephone Surveys

One of the major advantages of centralized telephone interviewing facilities is that they provide the opportunity for monitoring the telephone calls as they take place. Usually, survey contractors have trained supervisors to perform the following functions:

- Monitor interviews by listening in on the telephone calls, and, if CATI is being used, follow along with the data entry.
- Validate completed questionnaires in PAPI surveys. Once an interviewer finishes an interview, he or she checks the completed form to make sure it is complete and legible, and then turns the completed form into a supervisor, who validates that the form is in fact complete and legible.
- Ensure call sheets and tally sheets are being completed and processed correctly by respondents.
- Provide assistance to interviewers who have unexpected problems.

Sometimes, supervisors or survey team managers randomly call respondents for whom interviewers claim to have completed their interviews to verify: 1) that the interview did, in fact, take place; and 2) confirm the answers to a few key questions.

Many survey contractors are able to allow survey managers and clients to monitor survey calls remotely. Survey team members can listen from their own phones to the telephone interviews without being heard by interviewers or respondents. By monitoring pretest and actual telephone surveys, survey team members may be able to head off potential problems before they have too large of an effect on survey results.

Monitoring Mail Survey Data Quality

During the fielding of mail surveys and telephone-mailout-mailback surveys, the burden is primarily on the respondents. The survey team can do very little to maintain the survey's quality once it reaches potential respondents. However, the survey team is likely to remain quite busy throughout the fieldwork period collecting and evaluating bits of information and early survey results in an effort to monitor the survey's quality and to determine if any procedures should be revised in follow-up mailings.

The survey team will receive its first piece of information on survey data quality soon after the first mailing of either a pre-notification letter or of the mail survey materials, with the return of undeliverable mailings. There are a number of reasons that the mailings might be returned, including a wrong address or an outdated address for someone who has moved, and even in the telephone-mailout-mailback survey where people are asked to provide address information, some percentage of returned mailings is to be expected. The survey team should determine whether the number that are returned is in line with prior expectations. If it appears too high, then it is likely that there is either something wrong of a clerical nature or that there is something wrong with the sampling frame.

Shortly after surveys are mailed, some completed forms will trickle in to the survey office. Survey team members should analyze these early returns fairly carefully to determine if any identifiable trends in item non-response or response errors can be detected. In addition, the survey team should evaluate the physical condition of the returned surveys, and whether the survey instruments appear to be sufficient in terms of space and layout to obtain readable responses. If problems are detected with early returns, some modifications and clarifications might be able to be made for follow-up letters and questionnaires. Finally, the survey team will need to respond to inquiries and complaints from respondents and potential respondents as they occur. It is usually very difficult to plan for staff time for this period, because of the variability of potential tasks that could pop up.

6.10 Coding and Data Entry for Household Travel/Activity Surveys

■ Key Issues

1. What needs to be done to translate survey responses into raw data?
2. What techniques are available for coding complex responses?

■ Section Summary

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6.10 Coding and Data Entry

Once the household travel/activity survey data are collected, the survey team needs to begin the process of transforming raw responses into usable data. Coding survey responses and entering the coded data into a database are the first steps of data processing for the household travel/activity survey. These tasks have become substantially easier due to improved computing capabilities – in fact, for CATI surveys, the tasks have been completely folded into the data collection task –but for mail surveys and PAPI telephone surveys, the tasks remain sources of potential serious errors, and for that reason should be carefully planned and carried out.

Translating Survey Responses Into Usable Data

Once the survey instruments are finalized, the survey team can begin drafting the survey's "code-book." This manual will serve as a guide for staff assigned to the coding task, and eventually as an important piece of survey documentation. The first draft code-book will set the basic coding conventions for each survey question's potential responses, and begin to outline any special coding considerations and procedures, such as the issues related to geocoding. This draft code-book will be revised after the survey pretest to incorporate any unexpected replies, and to include any new or revised questions. Finally, the code-book may be revised again as the survey results begin to filter in.

Using the code-book, survey coders go through the survey instruments, and either mark codes in the margins of the instruments or on separate coding sheets. Data entry specialists then enter the coded responses into a database file or an ASCII flat file. All codes should be clear and unambiguous, so that they can be easily seen and understood by those who enter the data.

In some instances, where all response categories are closed-ended, and the survey responses have been pre-coded, the coding and data entry task may be performed simultaneously. However, even if pre-codes are present, if a questionnaire has any complex questions or open-ended responses, it is usually better to formally code the responses before data entry.

Coding Complex Responses

The most difficult and time-consuming coding task is the coding of questions without response categories. Coding open-ended responses is a challenging intellectual task, requiring the coder to have a feel for subtleties of language, subject matter nuances, and the study area.[54]

Coders need to be consistent over time, and they must also be consistent with each other. Most household travel/activity surveys will have sample sizes that will require coding teams, rather than having one individual set all the codes. It is essential that each coder on the team performs his or her tasks consistently with the rest of the team. Usually, all members of the coding team are asked to code some of the same surveys, so that comparisons can be made between coders.

Among the most difficult questions to code are ones that ask for geographic locations. Chapter 14.0 discusses the many aspects of this task.

Data Entry

Once all responses have been coded, the data from all self-completion forms and completed PAPI telephone survey forms should be entered into data files. Survey data are most commonly entered in ASCII flat files, with specified character columns for each coded response. Alternatively, the survey data can be entered directly into database or spreadsheet software packages. These packages can be manipulated to provide user friendly data entry displays and reasonableness checks on entered data.

It is generally cost-effective to validate all data entry by having different data entry specialists enter the same data. Professional data entry personnel make typographical errors very rarely, and the probability that two people will make the same error is very small. By comparing the two files, almost all data entry errors can be detected. The small additional cost of entering all data twice is almost always preferable to the cost and time spent sorting out errors during the editing task.

[54]Charles Backstrom and Gerald Hursh-Cesar, *Survey Research*, 2nd edition. John Wiley & Sons (1981). p. 314.

6.11 Editing and Cleaning Household Travel/Activity Survey Data

■ Key Issues

1. What data cleaning tasks should be completed?
2. What can be done to validate survey responses?
3. What analytical techniques can be used to correct for non-response?

■ Section Summary

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6.11 Editing and Cleaning Data

The section summary page identifies three editing and cleaning tasks that can be completed for any survey effort, including a household travel/ activity survey. Once coded data are entered into the preliminary survey database, the survey team will need to spend a great deal of effort verifying the validity of the entered data, and editing the data, as necessary. Richardson, Ampt, and Meyburg summarize the data editing phase of the household travel/activity survey process, as follows:[55]

> The editing phase of the survey process is perhaps the most boring, but it is also one of the most important tasks. Most survey designers would admit that more time and effort goes into the editing task than almost any of the other tasks; and such effort is worthwhile. It is useless to proceed straight into analysis hoping that the data are free from error; there will always be errors in the data as initially coded.

Data Cleaning Tasks

Three simple types of errors are likely to be present in the raw survey dataset:

- Incomplete records;
- Invalid field entries; and
- Inconsistent field entries.

Simple visual inspection of the data file will reveal if records are of variable lengths. If a record is found to have the wrong length, then it has either been miscoded or has been entered incorrectly. The survey team should locate the original data collection instrument, and use it to correct the record.

Next, the survey team should compare all data field entries with the range of acceptable codes for the field, taken from the final code-book. The data collection instruments for records with any fields that are out-of-range should be located, and the records should be adjusted.

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[55]A.J. Richardson, E.S. Ampt, and A.H. Meyburg, *Survey Methods for Transport Planning*, 1995, Eucalyptus Press, p. 299.

Finally, the raw data should be examined by comparing related fields to ensure that they consistent with each other. Richardson, Ampt, and Meyburg recommend the following consistency checks:[56]

- If the last diary trip of the day is not to home, check the data collection instrument;
- If a trip's origin and destination are the same place, check the data collection instrument;
- Compare place types at origin-and-destination to origin-and-destination activities;
- Calculate implied trip speeds, and check records with very high or very low speeds;
- Check records with unusually long trip times;
- Check records with unusually long walk trips;
- Compare age and possession of a driver's license;
- All drivers should have licenses;
- Compare age and employment status, school status, retired status;
- Check vehicle, make, model, and body type consistency;
- Check to make sure that the number of diaries matches the number of household members; and
- Check to make sure that vehicle information has been obtained for all vehicles.

If the travel survey team has used a CATI system that has been programmed well, the CATI survey data should not have any of these data cleaning problems listed above. However, if the system failed to prevent an illogical response, the record may need to be deleted, or the respondent household may have to be re-contacted for clarification.

On the other hand, mail survey and telephone PAPI instruments are liable to have a number of data records that need to be verified and edited. Fortunately, the original data collection instruments are likely to be available for review.

[56]A.J. Richardson, E.S. Ampt, and A.H. Meyburg, *Survey Methods for Transport Planning*, 1995, Eucalyptus Press, p. 299.

Validation of Survey Responses

Survey teams should seek ways to test the validity of the collected survey data. For interviews, the most simple validation technique is to re-contact a small number of respondents to verify that they completed the survey, and that they provided certain answers in the database. In addition to allowing the survey team to check-up on interviewers, this approach is used to test the reliability of questions (whether they receive the same answers from the same respondent over time). This type of validation can also be used to a limited extent with mail surveys, provided that respondents have listed telephone numbers, or that the mail survey asks respondents for their phone numbers.

Both mail and telephone surveys can be validated with aggregate third-party data from other survey efforts, the Census, or the agency's databases. For instance, demographic distributions should be compared to Census distributions. In addition, preliminary trip-rate information could be compared with existing model estimates.

Corrections for Non-Response and Response Errors

Strategies for Dealing with Item Non-Response

In every household travel/activity survey, some respondents will be unwilling or unable to answer all the questions they are asked. In particular, respondents often refuse to answer income questions. If the survey team intends to use income data in later analyses, they need to do one of the following:

- Ignore the non-response;
- Use a modeling variable to describe the non-response; or
- Apply statistical procedures to impute missing or incorrect data items.

In the first strategy, the survey team develops travel models and other analyses with the data records that are complete. These records with missing data are not used in the analyses. This strategy is the most straightforward approach for getting into the analysis, and for obtaining results, but the resulting analyses are hampered by higher levels of imprecision (due to smaller numbers of input data records) and potential non-response bias. If the incomplete records are treated as non-responses, and the survey team has high-quality socioeconomic demographic data, (such as Census data) the bias may be reduced somewhat through the application of correction weights. This correction is described in the next section.

A second approach for dealing with missing data fields is to develop models and analyses using one or more parameters that indicate whether a record is missing certain data items. These parameters are used to explain the non-random nature of item non-response and limit the effect of the bias, but they can be problematic when the estimated models are applied.

Suppose a multiple regression trip generation model were developed from a household travel/activity survey, and that a dummy variable for missing income information (equals one if income data are missing; zero if income data are present) is included in the model estimation. If the coefficient on the summary variable is positive, and significantly different from zero, the model indicates that income non-respondents travel more than income respondents (all other things being equal). The model parameter identifies and quantifies the relationship between income non-response and travel levels. The problem is that when the regression equation is applied to the population, it is necessary to predict how many and which members of the population would have answered the income question if they had been asked it.

Two methods can be used to apply such models. First, the parameter can simply be ignored during application, and be used only in estimation. Alternatively, a separate regression, discrete choice, or simulation model could be constructed to determine whether a household is likely to respond to the particular data item.

Note that the first two strategies for dealing with item non-response do not require the survey team to change the survey database in any way, except for adding a few simple dummy variables. In the third approach, missing data are actually estimated, and input into the database.

To limit the effects of item non-response, European and Australian travel survey teams commonly develop statistical relationships between different survey variables, which can then be used to predict the value of a particular missing item. These methods are also beginning to gain acceptance to some degree in the U.S.[57]

In its most simple form, data imputation involves using completed survey records to develop mathematical models that try to predict the missing components of the other survey records. For instance, if a household travel survey consists of 1,200 records with valid responses for questions about household income and all other household variables, and 100 records with valid responses for all the variables except income, the survey team could use the 1,200 records to estimate a regression, cross-classification, or discrete choice model that relates income to the other variables, and then apply the estimated model to the 100 other records to predict

[57]Chandra Bhat, *Estimation of Travel Demand Models with Grouped and Missing Income Data,* Transportation Research Record 1443 (1994) Transportation Research Board, pp. 45-53.

their income levels. The survey records for these 100 records could then be edited to include the imputed estimates.

The problem with this simple imputation approach is that it fails to recognize that the factors that lead respondents to fail to report data items may be the same factors that are being used as explanatory variables in the imputation model. To address this, Bhat suggests estimating two simultaneous models – one model seeks to explain the reporting/non-responding phenomenon and the other develops the relationship between the variable of interest and other variables – using maximum likelihood estimation techniques.

Some travel surveyors have raised concerns that imputing data can increase bias in some cases. To some analysts, imputing survey data is the same as simply making up data. However, the recent non-response workshop at the TRB Conference On Household Travel Surveys: New Concepts and Research Needs, endorsed the use of imputation techniques, provided that they were done with care and were well-documented. All changes and corrections to the original survey data need to be noted, and where possible, the effects of these changes should be evaluated.

Strategies for Addressing Response Errors

In general, it is quite difficult for survey teams to identify response errors. If a respondent answers a question incorrectly for some reason, the survey team will almost never be able to determine it. However, for com-plicated multi-part questions, such as travel and activity diaries, response errors (primarily in the form of incomplete information) are sometimes discernible and correctable.

Travel and activity diaries, like those shown in Figures 6.4 through 6.11, often request a great deal of information on single activities or trips. It is easy (and quite common) for respondents to miss certain questions under these conditions. Fortunately, it is often possible for survey editors to determine what the respondent should have filled-in. For instance, probably the biggest single response error on travel diaries is for respondents to forget to mark whether a given time was a.m. or p.m.

Clever editing staff can often determine trip purpose, activities and modes (among other things) in incomplete diary entries by examining other trips or activities of the respondent or the respondent's fellow household members. Although this detective work is generally slow, and tedious, the rewards, in terms of cleaner data for analyses, are significant. It is recommended that survey teams that field diary surveys budget significant resources for such efforts.

If a diary cleaning effort is undertaken, it is imperative that editors:

- Correct only those data items that can be unambiguously determined; and

- Carefully document any changes made to the survey database.

A special type of diary response error is the unreported trip (or activity). It is very important that the survey team seek to minimize these errors, because one of the most common survey analyses is the calculation of average household trip rates, and because there is evidence that unreported trips are not representative of the population of total trips.

Without other information about respondents' trips, or activities it is usually very difficult to impute an entire trip, along with its details.

However, there are ways to detect missing trips, including:

- Are the trip ends or activity locations listed in the diaries linked properly? Does trip number N start where trip number N-1 ended?

- Do other household members report being with the respondent at a time or place not reported by the respondent?

- Do all trips back to a respondent's home seem to be reported? Return home trips are the most commonly omitted trips in diaries.

- Does the respondent make it back home by the end of the period? Not all respondents finish the diary period at their homes, but the vast majority do.

- Does the respondent report the expected amount of time and number of instances of particular activities, such as meals, sleep, etc.?

If the data retrieval is completed with CATI techniques, these or other tests can prompt interviewers to probe for further details. When mail surveys or PAPI retrieval calls are used, the survey team should consider validation/verification contacts, and perhaps adjustments to trip rate calculation procedures.

6.12 Programming and Compiling Data for Household Travel and Activity Surveys

■ Key Issues

1. Are the responses adequate for analyses?
2. How should the household travel/activity database be structured?
3. How should the survey data be expanded for future analyses?
4. What survey data summaries should be compiled?

■ Section Summary

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■ 6.12 Programming and Compiling Data

The key issues related to programming and compiling data for household travel/activity surveys are briefly discussed in this section. The programming and data compiling activities are directly related both to the objectives of the survey analysis and to the design of the survey which is also guided in part by the ultimate survey analysis objectives.

Determining the Adequacy of Responses

Once individual records have been cleaned and edited to the maximum extent possible, they should be evaluated for completeness and usability for analysis. The survey team should examine the database, and drop any data records that:

- Have been developed from out-of-scope individuals or households that may have been surveyed by mistake;

- Exhibit serious basic flaws in consistency and logic; or

- Are too incomplete to be useful in the anticipated analysis.

Sometimes, despite efforts to the contrary, survey responses are obtained from people who live outside the study area or for people who should have been screened out of the survey process. Before conducting any analysis, the records for these individuals should be dropped from the database. These records should not be considered in the calculation of response rates, nor should they be included in any tabulations.

The second type of data record that should be removed from the database are those that contain numerous inconsistencies and illogical information. Despite efforts to edit and clean the data, some records will still contain basic flaws that will make them unusable. If attempts to verify or correct response problems are unsuccessful, and the problems are felt to cover several data fields or particularly important pieces of information, the corresponding data record should be marked unusable and deleted from the analysis dataset. In this case, the record would be counted in the same way as a refusal in the calculation of the final survey response rate.

In household travel/activity surveys in which all household members provide information, it is common to be unable to get the requested information from one or a few individuals. Usually, repeated efforts are made to track down these elusive respondents with follow-up calls and mailings, but there will almost always be a few people who cannot be contacted or who refuse to participate. In these cases, it is important that the survey team have a clear description of what will be considered a "completed household". For some transportation planning analyses, it is essential that data be collected for all household members. For other analyses, planners can work around having some incomplete data by weighting or by estimating key parameters for the missing individuals.

As discussed in Section 6.3, the survey team should determine the definition of a completed record prior to any field work, because the definition will affect the survey follow-up strategy. It is quite easy to spend hundreds of dollars trying to complete surveys on households with elusive members. The survey team should consider at what point it is more cost-effective to give up on a particular household, and find a different one, so the definition of an acceptable response is important.

If a household data record is unacceptably incomplete, according to whatever standard definition the survey team sets, then the record should be marked unusable and dropped from the dataset. The record would be counted the same way as a refusal in the calculation of the final survey response rate.

Database Structure

Household travel/activity surveys can differ considerably with respect to the level of detailed travel information that is collected in the survey, the focus of the survey on the travel behavior of the household as a whole versus its individual members, or the broader analysis framework that may require an activity-based rather than the more traditional trip-specific approach.

The database for a household travel survey could therefore be developed to accommodate a hierarchical structure which can include up to four layers nested within each other. For the most detailed household travel/activity survey, the corresponding units of analysis at each layer would thus be:

- The household treated as a whole;
- Each surveyed member of the household treated individually;
- Each trip made by the household members that were surveyed; and
- Each activity carried out as part of a specific trip.

The original raw database for the household travel/activity survey would include all the household-related information and would thus consist of as many records as there are usable responses. However, such a database could also be used as a basis to create three additional databases that could be used to support the analysis of individual travelers' trip making, the analysis of specific trips, or the analysis of activities undertaken by the respondents. As a result, each of the four datasets that would be created would have all the information necessary for transportation analysis and modeling.

The contents of each dataset can be distinguished between information that is unique to each layer of analysis and information that is common to two or more hierarchical layers. Information that uniquely characterizes each household such as income and household size, location of residence, automobile ownership, and household trips rates would be linked to or included in each person, trip or activity data record. Similarly, information that uniquely characterizes individual members of the household such as age, sex, occupation, education, location of workplace, and auto availability would be linked to or be repeated in each trip and activity record generated by the respondent. Finally, if activity-based design is being used, trip-specific information on mode choice, total cost, travel time, and distance traveled would be linked to or be repeated in the record of each activity that was part of the same trip.

Although such a database structure results in a set of four internally-consistent datasets from the household survey, it does not always represent the most efficient way of storing information. This is particularly true in the case of extensive surveys with large sample sizes. In such cases, a relational database structure could be used instead of the four-file structure to reduce the amount of overlap and the repetitiveness of information across the different layers.

Expansion of Survey Results

The objective of data expansion is to make it possible to reach valid conclusions about the entire study population based on the survey results. Data expansion for simple random samples is straightforward. Suppose a sample of 100 households is drawn from a population of 65,000 households, and that 12 households of the 100 are found not to have any automobiles available to them. We can expand the survey results to say that there are 65,000 x 12/100=7,800 households in the study area that do not have an available auto. Unfortunately, the expansion of household travel and activity survey data is complicated by two factors:

- Household survey sampling is generally performed using stratified random sampling procedures, rather than simple random sample procedures; and

- Invariably, because of random sampling error and various survey biases, such as nonresponse, interviewer error, etc., the actual survey sample will not be totally representative of the survey population in terms of the variables that explain travel behavior.

Expanding the household survey data set, given these limitations, is discussed below.

Using the U.S. Census Data for Survey Expansion

Fortunately, in most cases, the survey team has an excellent source of information on study area respondents from which the household survey data may be expanded – The U.S. Census data. The Census summary tape files provide the survey team with detailed socioeconomic and demographic summary information for small geographic areas. In addition, detailed cross-tabulations of key travel-related data are available from the Census Transportation Planning Package.

These and other Census products are described in Appendix B of this manual.

If the household travel/activity survey is performed more than a few years after the Census, the travel survey team may need to consider ways to update the Census data to more accurately expand the household survey. Some potential strategies for using the Census data for expansion purposes in non-census years include:

- Accept the last Census as the most accurate information source and use the data without adjustment;
- Make ad-hoc adjustments to the Census data based on available Census, state, and local estimates and, perhaps, on econometric models developed from Census PUMS data; and
- Use one of the first two options temporarily, and then re-expand the data with the next Census data or with interpolated estimates based on the two Censuses.

Household Characteristics Used in Survey Expansion

The survey team should expand the household survey data so that the demographic characteristics that best describe variations in key travel behaviors are made to match those of the study area population. The survey team should select the characteristics based on the expected uses of the survey results and on the availability of data on the survey population.

For most household travel and activity surveys, a key analysis will be the determination of household trip rates and trip generation. Key expansion variables that are commonly used in this situation include:

- Geographic location (such as super district);
- Household size;

- Number of vehicles available per household;
- Number of workers per household;
- Type of housing unit; and
- Household income.

The first three variables are probably the most common in the U.S., but for highly specific analyses, the survey team should consider other appropriate variables. Expansion variables are typically categorized into a small number of categories for expansion. The variables used for expansion can be limited to those used for stratifying the sample (assuring a stratified sample) or include other variables, as well.

Data Expansion with a Single Control Variable

When a survey team is seeking to use a single variable for data expansion, the process is not complicated. The expansion factors are just the actual number of people in each data category for the population, divided by the number derived from the survey. Suppose a household travel survey for a region obtains the geographic distribution of households shown in Table 6.21.

Table 6.21 Geographic Distribution of Household Survey Responses for an Example Survey

Subregion	CBD	NE	E	SE	S	SW	W	NW	N	Total
Responses	115	114	111	97	108	113	106	120	116	1,000

The relatively equal distribution across subregions is consistent with a survey effort that was stratified on the basis of geography. Table 6.22 shows the actual number of households in each subregion based on Census data.

Table 6.22 Actual Distribution of Households for the Example

Subregion	CBD	NE	E	SE	S	SW	W	NW	N	Total
Responses	1,200	3,800	4,400	9,000	8,500	5,200	11,400	10,300	10,400	64,200

The expansion factors for the household survey are shown in Table 6.23.

Table 6.23 Calculated Expansion Factors for the Example

Subregion	CBD	NE	E	SE	S	SW	W	NW	N
Responses	10.4	33.3	39.6	92.8	78.7	46.0	107.5	85.8	89.7

This means that each of the 115 survey records for households in the CBD is equivalent to 10.4 actual households (1,200/115=10.4). Each of the 116 survey records from the North Subregion represents 89.7 households (10,400/116).

This simple expansion process may be applied on two or more variables, if the expansion data provide cross-tabulations. Suppose the survey team wants to expand the survey data based on both household size and number of vehicles available per household. As long as this cross-tabulation is available for the population, from the Census or another source, the process is the same as shown above. Tables 6.24, 6.25 and 6.26 illustrate an example of this expansion.

Note that the calculations are the same as for the previous example, except that the two categories representing one-person households with more than one vehicles are combined. It is generally a good idea to avoid expanding variable categories with either a very small number of responses or with a small actual population because very high or very low expansion factors may result in skewed analyses.

Data Expansion with Multiple Control Variables

Often the survey team faces a situation where it would be advantageous to expand the survey data using two or more variables for which there are no cross-tabulations for the population. This may occur when the Census Bureau does not publish such a cross-tabulation or when the Census cross-tabulation is not yet published. Census Summary Tape File data have become available two to three years before the Census Transportation Planning Package cross-tabulations.

In this situation, survey teams generally rely on the marginal variable totals for controls, and use an iterative method to develop the specific expansion factors. As an example, suppose the survey team wants to develop control totals based on both single variable controls, shown above, but for some reason cross-tabulations are not available. Table 6.27 shows the household survey cross-tabulation of the variables of interest.

Table 6.28 shows the information available for use as control totals. In this situation, the survey team develops the expansion factors iteratively by

Table 6.24 Household Size and Vehicles Available Responses for the Example Survey

Household Size	1				2				3				4				
Vehicles	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	Total
Responses	31	189	31	2	13	140	74	40	16	65	86	80	15	52	78	88	1000

Table 6.25 Actual Distribution of Household Size and Vehicles Available for the Example

Household Size	1				2				3				4				
Vehicles	0	1	2	3+	0	1	2	3+	0	1	2	3+	0	1	2	3+	Total
Responses	2,200	17,100	1,000	100	1,100	11,600	7,500	1,700	400	2,600	3,100	2,200	300	1,900	4,400	7,000	64,200

Table 6.26 Calculated Expansion Factors

Household Size	1			2				3				4			
Vehicles	0	1	2/3	0	1	2	3+	0	1	2	3+	0	1	2	3+
Expansion Factors	71.0	90.5	33.3	84.6	82.9	101.4	42.5	25.0	40.0	36.0	27.5	20.0	36.5	56.4	79.5

Table 6.27 Crosstabulation of Subregion and Household Size/Vehicles for An Example Survey

Household	Subregion									
Size/ Vehicles	CBD	NE	E	SE	S	SW	W	NW	N	Total
1/0	18	6	2	0	1	0	1	2	1	31
1/1	17	22	21	23	16	21	21	23	25	189
1/2-3+	0	5	6	4	6	4	2	3	3	33
2/0	11	0	0	0	0	0	0	2	0	13
2/1	20	12	12	12	18	19	14	15	18	140
2/2	6	10	7	6	11	6	8	10	10	74
2/3+	1	5	8	5	4	5	5	4	3	40
3/0	9	1	1	0	1	2	0	1	1	16
3/1	9	4	8	5	9	8	6	11	5	65
3/2	9	9	8	11	9	8	11	10	11	86
3/3+	4	11	10	7	9	11	9	9	10	80
4/0	6	4	1	0	0	0	1	1	2	15
4/1	3	4	8	5	8	9	6	7	2	52
4/2	1	9	8	11	9	8	11	10	11	78
4/3+	1	12	11	8	7	12	11	12	14	88
Total	**115**	**114**	**111**	**97**	**108**	**113**	**106**	**120**	**116**	**1,000**

Table 6.28 Actual Distribution of Households by Subregion and Household Size/Vehicles for the Example

Household Size/Vehicles	Subregion CBD	NE	E	SE	S	SW	W	NW	N	Total
1/0										2200
1/1										17100
1/2-3+										1100
2/0										1100
2/1										11600
2/2					(Only the Marginal Totals are Available)					7500
2/3+										1700
3/0										400
3/1										2600
3/2										3100
3/3+										2200
4/0										300
4/1										1900
4/2										4400
4/3+										7000
Total	1,200	3,800	4,400	9,000	8,500	5,200	11,400	10,300	10,400	64,200

first developing expansion factors based on the row control totals, then by adjusting these preliminary factors to match column control totals, and then repeating the process until the expansion factors produce a reasonably accurate representation of both the row and column control totals. This iterative procedure, commonly referred to as iterative proportional fitting or the Furness Method, is the same process that is used in the Fratar trip distribution model.

Data Expansion Procedures for Non-reported Trips and Trips by Nonrespondents

Because the calculation of trip generation rates is often an important use of household survey data, many survey teams perform data expansion exercises to incorporate into the survey database the likely number of trips that were missed in diaries that were not returned. To include trips by household members that failed to complete the diary, survey teams have used completed diary data to develop person-based trip generation models that relate socioeconomic and household relationship variables to the number of trips being made. These trip generation models are then applied to the individuals who failed to complete the diary so that the household's total trip generation may be approximated.

Another potential survey data expansion option for some household travel and activity surveys is to use survey follow-up data to estimate household trip rates for non-respondent households.

Limited research has shown that the travel and socioeconomic characteristics of respondents that reply to each wave of follow-ups are successively closer to the characteristics of those who never respond.[58] [59] [60] By tracking the characteristics of respondents at each follow-up stage, and extrapolating, the survey team can estimate the characteristics of non-respondents. Figure 6.21 illustrates the extrapolation process that Wermuth, Richardson, Ampt, and Meyburg advocate based on empirical survey data from Germany and Australia. The estimates for non-respondents can be used to adjust the survey estimates or to simply determine whether non-response bias is likely to be present for a survey effort.

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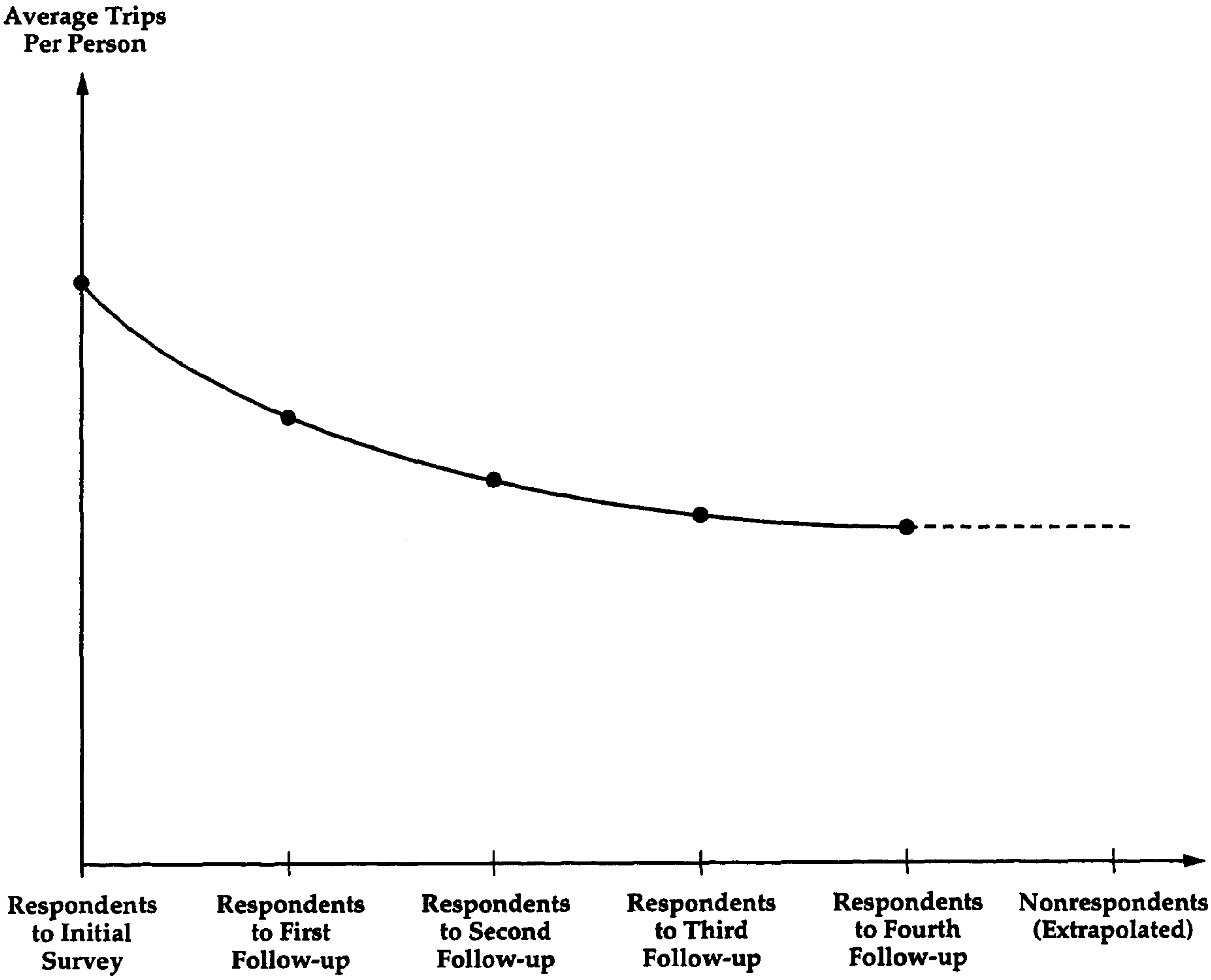
[58]Manfred Wermuth, *Non-Sampling Errors Due to Non-response in Written Household Travel Surveys* in Ampt, E.S., Richardson, A.J., and Brög, W. (1985) New Survey Methods in Transport, VNU Science Press: Utrecht, The Netherlands, pp. 349-365.

[59]A.J. Richardson, E.S. Ampt, and A.H. Meyburg, *Survey Methods for Transport Planning*, 1995, Eucalyptus Press, pp. 321-335.

[60]W. Brög and A.H. Meyburg, *Influence of Survey Methods on the Results of Representative Travel Surveys*. Presented at 61st Transportation Research Board, Meeting, January 1982.

Figure 6.21 An Example of Using Survey Follow-up to Estimate the Characteristics of Nonrespondents



Data Expansion with Choice-Based Samples

It is becoming a common practice to supplement the household survey's random sample or stratified random sample with a smaller choice-based sample to increase survey representation of certain types of households, people, or trips. The most common form of choice-based sampling in household travel and activity surveys is to recruit a certain number of households who are known to have transit riders. This is usually done to improve the mode choice model estimation process.

Survey teams need to remember that samples of this type need to be expanded separately and differently from the random sample or stratified random sample. Although the trip or activity records from these households may be used in conjunction with the trip or activity records of the other households for disaggregate analyses, such as multi-nominal logit mode choice models, they usually cannot be expanded to the general survey population because: 1) their sampling frame includes an undefined portion of the study area population, and in some cases, 2) the samples are not probability-based. The choice-based records can only be used for population expansion if:

1. The choice-based or targeted sample has been drawn from a sampling frame that describes a defined population using a probability based sampling method;

2. The defined population is able to act as a separate sample stratum for the larger survey effort, and the members of this stratum can be identified in the larger sampling frame; and

3. Information is available for defining the total size of the defined population and for setting control totals.

These conditions are rarely met in practice, but it is important to note that choice-based data are often collected for disaggregate mode choice model development. Some of the most common analytical procedures to develop these models, such as multinomial logit modeling, are better performed on data that are unexpanded.

A number of excellent discussions of the practical aspects of household travel and activity, survey data expansion can be found in the transportation literature. [61,62,63]

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[61]Ian Harrington and Chen-Yuan Wang, *Adjusting Household Survey Expansion Factors*, presented at the 5th Conference on Transportation Planning Applications, Seattle, April 1995.

Summarizing Survey Results

Although this manual does not discuss the presentation or analysis of survey results, three procedures for summarizing household survey results provide important diagnostic information about the survey effort that can be used in later analyses. It is recommended that all household travel and activity survey teams:

- Perform a detailed set of survey data tabulations; and
- Calculate actual precision levels for key survey variables; and
- Formally calculate and report the survey response rate.

These procedures are discussed below.

Survey Data Tabulations

Tabulation of the survey data is a very important, although sometimes overlooked, aspect of the survey analysis. Its value is even more pronounced given the small amount of effort that is required to specify the analyses and produce the summary statistics for a preliminary analysis. A careful review and interpretation of the preliminary one-way and cross-tabulations could be instrumental in:

- Finding and correcting errors in respondents' answers, as well as errors due to coding and programming;
- Making reasonableness checks for variables included in the survey;
- Identifying survey responses with extreme values and determining whether the response to a particular question should be treated as an outliner or whether the data are unreliable, in which case the data record should be dropped from the analysis;
- Obtaining a fairly accurate picture of the distributions for different variables of interest and identifying differences due to geographic, socioeconomic, or choice behavior factors; and

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[62]Peter Stopher and Cheryl Stecher, *Blow Up: Expanding a Complex Random Sample Travel Survey*, Transportation Research Record, 1412, Transportation Research Board, 1993, pp. 10-16.

[63]Hyungjin Kim, Stephanie Rodman, Ashish Sen, Siim Soot, and Ed Christopher, *Factoring Household Travel Surveys*, Transportation Research Record, 1412, Transportation Research Board, 1993, pp. 17-22.

- Uncovering response patterns that may be useful for subsequent more detailed analyses.

To accomplish these objectives, a set of preliminary survey data tabulations need to be specified. These would include both frequency analyses of the survey variables (also referred to as one-way tables) and cross-tabulations (also referred to as two-way tables) that relate the frequency of a particular variable to other variables of interest. For example, a frequency analysis would provide us with the total number of households with no, one, or two or more vehicles, while a cross-tabulation would further provide the same information on automobile ownership in the study area broken down by county.

For each continuous variable, the *distribution* of variable values in the sample is obtained by measures of the mean, median, and standard deviation. For categorical (discrete) variables and for continuous variables that can be easily grouped into different categories (e.g., 10-minute categories of travel time), the distribution in the sample can be assessed by examining the frequency of values in each variable category both in absolute and percentage terms. For example, the mean household trip rate in the study area, the distribution of automobile ownership, and the share of transit could provide some useful preliminary information on existing travel patterns in the area.

A preliminary assessment of *relationships* among variables of interest can be obtained by cross-tabulating each variable of interest to a variety of geographical, socioeconomic, or choice-based variables. These tables can offer a means of checking the reasonableness of existing differences by market segment and can also provide the rationale for further more detailed types of analysis. For example, differences in the mean household trip rate, automobile ownership, and transit share by county or by household income can help validate the existing data and can provide insights into the factors affecting trip making and mode choice behavior.

Calculation of Precision Levels for Key Survey Variables

Prior to conducting the survey, the survey team will have made an estimate of the required sample size to achieve some pre-determined levels of precision and confidence for important survey variables. Once the data collection is complete, the survey team can use the relationships presented in Chapter 5.0 to determine the actual precision of the survey estimates.

The degree of precision for any variable is dependent on its variance and mean a pre-determined desired statistical confidence level, and the sample size and population size. If the actual values of these parameters are different than the pre-survey estimates, the precision level for the variable will also be different than expected. The survey team should report the degree of precision on all key survey variables and survey-derived parameters.

Response Rate Report

As discussed, a household survey's response rate is a basic measure of the quality of the data collection process. An unusually low response rate is an indication to users of the data that any analyses they conduct could be biased to a greater extent than they are accustomed. A strong response rate is an indication that the input data to their analyses are more likely to be accurate. However, before any conclusions can be drawn from response rate information, it is important to understand exactly how the rate has been calculated. Unfortunately, despite the fact that the term "response rate", has a very specific technical definition, it is frequently used carelessly and incorrectly. "Response rate" has come to mean many things to many people.

This problem is not restricted to household surveys or travel surveys. Misuse of the term has been, and continues to be, common in many fields. In the early 1980s, the Council of American Survey Research Organizations (CASRO) commissioned a blue-ribbon committee to establish standardized definitions of survey response rate and completion rates.

The basic definition of response rate is: [64]

$$\text{Response Rate} = \frac{\text{Number of Completed Interviews with Reporting Units}}{\text{Number of Eligible Reporting Units in the Sample}}$$

There is an interpretation of this basic definition for each type of household survey effort. However, it is likely that the number of eligible units may not be known exactly, and that the response rate can only be approximated. For example, in a telephone survey the eligibility of phone numbers that are never connected (always busy, unanswered, or routed to an answering machine) cannot be determined. The best strategy is to make repeated attempts until contact is made.

One useful way to provide response information is to develop a process chart, similar to those shown in Chapter 3.0 (Figures 3.8, 3.10, and 3.11) manual, for the specific survey effort, and then to record the disposition of all survey field work on the chart. With this information, analysts can

[64] Council of American Survey Research Organization, *On the Definition of Response Rates*, a special report of the CASRO Task Force on Completion Rates, Lester Frankel, Chairman, June 1982.

calculate each completion rate of the survey effort. This type of reporting will be especially useful for future household survey teams trying to plan fieldwork resources.

Table 6.29 presents an example of response rate information from a recent household travel/activity survey in New Hampshire. This table provides information on the number of contacts, the contact percentage, eligibility percentage, reasons for ineligibility, participation rate, and overall response rate. The response rate that corresponds to the CASRO definition is 19%; however, some analysts also consider the percentage of those recruited (53% in this case). It is recommended that complete summaries such as Table 6.29 be prepared for all household surveys to provide the variety of information needed by different analysts.

In the New Hampshire survey, the eligibility of 28,125, or 97%, of the 29,036 different phone numbers was eventually determined. The response rate of 19% was computed assuming that none of the phone numbers not reached was eligible. This is obviously an oversimplification; the true percentage of eligible respondents among the 911 numbers that were never connected to cannot be known. Given that survey recruitment was done in the evening, it is likely that the eligibility percentage of the non-connects was lower than for those that were reached (since many businesses are not open at night). However, even in the unlikely event that all of those numbers were eligible, the response rate would not have been much different (18%). The true rate, of course, is somewhere in between. The fact that the range can be computed so narrowly illustrates the advantage of continuing to attempt to contact potential respondents who are not reached on the first attempt.

Table 6.29 Example of Response Rates from a New Hampshire Activity Survey

Total Dialings [1]	**60,638**	
Total Non-Connects	**32,513**	
No Answer	19,226	
Busy	2,907	
Answering Machine	10,380	
Total Connects	**28,125**	46% of dialings
Scheduled for Callback	5,942	
Non-Working [2]	4,312	
Ineligible [3]	2,718	
Language Barrier/Deaf	157	
Eligible	**14,996**	53% of connects
Not Available [4]	83	
Refused to Participate	2,031	
Party Terminates [5]	5,628	
Question Terminates [6]	1,851	
Recruited	**5,403**	36% of eligible
Completed [7]	**2,844**	53% of recruited 19% of eligible

(1) Includes retrying non-connects. Total numbers called = 29036.
(2) Non-working numbers included disconnected, changed, and not in service.
(3) Ineligible include businesses and other non-household phone lines.
(4) Not available means eligible party (i.e., adult) not at home.
(5) Party terminates - would not speak to interviewer.
(6) Question terminates - respondent terminated interview after hearing specific question.
(7) "Completes" defined as activity information received from all household members.

7.0 Vehicle Intercept and External Station Surveys

Vehicle intercept surveys are conducted to collect profiles of vehicle trips that use a specific roadway segment. The surveys commonly collect origin and destination data, as well as other information, such as trip purpose, auto occupancy, and trip start and end times. The most common use of this survey type is the external station survey, in which survey teams gather the vehicle trip information at the boundary of the model study area to develop external-external and external-internal vehicle trip tables for the model.

Vehicle intercept surveys are also used at roadway segments within the model study area to provide additional origin-destination data from which to calibrate or validate travel demand models. Vehicle intercept surveys are also conducted at these internal locations to gather travel behavior information for interim travel demand model calibration efforts in lieu of expending the substantial resources required to collect household travel survey data.

Typically, household travel survey data have been collected in a particular metropolitan area every 10 or 15 years. The planning agencies then use vehicle intercept survey data, in conjunction with other survey collection efforts (such as transit on-board surveys), to estimate their regional travel modeling systems. Every five years or so, the agency may re-calibrate their estimated travel models to create incremental or interim regional travel models. In most cases, less expensive data collection efforts, such as traffic count programs and vehicle intercept surveys, are used to recalibrate travel models to match existing highway and transit conditions.

Vehicle intercept surveys are also commonly used at specific sites to analyze the potential traffic effects of proposed new developments or infrastructure improvements.

■ 7.1 Organization of This Chapter

Since the publication of the 1973 travel survey manual, the vehicle intercept and external station survey has been used extensively for these and other reasons.[1] The survey methods and procedures described in the 1973 guide are still commonly accepted and practiced, but over the years, technologies, such as improved camera equipment, hand held computers, and CAPI, have improved traditional vehicle intercept survey techniques.

The key issues discussed in each section are outlined in Table 7.1.

7.2 Assembly of Background Data

Three types of background data are useful for designing and implementing vehicle intercept surveys:

- Data used for designing survey questions;
- Data used to identify survey locations; and;
- Data used for designing survey stations and selecting data collection methods.

Background Data to Help Design Survey Questions

Because vehicle intercept surveys are commonly used in conjunction with other previous or on-going survey efforts, it is important that the survey team obtain copies of any survey instruments from complementary survey efforts. As discussed in Section 7.6, the vehicle intercept survey questions should be consistent with questions on the other surveys in terms of:

- Matching or consistent response categories;
- Same level of detail; and
- Same concept definitions.

The survey team should obtain any recent survey efforts from the sponsoring agencies, and prior to conducting any data collection the team should determine how different data sources can be combined for the anticipated analyses, and what effect these analytical needs have on sample design and questionnaire design.

[1] U.S. Department of Transportation, Federal Highway Administration, *Urban Origin-Destination Surveys*, Washington, D.C., 1973 (reprinted 1975).

Background Data to Help Identify Survey Locations

Often, the identification of survey locations is defined for the survey team by the survey data requirements. For instance, travel demand modelers may have pre-specified locations for external stations, or else the survey may be related to the analysis of one or more specific roads. However, for other analyses, the survey team may need to decide where surveys are to be conducted. Particular studies may have specific study area boundaries, around which external vehicle surveys are desired only for the most important highways. Similarly, analysts may want survey data for key screenline locations, but resource constraints may require the survey team to choose only a sample of the locations.

If the survey team is in the position of determining survey sites, the following data sources are likely to be valuable:

- Existing origin-destination trip table information, including Census Journey-to-Work data, that will help define the desired movements within the study area. Even if the data are outdated or are scheduled for revision, these sources will give the survey team a feeling of the relative importance of different interzonal flows.

- Road maps and highway network maps illustrating the project "study area" and the potential areas for survey locations.

Table 7.1 Organization of theVehicle Intercept Survey Section

Chapter Section	Discussion Topics
Section 7.2 – Background Data	Data used for designing survey questions Data used to identify survey locations Data used for designing survey stations Data used for selecting data collection methods
Section 7.3 – Survey Design	Selection of sites Selection of survey method (roadside interview, handout, postcard) Selection of survey techniques Survey station design
Section 7.4 – Organization	Management of the survey Staffing and hiring Coordination and publicity
Section 7.5 – Sampling	Selecting time periods Selecting vehicles
Section 7.6 – Questionnaire Construction	Data elements Writing questions Designing survey instruments
Section 7.7 – Pretesting	How and when to conduct pretests
Section 7.8 Training and Briefing	Training Topics Training Procedures
Section 7.9 Fieldwork	Fieldwork procedures
Section 7.10 Coding and Data Entry	Coding procedures
Section 7.11 – Editing and Cleaning	Data cleaning tasks

- Existing travel demand models with which highway assignments and select link analyses can be performed.

- Permanent traffic count station information describing the roadway attributes, typical traffic volume flows by time period, and vehicle mix by station location (this information may be available from State Departments of Transportation (DOTs) responsible for certain roadways).

- Additional traffic volume flows, vehicle mix, and auto occupancy data describing the attributes of potential survey locations (this information may be available from local traffic engineering and planning departments, private consultants, and developers).

The survey team will need to choose the survey sites (or at least narrow the options) based on the survey data needs and these data sources.

Background Data to Help Design the Survey Procedures

Once roadways are identified, the survey team needs to collect detailed information about the relevant segments of the roads to design survey procedures in detail.

Specific background information sources to be assembled for survey site design include the following:

- Aerial photographs describing roadway contours, terrain, and intersecting bridge-overpass locations to assist in designing potential survey locations; and

- For each potential survey location, roadway cross section diagrams describing roadway section widths, number of travel lanes, median and shoulder widths, traffic signal and intersecting roadway locations, bus stops, parking spaces, and sidewalk widths.

These data may be obtained from the agencies responsible for jurisdiction of the roadways under consideration. In most cases, major highway facilities such as freeways, highways, state routes, and principal arterials fall under the jurisdiction of State DOTs. In some states, most secondary and major collector roadways are also owned by State DOTs. Other lower level roadway facilities, such as urban primary arterials, may fall under the jurisdiction of county and city/town DOTs and/or Departments of Public Works.

Assembling roadway design information is generally a slow process. Formal written requests for this information are often required. The process for obtaining these data includes the following steps:

1. Establish contact with the appropriate agency responsible for the roadway(s) to be surveyed. Outline the reasons for the survey and identify the project sponsor(s) responsible for the survey.

2. Outline the specific background data needs in a formal letter of request. This request should be sent to the appropriate staff person identified in the initial contact.

3. Following Steps 1 and 2, schedule another telephone or in-person interview with the identified staff person. Interviews should be scheduled at least two-weeks after the initial contact to allow adequate time for agencies to compile the requested data.

4. Collect all relevant information via in-person meeting, mail, or electronic mail.

In some cases, the formal process outlined above may not have to be followed, but the survey team should allow extra time for this data assembly task.

■ 7.3 Vehicle Intercept Survey Design

The survey team has four key issues in designing the vehicle intercept survey:

1. What sites should be surveyed?

2. What survey method should be used at each survey site?

3. Given the survey method, what data collection techniques should be used?

4. How should the survey stations be designed?

These issues are described below.

Site Selection

There are two elements of the site selection process for vehicle intercept surveys. First, the survey team needs to identify the roadway segments that should be surveyed. This task may or may not be necessary, depending on the reason for the survey. Second, the survey team needs to identify the precise location of the survey station within a selected roadway segment.

Selection of the Roadway Segment

If the survey team is performing the vehicle intercept survey to analyze a specific highway or a well-defined corridor, the highway segments that need to be analyzed may be obvious. Similarly, if the survey team is seeking to perform an update of a previous vehicle intercept survey effort, then the task of selecting the roadway segments to be surveyed is trivial.

However, in many cases, the survey team must define the best set of highway segments to include in the survey for a particular anticipated analysis effort. Of course, the key parameter in making these selections is the precise nature of these analyses, so it is difficult to describe the best selection strategy. However, a few common approaches can be defined for one type of vehicle intercept survey analysis, the development of origin-destination trip tables.

In many cases, the survey team's primary interest in the vehicle intercept survey data is to develop origin-destination trip estimates for vehicle trips entering (or leaving) the study area of interest or for vehicle trips crossing a pre-defined model screenline or cutline. The first step, of course, is to identify the boundary line.

In the case of defining a travel model study area, the 1973 Urban Origin-Destination Survey Manual provides the following guidelines for the determination of study area boundaries (cordons):

1. The cordon line should include entire political jurisdictions, e.g., towns, cities, Census tracts, special districts. This is more convenient for assembling and analyzing existing data, it establishes a better basis for good relations with those jurisdictions, and it gives an improved ability to serve all agencies.

2. The cordon line should also include the various planning boundaries that have been established, such as the Census Urbanized Area and the Federal Aid Urban Area.

3. The cordon line should not extend through a network of streets or roads that would necessitate an excessive number of cordon crossings.

4. If possible, the cordon line should intersect all roads at points which are suitable for performing vehicle intercept external surveys.

5. If possible, the general course followed by the cordon line around the study area should be uniform in nature, without major deviations inward or outward. This will help to eliminate double crossings at the

cordon, as well as any unusual travel patterns in the traffic assignment process. If a natural boundary, such as a river, is available, it should be considered for use as the cordon boundary.

6. If the cordon line is closely parallel to an existing or planned transportation facility that serves internal traffic, the cordon line should be placed so that the facility falls inside rather than outside the study area.

7. All dwelling units in the vicinity of outlying public transit stations should be included inside the cordon line, if possible.

8. Special generators, such as airports and military bases, located in the outlying fringe areas should be placed inside the cordon, if possible.

Since boundaries and screenlines are often crossed by more highways than the survey team is willing or able to survey, the survey team may need to select a subset of highways. Two approaches are commonly used to perform the selection of roadway segments:

- Select the segments with the highest traffic volumes; and

- Select the highway segments that are likely to provide the most origin-destination information.

The first approach simply involves reviewing the most recent traffic count data for the candidate segments, and then selecting the highest volume locations that can be surveyed with the available cost and time resources. This simplistic method is the most common site selection approach, but it has a few drawbacks. First, new traffic count information may need to be obtained (or estimated) for some segments before they can be compared to others. Mid-level and lower volume highway segments may not have recent traffic count information to make the selection. Second, sometimes lower volume highway segments provide key origin-destination information that would be valuable for trip distribution modeling.

A better approach to selecting roadway segments for origin-destination analyses is to use available trip table information and highway assignment and selected link analysis output from an existing travel demand model, if one is available. By analyzing the model output, the survey team can determine the combination of roadway segments that provide the most origin-destination information for the available resources. Adler, et al. recently applied a mathematical programming model to highway network model output to optimize the selection of vehicle intercept survey sites[2].

[2]Thomas Adler, Stephen Lane, Nicholas Brand, and Harold Wilson, A *Quick Response Screening Model for Planning Statewide Origin-Destination Surveys*, presented to the 5th National Conference of Transportation Planning Methods Applications, Seattle, May 1995.

Other planners have used far less rigorous approaches, combining simple decision rules and approximations to obtain an effective (though, possibly not optimal) combination of survey sites.

Selection of the Survey Site Within a Chosen Roadway Segment

Once a highway segment has been identified for the survey effort, the survey team needs to review the physical and geometrical features of the segment to determine the best site for the survey. The highway segment review can be accomplished in two steps. First, the survey team can evaluate any available detailed information on the roadway segment, possibly including aerial photographs, highway geometric summaries, and maintenance management information. With this information, the survey team can perform preliminary screening of specific sites, and identify those segments that appear not to have suitable survey locations.

Potential survey sites should be evaluated on the basis of:

- Sight distance;
- Proximity to intersections, on-ramps, etc.;
- Vertical and horizontal curvature;
- On-going repair and construction projects;
- Shoulder width;
- Availability of overpasses (see license plate survey description below); and
- Traffic signals and tollbooths.

After the preliminary screening, the survey team should conduct field inspections of each roadway segment to confirm the preliminary evaluations.

If no suitable survey sites can be identified within a particular highway segment, the survey team should consider the possible consequences of surveying adjacent segments upstream or downstream from the original segment. A small shift in the survey location often greatly complicates survey analysis, because some trips may be ineligible for analysis. For instance, if a roadway segment outside of an external boundary were used, the survey team would need to factor out those trips that did not enter the actual study area, or that could have crossed into the study area on a highway segment that is already being surveyed. In cases where the small shift in survey location is considered to be a problem, the survey team should choose another eligible highway segment.

Survey Methods

There are four general methods for conducting vehicle intercept surveys:

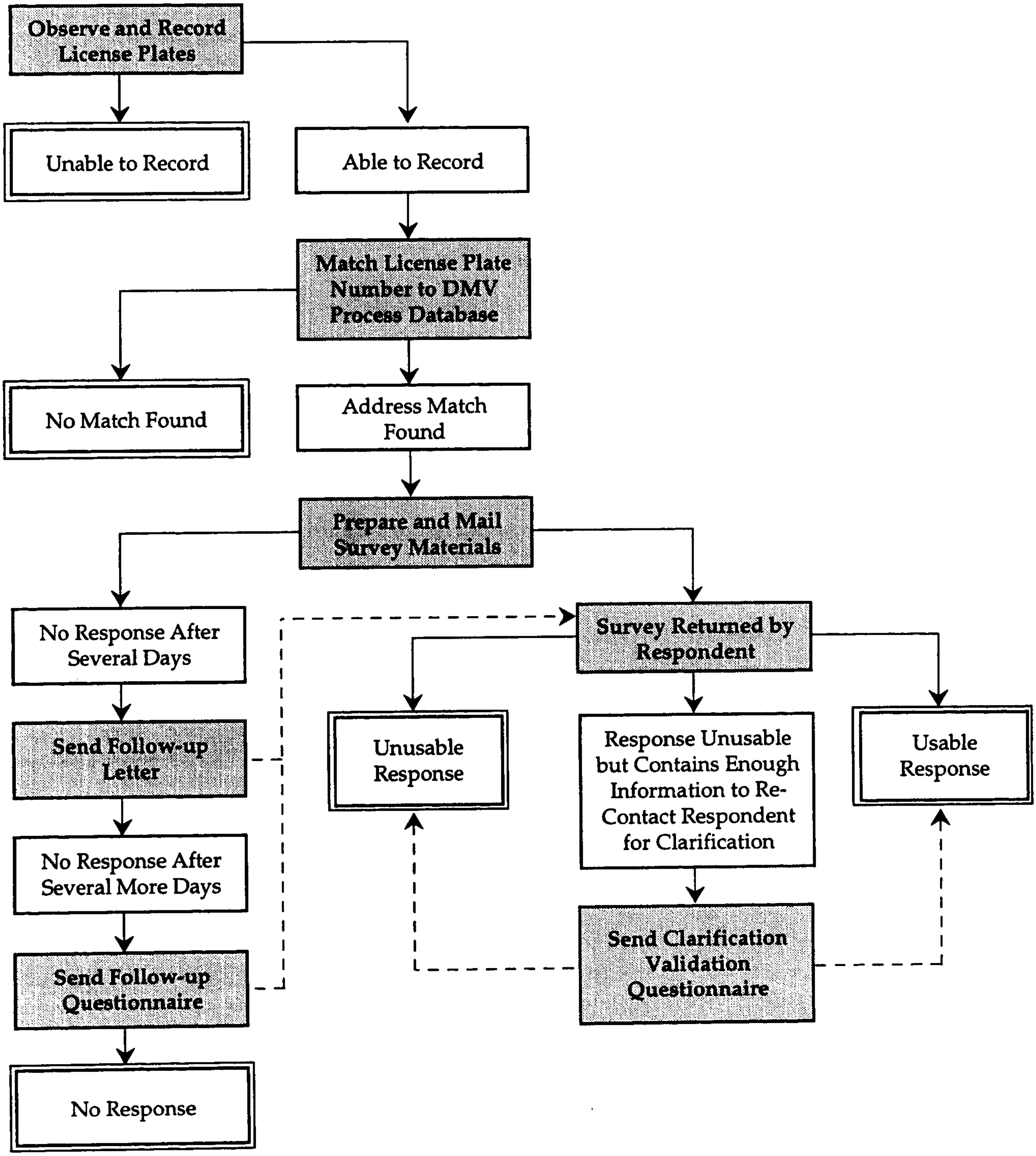
- **The License Plate Survey** – Fieldworkers record the license plate numbers of vehicles passing the survey location, the vehicles' owners are determined using data from one or more state's Department of Motor Vehicles (DMV), and the vehicle owners are then sent a mail survey.
- **Roadside Handout Survey** – Fieldworkers stop some or all vehicles passing the survey location, and hand out self-completion mailback survey forms.
- **Roadside Interview Survey** – Fieldworkers stop some or all vehicles passing the survey location, and conduct short interviews with drivers.
- **Combined Roadside Interview and Handout Survey** – Fieldworkers stop some or all vehicles passing the survey location, conduct short interviews with drivers, and then hand out self-completion mailback survey forms.

The License Plate Survey

Figure 7.1 shows an example process diagram for a license plate survey. At the survey site, the survey team observes and records license plates of cars passing the survey station. As discussed below, there are several data collection techniques for achieving this, but none will be perfect, so a certain percentage of vehicle license plates will not be recorded. The registration numbers that are recorded are entered into a database, which is then merged with one or more Department of Motor Vehicles (DMV) vehicle registration databases. The vehicle license plate numbers are matched with auto owners and their addresses.

If an address match is found, the survey team mails the vehicle owner a survey form requesting information about the trip that was being taken when the license plate was recorded and/or about other topics. The

Figure 7.1 Process Diagram for an Example License Plate Survey



survey then follows the same course as a standard mail survey, with optional follow-up mailings and clarification.

Table 7.2 describes the advantages and disadvantages of the license plate survey. Because it is the only method that does not require stopping traffic, it is usually the preferred approach for high-volume locations. The main challenges of the method are to be able to convert the raw license plate data into a name and address list in a very short period of time, and to get respondents to reply to the questionnaire in a timely fashion. The longer it takes to get the survey to the vehicle owner, the more likely the results will suffer from recall problems and non-response.

The license plate survey requires the survey team to complete the following preliminary design steps:

1. Establish contact with the appropriate local agencies and departments requesting cooperation, permission, and support for the survey effort. Contacts should be made with the appropriate agencies responsible for jurisdiction of the roadway(s) to be surveyed; the local Department of Motor Vehicles and the DMVs of other states from which the survey team will need to seek data; and the state and local police departments. This support is required to proceed with the license plate survey effort because staff from each relevant agency will need to provide the go-ahead and potentially participate in the survey effort. (This step should be established well in advance of the subsequent steps to obtain agency approvals for the survey effort.)

2. Identify the roadway locations and time periods for surveying, as discussed above.

3. Conduct a field inspection of the roadway locations to be observed. The purpose of the inspection is to determine the logistical needs of the survey including the crew, equipment and supplies, coning, police setup, and license plate identification operation requirements. This should be conducted at each roadway location to be surveyed.

4. Develop the questionnaire mailout logistics. The cooperation of DMV, and the quick turnaround of address information of the observed vehicles are developed during this step. The quick turnaround of address information is necessary to ensure that persons traveling on the surveyed roadways receive questionnaires within a few days after using the roadway.

The Roadside Handout Survey

The roadside handout survey is an example of an intercept/self-administered survey. A typical process diagram for this type of survey was shown in Figure 3.9. In the roadside handout survey, the survey team establishes a survey station at a location where some or all motorists are directed to slow to a stop, and then are asked by fieldworkers to complete a self-administered survey form, and to mail it back. Once the forms have been distributed, the survey team must simply wait for replies.

Table 7.3 describes the advantages and disadvantages of this method. The roadside handout survey is superior to the license plate survey in that it has lower processing costs. In addition, it provides the opportunity for fieldworkers to screen potential respondents. For instance, if a particular survey is interested only in people who live outside a study area, then the fieldworker could ask a short question of the driver and distribute the forms only to relevant individuals. The main drawback of the method compared to the license plate survey is that it is disruptive to traffic. The survey team also loses the ability to follow up with non-respondents, unless they are tracked using DMV files, as for the license plate survey.

The roadside handout survey is generally used on medium volume roadways (8,000 to 12,000 vehicles per day) because it is less expensive than the license plate survey and less disruptive than the roadside interview method.

The Roadside Interview Survey

The third survey method, the roadside interview survey, is a form of the simple interview survey, as diagrammed in Figure 3.8. As in the roadside handout survey method, the survey team stops vehicles at the survey site, but rather than asking drivers to fill out a form, the fieldworkers perform short interviews.

The advantages and disadvantages of the roadside interview survey are shown in Table 7.4. The method is far more disruptive than the license plate or roadside handout survey, but the high response rate relative to the other methods means that the survey data are likely to be of substantially higher quality. The response rate for this method could be up to five times higher than for the other methods.

The method is primarily used on lower and medium volume roads.

Combined Roadside Interview and Handout Survey

A common variation on the basic methods is to combine the roadside handout survey and the roadside interview survey. The survey team intercepts a vehicle passing the survey location, and an interviewer asks the driver of the vehicle a few questions. When the short interview is completed, the interviewer gives the driver a mailback questionnaire with more detailed questions.

The primary advantage of this approach is that a small amount of data are collected from potential respondents before they answer the main

Table 7.2 Advantages and Disadvantages of the License Plate Survey

Advantages

1. This method is the safest, because traffic is not stopped as opposed with the other methods.

2. The number of field personnel is typically less than the other methods.

3. The mail questionnaire can be more extensive than interviews in terms of the number of questions asked (especially about socioeconomic and household related questions).

4. Although survey operations at night are difficult and unreliable for all the methods, improvements in videotaping equipment technology are making the collection of license plate information at night more feasible.

5. No traffic delays at survey stations, even at high-volume locations.

Disadvantages

1. No personal contacts are made between surveyors and potential respondents, so there is no opportunity to answer questions or explain aspects of the survey.

2. It is critical that the questionnaires be mailed to potential respondents within a short-time period after the license plates are observed (one to two days is usually the maximum). Logistically, this proves difficult because of multi-agency coordination requirements and difficulties in identifying the license plate numbers from the videotape, audiotape, or fieldworkers' notes.

3. The method is essentially a mail survey, so it is likely to have relatively high non-response and strong potential for response bias.

4. People driving rental or lease cars will not be surveyed. In addition, people driving someone else's vehicle will not receive the questionnaire unless it is passed on by the vehicle owner.

questionnaire. This allows the survey team to perform screening of potential respondents, and to provide potential respondents with customized mailback questionnaires. For instance, study area residents can be given a different questionnaire than non-residents. In addition, based on the interview data, the survey team is able to detect and possibly correct for systematic non-response bias in the mailed survey returns. The main problems with the approach are that it is more expensive and that it disrupts traffic almost as much as the roadside interview survey.

Data Collection Techniques

Depending on the data collection method to be used, the survey team has a variety of data collection techniques available.

Data Collection Techniques for License Plate Survey

Travel surveyors have applied a number of approaches for observing and recording vehicle license plates, including the following:

- A fieldworker observes a license plate and then simply writes the number down. The written notes are then entered into a data file in the office.

- A fieldworker observes a license plate and reads it into a tape recorder. The audiotape is then transcribed into a data file in the office.

- A fieldworker enters the license plate number directly into a portable computer, or reads it aloud to another fieldworker who performs the data entry.

- A fieldworker sets up and monitors a video camera that records license plates. The videotape is then sent to the office for data entry.

The selection of the best technique depends on a number of practical considerations and constraints. The most basic technique, having fieldworkers simply write down passing license plate numbers, has the advantage of simplicity. There is no equipment to maintain or keep track of. The fieldworker is completely mobile, and he or she can adapt to unforeseen conditions. Unfortunately, the simple data collection technique is likely to have the most problems in converting the numbers into the data file. It is common for fieldworkers to reverse digits or make other entry errors, or to write illegibly since they are in a hurry to record many license plates. Having the fieldworkers read the numbers aloud into a tape recorder reduces the number of errors in the field and frees the fieldworkers' hands to use binoculars, but because survey locations are likely to be quite loud, it is often difficult for office staff to transcribe the tapes.

Table 7.3 Advantages and Disadvantages of the Roadside Handout Survey

Advantages

1. This method is usually less expensive than the other methods.
2. Traffic delays are less of a problem than for the interview method.
3. Screening for certain types of respondents is possible (unlike license plate method).

Disadvantages

1. This method requires traffic stoppages (albeit short ones).
2. The response rate tends to be low, and there is little opportunity to conduct follow-ups.
3. Pulling vehicles over without a legitimate law enforcement reason is not permitted in many states.

Table 7.4 Advantages and Disadvantages of the Roadside Interview Survey

Advantages

1. The response rate is much higher than the other methods, so the potential for survey bias is not as great.
2. Personal contacts are made between surveyors and respondents.
3. Selected survey samples can be identified at each location to satisfy standards for statistical analysis.
4. The data are available much sooner than for the other methods, which rely on mailback surveys.

Disadvantages

1. Traffic delays occur especially on high-volume facilities and during peak traffic periods.
2. The method is not permitted in a number of states.
3. This method is more expensive than the Roadside Handout Survey.
4. The method is the least safe of the methods.
5. Because of the potential for delays, the interview must be extremely short.

In cases where a tape recorder is used, a microphone which reduces background noise (directionality, and range) should be chosen.

Some surveyors have tried to eliminate the need for office data entry by having fieldworkers enter the data directly into portable personal computers. The technique can reduce survey costs, but it has the same disadvantage of most computer-assisted survey techniques – there are no raw source documents. The only record the survey team has is the data file itself, and perhaps a printed record of the file once the data are brought to the office. With the other techniques, there are handwritten, audio, or video records that can be referenced, if necessary. It should also be noted that lack of familiarity with the portable computers may cause slower data entry relative to written or recorded data entry. Small inefficiencies can be a problem at high volume locations.

An increasingly popular observation technique is the video data collection approach. In this method, a video camera is aimed at one or more traffic lanes and is used to simply tape all vehicles going by. A fieldworker usually monitors the video taping, but is not needed for any active data collection. The technique can be highly effective for multi-lane high speed traffic locations, because fieldworkers recording information at these sites can become overwhelmed.

The technique is usually cost-effective for sites that would require more than one fieldworker to observe license plates directly, because a single person can monitor more than one video recorder. Videotaping has the following additional advantages:[3]

- It can be used at sites where it would be impossible to station fieldworkers for extended periods;
- It is more accurate than the other methods if taping is carefully monitored;
- It can be used to provide additional data about the survey site, including the classification of vehicles and vehicle occupancy; and
- The use of videotape data collection is expanding in a number of fields, and so it is possible to locate specialist companies that are quite experienced with the required procedures.

The technique does have some problems, however, such as:

[3] T. Brent Baker, Raymond Deardorf, and Cathy Strombom, *Sampling Travel Survey Participants Using Video Technology on the Tacoma Narrows Bridge*, presented at the 74th Annual Meeting of the Transportation Research Board, January 1995.

- It requires renting high quality video recorders (typically, top-of-the-line equipment is needed to capture the license plates of vehicles traveling at 60 miles per hour or more);

- Transcribing license plate information from the videotapes can be a tedious process (survey office workers need to fast-forward the tape to just the right moment, record the license plate, and then repeat the process again and again); and[4]

- The survey site is less flexible, and harder to adapt if special unforeseen circumstances arise (such as an unexpected lane closure or a rain shower).

Some researchers are now experimenting with automated collection and transcription of license plate data from videotapes. While this practice has not been thoroughly tested in actual surveys, it is expected that the technique will become practical in the near future. This development will not only reduce the cost of the survey since office screening and transcribing of license numbers would not be needed, but potentially would increase the accuracy of the data and provide a larger sample (i.e., more license plate "matches").

Data Collection Techniques for Roadside Interviews

Roadside interviews can be performed using conventional paper and pencil interviewing (PAPI) procedures or by using computer-assisted personal interviewing (CAPI) procedures. A number of recent studies have taken advantage of CAPI techniques for roadside surveys, including efforts in Florida, Georgia, Texas, and New Hampshire. Muntean lists the following advantages of CAPI for roadside interviews:[5]

- Real-Time Data Entry and Coding
  - Direct data entry to data file
  - Computer can date and time-stamp each record
  - Trained interviewers can actually complete the survey faster than with PAPI methods

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[4] Travel surveyors have developed a number of in-the-field approaches to improve the transcription process. For instance, for a Massachusetts survey, fieldworkers passed their clipboards in front of the camera right before a platoon of cars was about to pass. This would alert the office worker to switch from fast-forward to play. A Washington survey team deliberately over-exposed the videotape by a small amount so that the white license plates would stand out better (see Miller, et al. and Baker, et al.).

[5] David Muntean, Jr., *Origin-Destination Travel Surveys in the 1990s Using Microcomputers,* ITE Journal (January 1995) pp. 39-43.

- On-Site Editing
  - Instantaneous validity checks
  - Sip routines
  - Interviewer can review record upon completion of interview

- Automatic Geocoding
  - Computer provides interviewers with place name look-up tables
  - Interviewer can scroll through list or type first several letters to find the place name
  - Database can record zone number, as well as place name

These advantages have been realized in other studies, as well. As described in other chapters of this manual, CAPI also provides other advantages. However, because roadside interviews are by necessity relatively short, survey teams often do not require advanced capabilities.

The primary disadvantage of the CAPI technique is the expense of obtaining usable laptop or palmtop computers, or personal digital assistants (PDAs). Although the unit costs of these machines have dropped precipitously, most survey efforts require the purchase or rental of several machines. The computers used in roadside interviews need to:[6]

- Be small and lightweight;
- Have sufficient battery life for daily survey needs;
- Have a sunlight readable display;
- Have means of easily transferring data to office computers;
- Have time-of-day stamping capabilities;
- Have sufficient memory for the survey program; and
- Have sufficient storage space for a day or more of surveys.

[6] Marsha Anderson, *Development of Notebook Computer Software*, 1994.

Survey Station Design

The Design of Roadside Survey Stations

The final element of the survey design that is critically important is the design of the survey station. Roadside handout and interview surveys require survey fieldworkers to work in and around moving traffic, and, because most respondents will have never been asked to participate in such a survey effort, they are not likely to fully understand what they are supposed to do. Therefore, it is essential that the survey team carefully design the survey station to be as safe and clearly understood as possible.

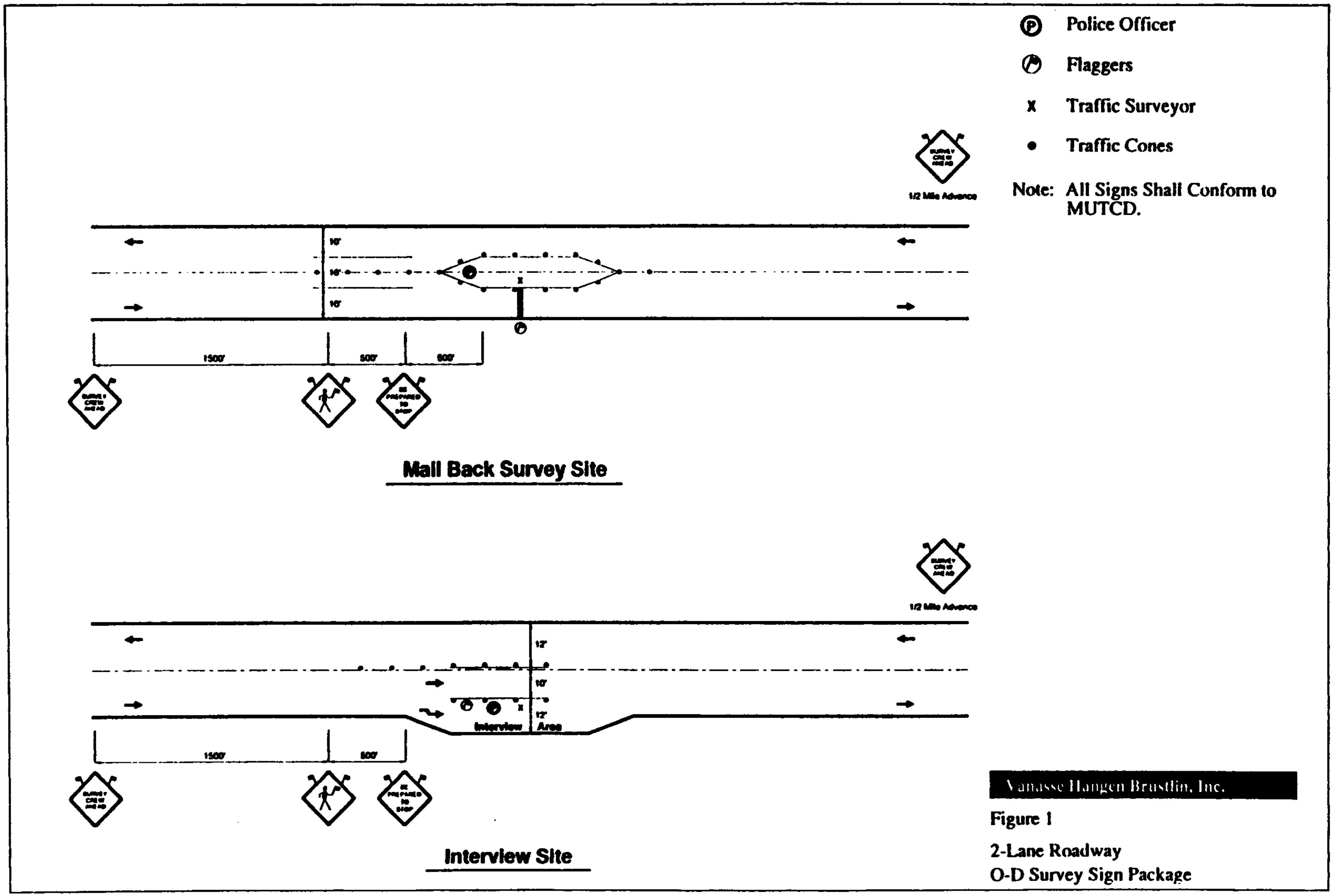
The survey station design is affected by:

- The survey method - license plate, roadside handout, roadside interview, combined method (in particular, the amount of time vehicles need to be stopped);
- The volume of traffic on the highway segment;
- The roadway geometry (in particular, the roadway and shoulder width);
- The availability of trained fieldworkers; and
- The percentage of vehicles passing the station that are needed for the survey.

The survey team needs to work closely with highway engineers and local law enforcement agencies to develop station designs and survey procedures that are acceptable in terms of safety and the potential effect on traffic flow.

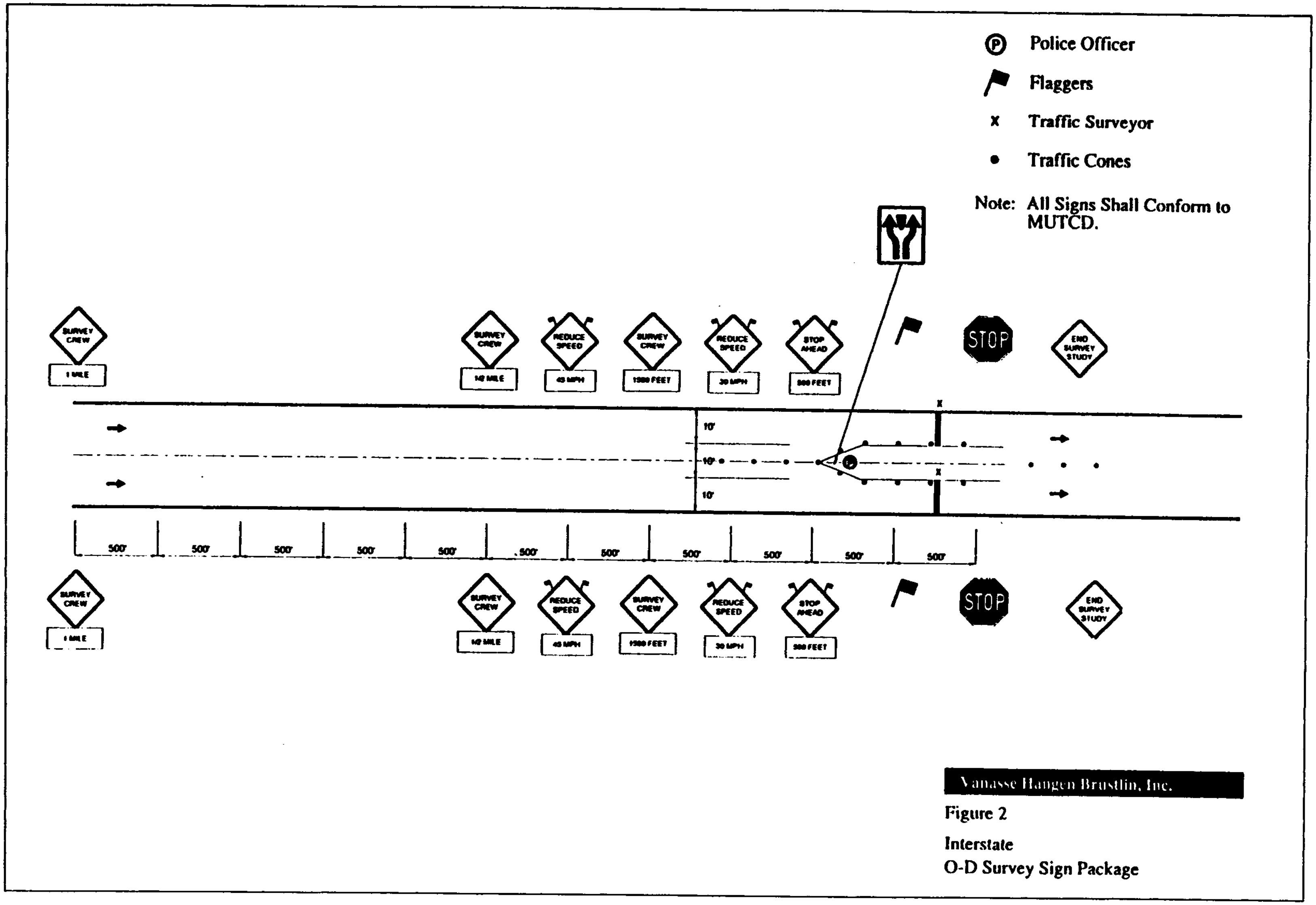
Figures 7.2 and 7.3 show some example survey station designs, but the survey team will probably want to customize their sites to match local conditions and specific survey needs. For instance, if the roadway traffic volume will support it, many survey teams use several interviewers or questionnaire distributors. Instead of intercepting a single vehicle at a time, an entire platoon of vehicles is intercepted together. In addition, some sites will allow for vehicles traveling in the survey direction to pass the survey station in a second lane while interviews are taking place, while other sites simply will not be wide enough.

Figure 7.2 Sample Vehicle Intercept Mailback and Interview Traffic Control Plans from Vermont



Source: Vanasse Hangen Brustlin, Inc., 1995.

Figure 7.3 Sample Vehicle Intercept Survey Site Design for Interstate Highways



Source: Vanasse Hangen Brustlin, Inc., 1995.

At a minimum, all roadside interview and roadside handout stations require the following:

1. Extensive signage, warning motorists of the survey (some survey efforts have used variable message signs);

2. A large number of traffic cones for channelling traffic;

3. Safety equipment for fieldworkers (orange vests, hard hats, etc.);

4. Supervisors and flaggers who have experience working in traffic; and

5. A police detail.

Even though police officers are not always required at the site, having officers on hand is usually worth the additional expense. Generally, police departments provide off-duty officers working overtime for efforts such as vehicle intercept surveys. The officers often have police cars available to them which can help attract motorists' attention to the fieldworkers on the roadway. In some cases, the police officer at the survey site plays an active role in directing vehicles into the survey station. In other cases, the officer simply oversees the safety procedures at the site. The police presence reduces the risk of accidents or incidents, because the officers are trained in safety procedures. In addition, the officers are much better able to deal with irate respondents than most survey crews.

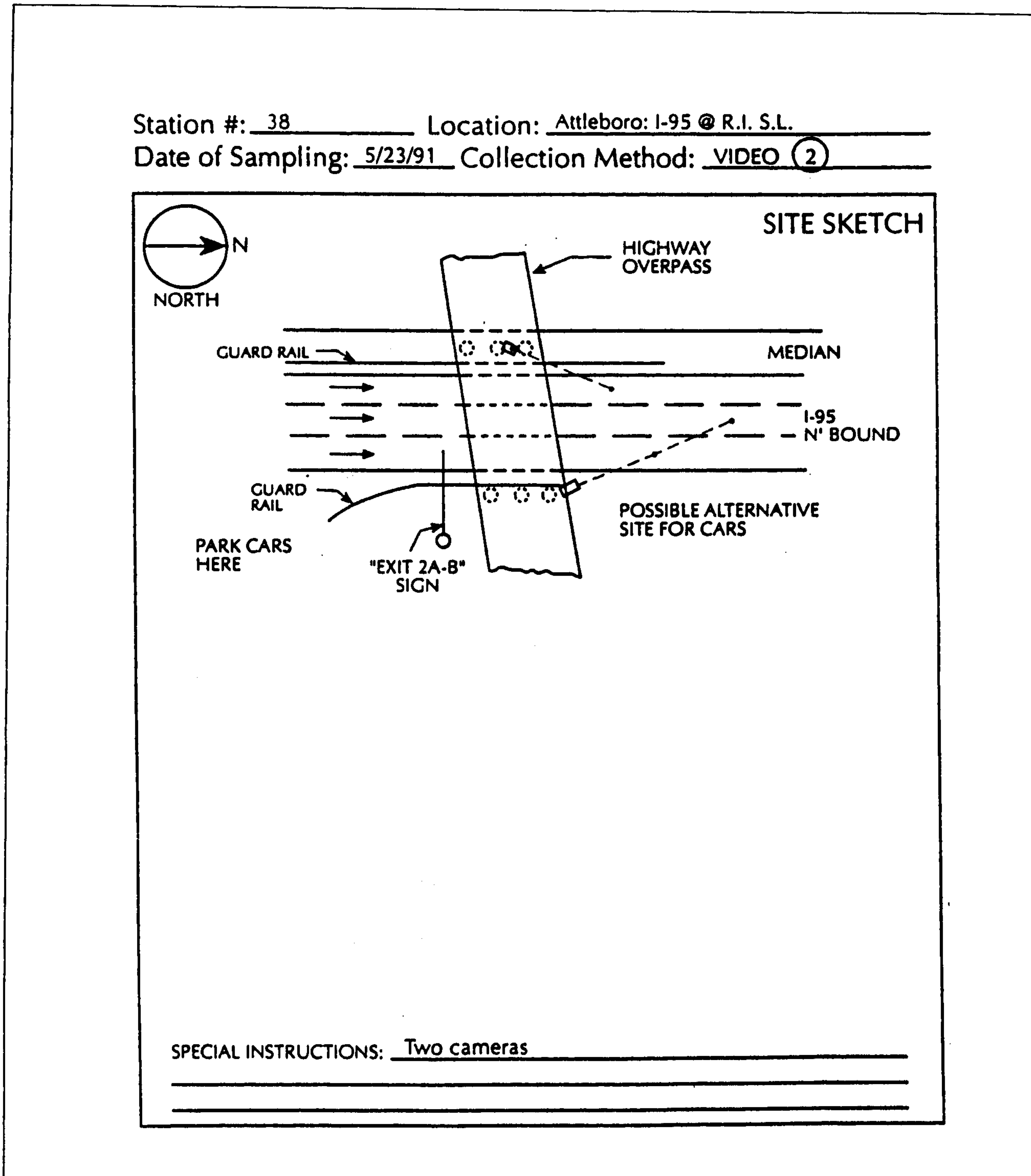
The Design of License Plate Survey Stations

The survey station for license plate surveys is much less complicated. The survey team simply needs to locate camera positions which can record license plates from all lanes of passing traffic and that allow fieldworkers to monitor the cameras. The stations are commonly established on highway overpasses. Fieldworkers for license plate surveys will also be near moving traffic as they work, so it is important that personal safety precautions similar to those used on roadside surveys be used.

Figure 7.4 shows an example survey station design for a videotape license plate survey. Like the roadside survey station designs, the license plate survey station designs need to be customized to the particular survey sites.

As discussed below, for both roadside surveys and license plate surveys, it is usually advantageous (or necessary) to conduct vehicle counts at or near the survey station. Usually tube counts are collected a few hundred feet beyond the survey station, and manual classification counts are made throughout the day. The count information is used for expansion of the data.

Figure 7.4 Example Vehicle Intercept Survey Design for a License Plate Survey



Source: Kenneth Miller, Thomas Harvey, Paul Shuldiner, and Cecilia Ho. *Using Video Technology to Conduct 1991 Boston Region External Cordon Survey*, Transportation Research Record 1412 (1993).

7.4 Organizing the Vehicle Intercept Survey

The organization of the vehicle intercept survey includes the following elements:

- Management of the survey effort;
- Staffing analysis;
- Hiring methods;
- Coordination with other agencies; and
- Advance publicity.

Management of the Survey Effort

Chapter 4.0 summarizes the three primary management tasks of travel surveys:

- Overall management and leadership of the effort;
- Day-to-day management of survey fieldwork; and
- Analysis of the survey effort from the data user perspective.

Vehicle intercept surveys present unique management challenges for each task, but perhaps the most important aspect of these surveys from a management perspective is the need to effectively adapt general survey procedures to specific survey sites, each of which is different from the others. Often survey efforts rely on more than one data collection method or technique, and even when the same general procedures are used, they must still be adapted to each site.

High quality field supervision is a key to the success of vehicle intercept surveys. The survey team should ensure that the supervisors understand the goals of the survey effort, and that they are equipped to make on-site decisions about how to solve unforeseen problems without endangering the overall data quality.

Staffing Analysis

The fieldworker staffing needs for vehicle intercept surveys are related to the survey method and the site being surveyed. The staffing analysis should consider attributes of each selected roadway, such as the number of travel lanes, average daily, morning, and afternoon peak-period traffic flows, time periods to be analyzed, and logical and safe survey operation locations. The basic steps presented below are recommended:

License Plate Survey

1. Identify the number of roadways, lanes, and the survey times. This information will establish the coverage of roadways to be surveyed. It will also identify specific videotape crew, license identification crew, and camera specifications per survey location.

2. Identify the estimated daily peak-traffic volumes using the roadways to be surveyed. Much of this information may already be available from existing traffic counts or volume estimates. Based on these volumes, define the analysis needs of the survey in terms of sampling (see Section 7.5) and travel demand modeling. This information, in conjunction with the various time periods identified in Step 1, should provide the appropriate level of survey coverage to represent typical peak and daily roadway travel on the selected roadways.

3. Identify the estimated number of license plates to be observed by time period and roadway lane. This information will be required to identify the data collection periods. In most cases, observation can be conducted in hourly segments to facilitate license plate identification and transferal of information for merging with DMV databases.

4. Estimate license plate transcription and data entry rates to determine office staff requirements.

Roadside Handout and Interview Surveys

1. Identify the number of roadways and survey times. This information will establish the extent of coverage of the roadways to be surveyed.

2. Analyze the traffic control plan developed during the survey design task for each roadway to be surveyed. This plan includes the setup and control of the roadway survey station. It should include a given number of surveyors, roadway flaggers (for each direction) to slow traffic, a given number of relief surveyors, and one or more supervisors. Each station should have a law enforcement officer on duty to ensure safety and motorist cooperation. This plan also provides information on the effort required for site setup, including coning roadway travel lanes and stationing of advance warning signs.

3. Identify the estimated daily and peak-traffic volumes using the roadways to be surveyed. Based on these volumes, the analysis needs of the survey are defined related to sampling and travel demand modeling.

4. Use the traffic control plan and the traffic volume information to estimate site productivity rates.

Hiring Methods

Based on the staffing analysis, the next task will be to identify the methods for hiring surveyors. The hiring options for the vehicle intercept surveys include the following:

1. Contract with a local or, in the case of the License Plate Survey, a specialized data collection firm to conduct the survey. The data collection firm will be responsible for hiring surveyors, and conducting, administering, and supervising the survey in the field.

2. Contract with a local or specialized data collection firm to conduct the survey with supervision provided by the project sponsor. The data collection firm will be responsible for hiring surveyors and conducting the survey in the field while the project sponsor will be responsible for overall management and supervising the survey in the field.

3. The project sponsor will be responsible for recruiting and hiring surveyors, and conducting, administering, and supervising the survey in the field

In most cases, the license plate survey will be conducted by private consulting firms specializing in this type of data collection. If consultant assistance is obtained for the roadside surveys, most survey teams usually hire traffic engineering firms, as opposed to survey research firms. This is because of the need for experienced traffic personnel. The engineering firms either use in-house staff or hire temporary employees for the work.

If the sponsoring agency chooses to manage the effort themselves, they should schedule interviews with prospective surveyors from various organizations, including college and university employment agencies, planning, and engineering departments; state and local government employment agencies; and private temporary employment organizations. Based on these interviews, the sponsor(s) will select the best qualified personnel.

In most cases, hiring surveyors familiar with the region to be surveyed is important. It may also prove useful for the project sponsor(s) to be involved in the initial administration and supervision of the survey (possibly during the pretest stage) effort to ensure that the surveyors (or local contractor) are conducting the survey properly.

Coordination

Coordination and communication between the various participating agencies should be established early on in the development and implementation of the vehicle intercept and external station survey. In many vehicle intercept surveys, State Departments of Transportation (State DOTs), Departments of Motor Vehicles (DMVs) from the survey state and perhaps from adjoining states, state and local Highway Patrols, and local Departments of Transportation and Public Works may potentially be involved in the survey effort.

The survey team needs to identify the special concerns of the different agencies early in the survey design. In some cases, agencies, such as State DOTs, require the use of standardized and accepted Traffic Control Plans to be used for vehicle intercept surveying. State DOTs may not allow vehicles to be stopped for surveying. There are also legal implications to stopping vehicles for surveys, including insurance liability issues for data collection firms. This initial coordination between the surveyor and participating agencies is critical to the successful implementation of the survey, and typically helps to identify the acceptable and appropriate survey method early on in the effort.

Advance Publicity

For vehicle intercept surveys, it is highly desirable to publicize the overall effort well in advance of the fieldwork dates. Potential respondents are more likely to believe that the survey effort is legitimate and important if they have heard that the survey will be taking place. This is especially true for the license plate method, because respondents will receive the survey instrument without any notification. The publicity effort is the only effort to alert potential respondents of the effort prior to the actual survey.

However, the survey team should exercise care in providing publicity about the specific sites to be surveyed. If motorists know that roadside surveys are being conducted at a particular location on a certain day, they may change their travel patterns to avoid (or to include) that location. In this case, the usefulness of the survey data is jeopardized, particularly if the collection of origin-destination data is the primary survey objective.

■ 7.5 Sampling

As noted above, the vehicle intercept and external station survey should be developed and conducted simultaneously with either an existing or proposed Traffic Count Program. The purpose of the Traffic Count Program is to identify the level of traffic volumes expected at each vehicle intercept survey location. These traffic volumes can help to define the sample size requirements of the total respondents required for given survey time period.

Each survey method – the License Plate Survey, Roadside Handout Survey, and Roadside Interview Survey – use the same sampling strategy. The typical sampling procedures for selecting sample time periods and vehicles are described in the following sections. A general description of sampling methods and statistical analysis appears in Chapter 5.0.

Selecting Time Periods and Days

The Staffing Analysis of the organizational plan describes the staffing requirements based on specific roadway location, time period, and number of days identified for surveying. Depending on the scale and scope of surveying, the following guidelines should be followed for selecting survey time periods and days:

1. Identify the schedule for surveying. This schedule should describe the start and end dates proposed for the survey. For example, the survey may be scheduled for one month, roughly starting April 1 and ending May 1. In most cases, vehicle intercept surveys are scheduled in the Spring (March through May) and Fall (September through November – before the Thanksgiving Holiday) of any given year.

2. Within the defined schedule, identify the number of potential roadway locations and weekdays for surveying. Vehicle intercept surveys are typically conducted on Tuesdays, Wednesdays, or Thursdays during the week to gather representative samples of weekday traffic.

3. Identify the time periods for analysis. Generally, a 12-hour time period, from 6:00 a.m. to 6:00 p.m., is selected for surveys of this type, but the selected period should be based on the daylight hours. A 12-hour period will provide representative samples of weekday daily, and morning and afternoon peak-period traffic volume flows.

At this point, a detailed schedule for the number of days and time periods for surveying should be identified. Adjustments to this sampling can be made to account for weekend surveying, peak-period surveying, and time extensions (from the spring to fall) because of large scale surveying.

Selecting Vehicles

The selection of the number of vehicles to be sampled is dependent on the number of vehicles using the particular roadway under study. The development of this survey sample should be made based on the most recent traffic volume information available. Typically, vehicle intercept surveys are conducted for 12-hour periods and include the following sampling procedures:

1. Identify the daily two-way directional volumes for each of the selected roadway locations to be surveyed. In some cases, previously collected traffic data can be used to estimate daily traffic volumes. Optimally, newly collected traffic volumes collected from the Traffic Count Program should be used.

2. Identify the proposed sample rate for each of the selected roadway locations to be surveyed. This proposed sample rate is commonly defined to achieve an accuracy of 15 percent (error) at a confidence of 95 percent for a 10 percent proportion of the surveyed roadway's total traffic having a particular origin and destination. This sample rate equation will provide the expected number of driver responses required at each roadway location.

Table 7.5 shows the sample size estimation for a multi-site license plate survey recently performed by the Metropolitan Washington Council of Governments.

During the conduct of the survey, a detailed account should be identified of the expected survey response rate and predicted number of completed questionnaires required for each roadway location surveyed. Adjustments to this sampling can be made to account for low response rates by specific location. For example, roadway locations can be surveyed again to obtain the proposed sample rates.

While the actual response rates, of course, are unknown until the survey is completed, the estimated response rates are critical information in the determination of sample size. The expected response rate will depend on the survey method, the type of roadway being surveyed, and the characteristics of the travelers on the roadway. Surveys which require a mail-back response will, naturally, have much lower response rates than in-person interviews.

If license plate matching is used, there is an additional factor in the response rate estimation: the plate match rate. The match rate is the percentage of observed license plates which are recorded and matched to a vehicle in the motor vehicle department file. There are two main reasons why some vehicles will not produce matches:

Table 7.5 Selected Survey Station Sites and Estimated Survey Samples

Sta.	ID	Location	Functional Classification	Mandatory/ Optional*	1992 AADT (2-way)	1992 AAWDT (AADT 1.1)	Station Volume Class**	Estimated 2-way Traffic 11 a.m.- 7 p.m.	Required No. of Completed Surveys	Required No. of Matched Plates @ 35% Rate of Response	Required No. of Recorded Plates @ 85% Match Rate
MD	1	US 50/US 301	Freeway	M	47,308	52,037	4	25,100	747	2,134	2,511
MD	2	MD 10 (S of I-695)	Freeway	O	33,725	37,098	4	17,900	747	2,134	2,511
MD	3	MD 2 (Ritchie Hwy) (S of I-895)	Princ Arterial	M	45,100	49,810	4	23,900	747	2,134	2,511
MD	4	1-97/old MDS	Interstate	M	68,850	75,735	2	38,500	1,681	4,803	5,650
MD	5	MD 648 (S og I-695)	Princ Arterial	M	26,175	27,693	4	13,400	747	2,134	2,511
MD	6	MD 170 (S of I-695)	Princ Arterial	O	14,500	15,950	5	7,700	549	1,569	1,845
MD	7	MD 295 (B-W Pkwy)	Freeway	M	60,550	66,805	3	32,100	1,076	3,074	3,617
MD	8	I-95 (AA/Balt CL)	Interstate	M	78,100	83,710	2	40,400	1,681	4,803	3,650
MD	9	US 1(Wash Blvd)	Princ Arterial	M	16,900	18,590	5	9,000	549	1,569	1,845
MD	10	I-95 (How/Balt CL)	Interstate	M	127,800	140,580	1	67,800	2,988	8,537	10,044
MD	11	MD 144 (Frederick Rd)	Minor Arterial	O	10,700	11,770	5	5,700	549	1,569	1,845
MD	12	US 40 (Balt Nat Pk)	Princ Arterial	M	36,300	38,830	4	18,700	747	2,134	2,511
MD	13	I-70 (How/Balt CL)	Interstate	M	54,250	59,675	4	28,800	747	2,134	2,511
MD	14	MD 28 (Liberty Rd)	Minor Arterial	M	25,700	28,270	4	13,600	747	2,134	2,511
MD	15	MD 140 (Westminister Pk)	Minor Arterial	O	31,415	34,557	4	16,700	747	2,134	2,511
MD	16	MD 30 (MD/PA SL)	Princ Arterial	M	11,225	12,348	5	6,000	549	1,569	1,845
MD	17	MD 97 (MD/PA SL)	Minor Arterial	O	4,025	4,428	7	2,100	269	769	904
MD	18	MD 19 (MD/PA SL)	Minor Arterial	O	3,300	3,630	7	1,800	269	769	904
MD	19	US 15 (MD/PA SL)	Princ Arterial	M	9,425	10,368	5	5,000	549	1,569	1,845
MD	20	MD 140 (MD/PA SL)	Minor Arterial	M	5,600	6,160	6	3,000	420	1,200	1,412
		Totals			958,148	105,1761		507,700	27,265	77,900	91,647

- The recorded plate is not from a state to which the data file will be sent for matching (usually it will be efficient to exchange data with from only one to three states; it is seldom worthwhile to exchange data for states with only a handful of plates); and

- The plate cannot be read or is mis-recorded.

There are several reasons why license plates are mis-recorded or unread. These include:

- Lack of light, or glare from sunlight;

- Obstructions, such as tow bars, bicycles, and dirt;

- Bad viewing angles, especially for vehicles which are changing lanes or have overhangs above the license plates; and

- Simple recording or keypunching errors.

Although a greater percentage of license plates may be read using video technology, the match rate may be even lower than for plates that are manually recorded. This is because the camera is in a fixed position and cannot "look around" obstructions or at plates that are outside the field of view. Automated plate matching programs can also have high error rates as similar characters (e.g. "D" and "O" "B" and "8") may be mistaken for one another, and plates that appear visible to the naked eye on a video display are too dirty or unlighted for the program to match. Still the potential savings in labor, both for license plate transcription and data entry, makes the use of video technology attractive and can more than offset the costs of having to collect a greater sample.

Table 7.6 shows response rates for a vehicle intercept survey in New Hampshire which used three different survey methods. In this survey, the response rate was 17% for the postcard handout/mailback survey and 21% for the license plate recording/mailout/mailback survey. With the match rate at 73%, this survey had an equivalent response rate of 15%. While the response for these two methods turned out to be similar, it should be noted that the license plate method was used only on two expressways on the Massachusetts border in the most heavily developed part of New Hampshire. The license plates were recorded from overpasses, which did not exist in most of the other locations. The same response and match rates might not have been achieved if the license survey were performed at other locations.

Table 7.6 Response Rates from A New Hampshire Vehicle Intercept Survey

Roadside In-Person Interviews	
Number of locations:	13
Average two-way AADT:	8,200
Range of AADT:	1,000-28,800
Total vehicles counted:	61,475
Total surveys conducted:	19,293
Total clean, usable surveys:	18,319
% Usable:	95%
Postcard Handout/Mailback Surveys	
Number of locations:	10
Average two-way AADT:	21,925
Range of AADT:	6,000-49,000
Total vehicles counted:	169,850
Total surveys distributed:	71,236
Total surveys returned:	13,056
Total clean, usable surveys:	12,204
Overall response rate:	17%
License Plate Recording/Mailout/Mailback Surveys	
Number of locations:	2
Average two-way AADT:	68,750
Range of AADT:	52,000-85,500
Total vehicles counted:	122,197
Total plates observed:	28,024
Total surveys distributed:	20,500
Match rate:	73%
Total surveys returned:	4,642
Total clean, uable surveys:	4,310
Overall response rate:	21%

Note: The survey method did not attempt to record every license plate.

7.6 Drafting and Constructing Vehicle Intercept Survey Instruments

Like the other surveys described in this manual, the wording of questions must be carefully considered and consistent with other types of travel surveys recently performed or currently underway. For example, consistent questions about trip-making should be determined for household travel surveys and vehicle intercept and external station surveys if they are to be used together for model development. This ensures consistent information will be collected, especially regarding travel behavior characteristics of persons within a region. In addition, information collected in the vehicle intercept surveys should also maintain consistency with the current Census data specifications. The household, trip, and person information typically collected in the intercept survey should maintain the same categories as specified in the latest Census including breakdowns of income levels, occupation codes, and ethnic status.

Survey instruments and questionnaire designs will be different depending on the survey method selected. General survey instrument and questionnaire guidelines related to the types of questions, survey instrument considerations, and timeframes are provided below.

Data Elements

Table 7.7 shows the data elements typically collected in vehicle intercept surveys. Questions should be structured to obtain information about travel and trip-making behavior, households, and individuals. Travel and trip-making behavior questions should include origin and destination locations, vehicle type, trip purpose, and auto occupancy information. Questions about households should include number of available automobiles, household income levels, and number of persons per household. Demographic questions about individuals should include sex, occupation, and employment status information. Vehicle intercept surveys are also commonly used to collect attitudinal and stated-response information from motorists.

Because vehicle intercept instruments are generally very short, the number of data elements collected by these surveys is limited. Many vehicle intercept surveys collect only the barest essentials about the auto trip. Therefore, the range of data elements covered in these surveys is much smaller than for the household travel and activity surveys. The survey team should define essential data elements and other desirable elements that would be included if space or time permit.

Table 7.7 Vehicle Intercept Survey: Typical Data Elements Collected

Data Elements	Information Typically Obtained
Travel Data	
Travel Purpose	Trip purpose categories of sufficient detail to characterize the trip in travel demand models.
Arrival and Departure Times or Travel Time	Trip start and end times are recorded.
Type of Vehicle Used	Type of vehicle used for the surveyed trip.
Address of Trip Origin and Destination	Street address, nearest intersection, or name of the establishment of both the ultimate origin and destination of the trip.
Vehicle Occupancy	Number of people traveling together in the surveyed vehicle.
Travel Routes	Description of roadways and routes used to enter and leave study area.
Frequency of Trip Making	Identifying how often people use the roadway surveyed during a given day, week, or month.
Demographic Data	
Household Size	Number of members of a household.
Household Income	Annual household income of the persons surveyed.
Age and Sex	The age and sex of each person in the household.
Attitudinal Data	
Perceptions about Congestion	Determine the respondents' attitudes about traffic congestion within the corridor surveyed. This may include identifying the magnitude of congestion, if there is congestion or not, or ideas about solving congestion problems.

Table 7.7 Vehicle Intercept Survey: Typical Data Elements Collected (continued)

Data Elements	Information Typically Obtained
Attitudinal Data (continued)	
Potential Use of Alternative Routes	Determine the respondents, potential use of alternative travel routes within the area of study because of congestion, increased travel times, etc.
Identify Alternative Means of Travel	Determine the respondents, potential use of travel modes other than the automobile in the corridor. This may include identifying the respondents' knowledge of other available travel modes.

Translating Data Elements Into Questions and Response Categories

As discussed in Chapter 6.0, a survey question should be included in a survey interview script or questionnaire if:

- The information obtained from the question is relevant to the models being developed or refined, or to other anticipated analytical efforts.
- The question and response categories are expected to be valid measures of the modeling variables.
- The responses can be coded meaningfully for modeling analyses.
- Analysts, interviewers (if any), and respondents agree unambiguously on the meaning of the question and response categories.
- The question and response categories have no wording problems. The wording of questions and responses is the same or equivalent to any measure from other surveys that will be used in the modeling work.
- Response categories exhaust all meaningful answers that can be anticipated.
- Response categories are meaningful and understandable to respondents.
- (For interviews) the questions and response categories are easily learned by interviewers.
- The benefits in the survey analysis from the question outweigh its costs in terms of survey length, respondent burden, and increased non-response.
- The information gained from the question is more useful than the information that would be gained from other questions that will not be on the survey.
- The question does not provoke respondents to be hostile to the survey effort or to question the goals of the surveying agency.

Chapters 2.0 and 6.0 provide detailed guidance on drafting survey questions.

Survey Instrument Considerations

For the License Plate Survey, the questionnaire layout parameters should be identified and implemented based on the types of questions selected, appropriate card stock, page layout formats, and return of address envelopes with postage. This layout should include a brief project description, a request for respondent participation, and a logical organization of the travel behavior, household, and demographic questions. For example, the "to trip" (inbound, to work) and "from trip" (outbound, from work) travel behavior questions should be separated and asked at the start of the questionnaire. Household and demographic characteristics questions should follow the travel behavior questions. The layout should also consider double-sided questionnaires to reduce printing requirements and costs. In addition, an upper limit on the number of questions should be identified to increase the survey response rate. A cover letter, signed by the project sponsor(s) and/or elected officials should also be provided along with detailed instructions for filling out the questionnaire.

Additional instrument considerations must be addressed in the License Plate Survey design to account for unreadable license plates on the videotape, license plate and DMV mismatches, and coding errors when transcribing license plates from the videotape. In addition, the DMV will not be able to identify out-of-state vehicle license plates that could be videotaped on a surveyed roadway. The surveyors must identify the appropriate strategies to account for these potential problems to maintain the established sampling strategy and response rates.

The Roadside Handout Survey can follow the same format as the License Plate Survey. Often, handout surveys include fewer questions, and utilize a postcard style format. This questionnaire form may be limited to questions specifically related to travel and trip-making behavior.

Many survey teams feel that it is imperative to keep the survey instruments as short as possible either because longer instruments require additional expense (in terms of higher postage, need for envelopes, etc.) or because of the concern that response rates will drop precipitously if the questionnaires are too long. Unfortunately, this policy is sometimes enforced to the point where analyses of the data are harmed, because key data elements are left out. The survey team should indeed keep the questionnaires short, but not at the expense of the analysis.

The appropriate card stock, page layout formats, and multi-language formats should also be developed. Questionnaires for this type of survey tend to be multi-colored card stock the size of a typical postcard, or slightly larger. In most cases, the questions are provided on one side of the questionnaire while the return of address and postage are provided on the other side. Figures 7.5 and 7.6 show two recent roadside handout survey forms.

The Roadside Interview Survey requires a similar, but slightly different, survey instrument as the Roadside Handout Survey because an interview between the surveyor and respondent is conducted. The questionnaire should include a questionnaire formatted on a single-sided, 8 1/2 by 11-inch paper. This format allows for quick interviewer (surveyor) tallying of driver responses and should be limited to the same types of travel and trip-making behavior questions asked for the Roadside Handout Survey. It is imperative to limit the interview time to one to three minutes to facilitate the conduct of the survey. Each interviewer will be given a clipboard and several questionnaires to conduct the survey. Figures 7.7, 7.8 and 7.9 show examples of roadside interview recording forms. Figure 7.10 shows a typical interviewer script used in a PAPI vehicle intercept survey. A computerized questionnaire would be similar, but would include error checking, look-up tables, etc.

Figure 7.5 Sample Vehicle Intercept Mailback Survey Form from Vermont

Travel Survey ▪ Vermont Agency of Transportation and New Hampshire Department of Transportation

Questions

Please take a moment to answer a few questions about your trip into or through Vermont (**excluding** any return trip). Your responses will be used to help determine the need for transportation improvements in this area. **Please record your responses on the attached card ▶**

1 Where did your trip begin? (the **last** place you entered your vehicle prior to receiving this card, excluding short stops for gas or food) 1

2 What type of place is your trip start point? 2

3 Where did your trip end? (the **first** place you exited your vehicle after receiving this card, excluding short stops for gas or food) 3

4 What type of place is your trip end point? 4

5 If your trip ended outside of Vermont, please specify which route you used to leave the state (check one) 5

6 What was the purpose of your trip? 6

7 How many people were in the vehicle, **including** the driver? 7

8 What type of vehicle were you in? 8

9 Please add any comments on transportation you may have. 9

Please complete, detach, and return the answer portion of the postcard as soon as possible. No postage is necessary. **Thank you very much for your cooperation!**

X

Travel Survey ▪ Vermont Agency of Transportation and New Hampshire Department of Transportation

Answers

Information should be provided only for the trip you were making when you received this card.

1 Street Address ____________
Nearest Intersection/Landmark ____________
Town ____________ State/Province ________ Zip ________

2 ☐ Your Primary Residence ☐ Workplace ☐ Store
☐ Your Summer Residence ☐ Hotel/Motel ☐ Recreation Area
☐ Other (please specify) ____________

3 Street Address ____________
Nearest Intersection/Landmark ____________
Town ____________ State/Province ________ Zip ________

4 ☐ Your Primary Residence ☐ Workplace ☐ Store
☐ Your Summer Residence ☐ Hotel/Motel ☐ Recreation Area
☐ Other (please specify) ____________

5 ☐ I-89 ☐ I-91 ☐ I-93 ☐ Route 4 ☐ Route 7 ☐ Route 9
☐ Other (please specify) ____________

6 ☐ Work Commute ☐ Business Related
☐ Shopping ☐ School
☐ Recreation ☐ Other (please specify) ____________

7 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 or more

8 ☐ Passenger vehicle/motorcycle ☐ Pick-up truck/van
☐ Truck (2+ axles, more than 4 tires) ☐ Other ____________

9 Comments ____________

Source: Vermont A.O.T., 1995.

Figure 7.6 Example Vehicle Intercept Mailback Questionnaire from Upstate New York

No. 95217

1. Type of vehicle?

   Passenger Car ___ Pickup ___ Van ___ Other Truck ___ Bus ___

2. Purpose of trip today?

   Work ___ School ___ Shopping ___ Recreation ___ Home ___ Personal Business ___ Other ___

   Business Related to Work ___ Serving Passenger ___

3. Where were you coming from when you received this questionnaire?

   ____

   Street Address (or nearest intersection) City Zip Code

4. Where were you going when you received this questionnaire?

   ____

   Street Address (or nearest intersection) City Zip Code

5. How many people in vehicle (including driver)? ______________________

6. How many days per week do you make this trip?

   1 ___ 2-3 ___ more than 4 ___ Other (please specify) ______________

7. Any additional information on your trip that you think might be helpful to us would be appreciated.

   ____

   ____

Proposed Message on Postcard:

"The New York State Department of Transportation is looking at ways to improve transportation in the Baldwinsville area. By completing this postcard, you will help to identify roadway improvements. Please answer the questions for the trip that you were making when you received this postcard. Return postage is free. Thank you.

Source: NYSDOT, 1993

Figure 7.7 Sample Vehicle Intercept Interview Form from Upstate New York

Baldwinsville O & D Survey

Station Location #______ Date ___/___ Time ___:___ am pm Interviewer __________

SAMPLE NUMBER	DIRECTION	Type of Vehicle	OCCUPANCY	Where did this trip begin?	Why were you there?	Where will this trip end?	Why are you going there?
	N E S W	1. Auto/Van 2. Motorcycle 3. RV 4. Pick-up Truck 5. Light/Medium Truck (Single Units) 6. Heavy Trucks 7. Bus	—	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger
	N E S W	1. Auto/Van 2. Motorcycle 3. RV 4. Pick-up Truck 5. Light/Medium Truck (Single Units) 6. Heavy Trucks 7. Bus	—	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger
	N E S W	1. Auto/Van 2. Motorcycle 3. RV 4. Pick-up Truck 5. Light/Medium Truck (Single Units) 6. Heavy Trucks 7. Bus	—	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger
	N E S W	1. Auto/Van 2. Motorcycle 3. RV 4. Pick-up Truck 5. Light/Medium Truck (Single Units) 6. Heavy Trucks 7. Bus	—	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger
	N E S W	1. Auto/Van 2. Motorcycle 3. RV 4. Pick-up Truck 5. Light/Medium Truck (Single Units) 6. Heavy Trucks 7. Bus	—	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger	Establishment or Street & Number City State	1. Home 2. Workplace 3. Shop 4. Social/Recreation 5. Personal Business 6. Work Related 7. Serving Passenger
				TRIP ORIGIN		TRIP DESTINATION	

Figure 7.8 Sample Vehicle Intercept Interview Form from Northern Colorado

Code: ___ ___ ___ - ___ ___ ___ ___ - ___

North Front Range TDM Project | 1995 Vehicle Intercept Survey

LOCATION: DATE: DAY:

SURVEYOR:____________________ HOUR: DIRECTION: ________

1. TRIP ORIGIN	**1. TRIP ORIGIN**	**1. TRIP ORIGIN**
____________________	____________________	____________________
____________________	____________________	____________________
(Street address or nearest intersection)	(Street address or nearest intersection)	(Street address or nearest intersection)
____________________	____________________	____________________
(City/Town)	(City/Town)	(City/Town)
2. TRIP DESTINATION	**2. TRIP DESTINATION**	**2. TRIP DESTINATION**
____________________	____________________	____________________
____________________	____________________	____________________
(Street address or nearest intersection)	(Street address or nearest intersection)	(Street address or nearest intersection)
____________________	____________________	____________________
(City/Town)	(City/Town)	(City/Town)
3. TRIP PURPOSE	**3. TRIP PURPOSE**	**3. TRIP PURPOSE**
o 1. Home	o 1. Home	o 1. Home
o 2. Work	o 2. Work	o 2. Work
o 3. Work Related	o 3. Work Related	o 3. Work Related
o 4. School	o 4. School	o 4. School
o 5. Shop	o 5. Shop	o 5. Shop
o 6. Dining	o 6. Dining	o 6. Dining
o 7. Personal Business	o 7. Personal Business	o 7. Personal Business
o 8. Social/Recreation	o 8. Social/Recreation	o 8. Social/Recreation
o 9. Pickup/Drop Off Passenger	o 9. Pickup/Drop Off Passenger	o 9. Pickup/Drop Off Passenger
o 10. Other:____________	o 10. Other:____________	o 10. Other:____________
____________________	____________________	____________________
4. Vehicle Class	**4. Vehicle Class**	**4. Vehicle Class**
o 1. AUTO	o 1. AUTO	o 1. AUTO
o 2. SCHOOL BUS	o 2. SCHOOL BUS	o 2. SCHOOL BUS
o 3. PUBLIC TRANSIT BUS	o 3. PUBLIC TRANSIT BUS	o 3. PUBLIC TRANSIT BUS
o 4. TAXI	o 4. TAXI	o 4. TAXI
o 5. VAN	o 5. VAN	o 5. VAN
o 6. MOTORCYCLE	o 6. MOTORCYCLE	o 6. MOTORCYCLE
o 7. RV	o 7. RV	o 7. RV
o 8. Other:__________	o 8. Other:__________	o 8. Other:__________
5. Vehicle Occupancy	**5. Vehicle Occupancy**	**5. Vehicle Occupancy**
o 1 o 2 o 3	o 1 o 2 o 3	o 1 o 2 o 3
Other: ______	Other: ______	Other: ______

Figure 7.9 Sample Vehicle Intercept Interview Form from Vermont

VHB
Vermont Statewide Model
Roadside Survey - Interview Form

Survey Location:__________ Interviewer:__________

Time Period:__________ Date:__________

Q1. Location of start point	Q2. Description of start point	Q3. Location of destination point	Q4. Description of destination point	Q5. Purpose of trip	Q6. Route to leave Vt.	Q7. # of pso.	Q8. Type of veh.	Code
Street Add:	Prim Res. Summ Res.	Street Add:	Prim Res. Summ Res.	Work Com. Rec.	I 89 / I 91	1	Pass	
	Work Store		Work Store	School Shopping	I 93 / Rt. 4	2	V. / P.U.	
Town:	Hotel Rec. Fac.	Town:	Hotel Rec. Fac.	Business Related	Rt. 7 / Rt. 9	3	Truck	
State/Zip:	Other:	State/Zip:	Other:	Other:	Other:	4	Other	
Landmark:		Landmark:				5+	ST.	
Street Add:	Prim Res. Summ Res.	Street Add:	Prim Res. Summ Res.	Work Com. Rec.	I 89 / I 91	1	Pass	
	Work Store		Work Store	School Shopping	I 93 / Rt. 4	2	V. / P.U.	
Town:	Hotel Rec. Fac.	Town:	Hotel Rec. Fac.	Business Related	Rt. 7 / Rt. 9	3	Truck	
State/Zip:	Other:	State/Zip:	Other:	Other:	Other:	4	Other	
Landmark:		Landmark:				5+	ST.	
Street Add:	Prim Res. Summ Res.	Street Add:	Prim Res. Summ Res.	Work Com. Rec.	I 89 / I 91	1	Pass	
	Work Store		Work Store	School Shopping	I 93 / Rt. 4	2	V. / P.U.	
Town:	Hotel Rec. Fac.	Town:	Hotel Rec. Fac.	Business Related	Rt. 7 / Rt. 9	3	Truck	
State/Zip:	Other:	State/Zip:	Other:	Other:	Other:	4	Other	
Landmark:		Landmark:				6+	ST.	
Street Add:	Prim Res. Summ Res.	Street Add:	Prim Res. Summ Res.	Work Com. Rec.	I 89 / I 91	1	Pass	
	Work Store		Work Store	School Shopping	I 93 / Rt. 4	2	V. / P.U.	
Town:	Hotel Rec. Fac.	Town:	Hotel Rec. Fac.	Business Related	Rt. 7 / Rt. 9	3	Truck	
State/Zip:	Other:	State/Zip:	Other:	Other:	Other:	4	Other	
Landmark:		Landmark:				5+	ST.	
Street Add:	Prim Res. Summ Res.	Street Add:	Prim Res. Summ Res.	Work Com. Rec.	I 89 / I 91	1	Pass	
	Work Store		Work Store	School Shopping	I 93 / Rt. 4	2	V. / P.U.	
Town:	Hotel Rec. Fac.	Town:	Hotel Rec. Fac.	Business Related	Rt. 7 / Rt. 9	3	Truck	
State/Zip:	Other:	State/Zip:	Other:	Other:	Other:	4	Other	
Landmark:		Landmark:				5+	ST.	

NH Border Form

Source: Vanasse Hangen Brustlin, Inc., 1995.

Figure 7.10 Sample Vehicle Intercept Interviewer Script

Vermont Transportation Study
Roadside Survey - Interview Questionnaire

Opening Statement:

"We are conducting a transportation roadside survey for the state of Vermont and would like to ask you a few brief questions." (go to Q1)

- If the driver requests additional information, say the following:
  "The information we collect will be used to determine travel patterns for a statewide transportation study."
  If this is not enough, hand them a detailed form, and proceed with Q1.

Note: If a person is reluctant to offer information, please don't force them !! Thank them and let them pass.

Q1. "Where did your trip begin?"
- Their response should be the last place they entered their car before stopping here, not including short stops for gas or food.
- Record the street address or nearby landmark (if an address cannot be provided), town, state, and zipcode.

Q2. "Is the place your trip began your primary residence, summer residence, workplace, a store, hotel, recreational facility, or something other?"
- Circle one of the responses given on the form. If something other, provide a brief description.

Q3. "Where are you traveling to?"
- This should be the next place they plan on leaving their car, not including short stops for gas or food.
- Record the street address or nearby landmark (if an address cannot be provided), town, state, and zipcode.
- This is an important question so accuracy is crucial!

Q4. "Is the place you are traveling to your primary residence, summer residence, workplace, a store, hotel, recreational facility, or something other?"
- Circle one of the responses given on the form. If something other, provide a brief description.

Q5. "What is the purpose for your trip? Commuting to work, business related, shopping, school, recreational, or something other."
- Circle one of the responses given on the form. If something other, provide a brief description.

If the driver's trip is ending within Vermont, ignore Q6!!

Q6. "What major roadway will you use to leave Vermont?"
- Circle one of the responses given on the form. If something other, provide a brief description.

After asking each of the questions, record the following information:

1. **The number of people in the vehicle.**
   (ex. one person driving alone = 1).
2. **The type of vehicle.**
   (ex. passenger car, van/pick-up, commercial truck w/ 2+ axles and more than 4 tires, or something other).
3. **The state in which the vehicle is registered.**

Source: Vanasse Hangen Brustlin, Inc., 1995.

■ 7.7 Pretesting

The pretesting requirements of the vehicle intercept and external station surveys will be dependent on the survey method selected. The survey logistics, procedures, and instruments should be thoroughly pretested before the full survey is implemented. Depending on the survey method chosen, the number of roadways (and in the case of the License Plate Survey, the number of lanes per roadway) should be identified to test the survey instrument, surveyor organization, and survey response rates under different conditions. These conditions may include surveying for peak-periods and daily conditions on different roadways to identify any problems that may arise through the conduct of the survey.

Fully implemented survey procedures should be pretested on at least two roadways with different characteristics, such as a freeways, highways, and arterials. For example, the entire survey method should be tested for an all-day period, generally from 6:00 a.m. to 6:00 p.m. The pretest staff should include the designers of the survey procedures and forms, survey supervisors, and key surveyors hired to provide support in the fully implemented survey. The surveyors conducting the pretest will use the same procedures and techniques identified for use during the survey training sessions.

The pretest requirements for the License Plate Survey will be more rigorous than the other survey methods. This pretest should include filming one lane in each direction for a selected multi-lane-divided highway and a two-lane state route. In this case, the fully implemented survey procedures should be followed from videotaping, license plate identification and processing, transferal of license plate information to the local DMV, transferal of address information to the project sponsor(s), mailout and collection of returned questionnaires, and questionnaire processing.

Pretesting for the Roadside Handout and Interview Surveys will be very similar to one another regarding the number and time periods of locations selected for pretesting and should be the same as conducted for the License Plate Survey pretest (6:00 a.m. to 6:00 p.m. for two roadways). However, slightly different pretesting needs are required for the Roadside Interview Survey to refine surveyor interviewing techniques. The pretest should be used as an opportunity to help surveyors refine their interview style and interview times before the fully implemented survey begins.

Because of the high cost of setting up a survey station, pretests are usually conducted at one of the sample locations. If the survey effort works well, the pretest data are used. To do this, the survey team should schedule one or two survey locations several weeks ahead of the rest. The results of the early survey can be evaluated, and procedures may be modified, as needed, before the general data collection occurs.

After completing the pretest, a debriefing meeting should be held to identify any discrepancies in the survey procedures. The survey control sheets (which vary by the selected survey method) should be rigorously examined after the pretest for discrepancies and uncontrolled information. The information contained in the returned questionnaires should also be processed immediately to identify any potential problems associated with respondents filling out the survey properly. Frequency distributions should be conducted on each question to determine the validity of the survey instrument.

■ 7.8 Training and Briefing

Training methods will vary according to the survey method chosen. License Plate Survey training may require license plate identification and geocoding while the two roadside survey methods will require additional training. In general, survey staff training should consist of a project briefing and demonstration of the surveyor responsibilities. In addition, surveyors should be provided with the necessary materials and procedural notes to conduct the survey. In cases in which local data collection firms are hired, it proves highly useful for the project sponsor(s) to train survey administration and surveyor staff. Typical survey training procedures include:

1. **Project Briefing –** The project sponsor(s) should hold a project briefing for all hired survey staff (or local contractor survey staff). This meeting should be used to describe the background and purpose of the survey, and the administrative procedures to be followed during the course of the survey. At this point, all surveyors, including the "break" or replacement surveyors, should be given their survey assignments and work schedules.

2. **Survey Demonstrations –** The surveyors should be given individual demonstrations on the procedural conduct of the surveys. This includes describing the tasks of the surveyor regarding responsibilities for distributing (handing out) survey materials to drivers and/or collecting travel behavior information (interviewing or license plate data collection). The traffic control setup and breakdown requirements for each of the roadside surveys will also be demonstrated during this step.

3. **Survey Materials –** Each surveyor should be given the appropriate survey materials and supplies at the start of his/her survey shift. The materials provided are dependent on the scale and method of the survey to be undertaken. The materials for conducting the License Plate Survey will be provided by the contractor hired by the project sponsor(s). The materials identified below are intended to provide basic

guidelines for each roadway to be surveyed using either of the roadside survey methods:

- Individual packages containing questionnaires to either hand out or tally responses, pencils for tallying responses, and large pencil erasers;

- Survey assignment sheets;

- One or more envelopes per specific time period and direction;

- Traffic cones and advance warning signs; and

- Surveyor badges, hard hats, and (highly visible) safety vests.

4. **Survey Procedures** – Each surveyor should be provided with an outline (in writing) of the procedures described in the previous training sessions. In some cases, several copies of a letter describing the reasons for the survey may be enclosed with this package. The letter should be signed by the project sponsor(s) and should provide interested drivers with information about the survey. In addition, this will ensure that the surveyor will not be distracted from his/her responsibilities by answering questions about the survey that may be served through this letter. At a minimum, the procedures outline should contain the following information:

   - Where and when survey crews are to meet at the start of the survey shift;

   - The set up of the survey traffic control plan at the specified roadway location;

   - How to determine which questionnaires are to be used for specific roadways, directions, and time periods;

   - How to hand out questionnaires and/or conduct the interview and how to complete tally sheets for those drivers agreeing to participate in the survey;

   - (Roadside Interviews) What to do with completed questionnaires;

   - What to do with the survey control sheets that track the number of completed, incomplete, and refused interviews; and

   - Removal of the traffic control equipment at the end of the survey shift.

- (License plate surveys) Procedures for transferring raw license plate data to the office, procedures for matching the license plate database to DMV databases, and procedures for mailing surveys.
- Office staff procedures to follow when completed survey forms are mailed back.

■ 7.9 Interviewing and Questionnaire Distribution

This section describes the typical techniques used in Roadside Handout and Interview Surveys. For each survey method, the surveyor should be trained to solicit agreement of participation from drivers traveling on the selected roadways. Descriptions of surveyor interviewing techniques are described below for each survey method chosen.

Roadside Handout Survey

1. Set up the traffic control plan for purposes of providing advance warning to drivers of the upcoming survey.
2. Once questionnaires are handed out, surveyors should be trained to briefly describe the survey to solicit passenger participation. Topics covered include the purpose of the survey and description of the length of response time. Politeness and conciseness are required for each surveyor to obtain representative survey samples.
3. If passengers refuse to participate, surveyors should politely and quickly thank them for their time. If passengers agree to participate, the surveyor should distribute the questionnaires to potential respondents for mailback.

Roadside Interview Survey

1. Set up the traffic control plan for purposes of providing advance warning to drivers of the upcoming survey.
2. Surveyors should be trained to briefly describe the survey to solicit driver participation. Topics covered include the purpose of the survey and description of the length of interview time. Politeness and conciseness are required for each surveyor to obtain representative survey samples.

3. If drivers refuse to participate, surveyors should politely and quickly thank them for their time and move on to the next driver. If passengers agree to participate, the surveyor should ask the related travel behavior questions and tally the passenger responses. The surveyor will be equipped with several survey questionnaires, a clipboard, and pencils to tally passengers responses. The surveyor should limit individual interview time to one to two minutes.

4. Surveyors should record all collected information neatly and accurately on the questionnaire forms. During the slack periods, the surveyors should use the time to code each questionnaire for all information other than the origin and destination data obtained during the interview.

5. Surveyors will be responsible for organizing questionnaires collected from drivers by uniquely coded time period and one-way roadway manila envelopes for data processing/checking purposes.

The surveying and interviewing techniques for each survey method described above are very similar. Variations of these techniques can be used by the survey team to respond to unique situations likely to be encountered in different areas throughout the country.

Additional Administration Issues

The organization plan outlined previously in this chapter identifies the staffing analysis, hiring methods, and supervision required for each survey method. Additional administrative support issues should be considered before the survey is fully implemented. The requirements for this administrative support include:

- Developing the necessary forms such as the questionnaires, control sheets, and surveyor assignment sheets;
- Providing schedules to survey crews (make sure surveyors and film crews will show up at their scheduled times);
- Developing a manual of survey instructions;
- Developing and conducting the surveyor training program;
- Specifying and assembling survey materials including surveyor badges, vests, hard-hats, pencils, clipboards, envelopes, traffic cones, and advance signs;
- Conducting the pretest; and
- Ensuring the appropriate level of police enforcement.

This material must either be compiled and/or purchased at least one month before the implementation of the full survey. Additional materials, especially cones, and surveyor vests, and hard hats may be required for purchase as a contingency.

7.10 Coding

Vehicle intercept and external station surveys are coded using similar procedures as for other surveys described in this manual. In the case of the vehicle intercept, similar techniques are used to code the mailback/self-administered questionnaires obtained from the License Plate and Roadside Handout Surveys. The survey questionnaires are typically designed to be self-coding (except for the origin-destination information), where each survey response can be coded to correspond to its answer check box number.

Roadside Interview Survey coding can use the same techniques as the other survey methods. For example, the interviewers typically code the motorist responses into the check boxes on the questionnaire form, either by tallying motorist responses directly onto the forms or by directly entering responses into the survey databases on hand-held computers. Data coding can be completed manually or entered directly (using hand-held computers) into the coding database, by motorists completing the self-administered mailback survey, or by CAPI.

The survey data are typically punched into a numerical ASCII data block for a specified width and length as determined by the number of questions/responses and sample size of the survey. Individual survey questionnaire responses are typically given an identification number to track the responses for each vehicle surveyed. Survey origins and destinations must be geocoded to identify the geographic locations of the vehicles surveyed. Chapter 14.0 provides a detailed discussion of survey geocoding techniques.

7.11 Cleaning and Editing

The requirements for data editing the returned questionnaires is very similar for each selected survey method. However, the requirements for the License Plate Survey also require the additional task of editing and cleaning license plate information gathered from the videotapes and addresses obtained from the motor vehicle departments. Since turn-around time is critical, electronic data file transfer is becoming increasingly popular. Requirements for the Roadside Interview Survey consist of ensuring that all responses are tallied legibly and accurately by the surveyors. The questionnaires for each completed one-way roadway trip should be edited as soon after collection as possible to ensure that the questionnaire represents a valid response. At the end of each day, the trip envelopes should be opened and the control sheets should be checked for completeness.

For each survey method, the number of completed questionnaires and blanks should be tallied for each trip. Once the editor is satisfied that the trip information is complete, the questionnaires returned for that trip are sorted. Blanks can be discarded while the completed questionnaires should be sent for data entry. Each completed questionnaire may not have all questions answered. Therefore, the rules to identify a completed questionnaire should be given to the editors. Generally, a questionnaire is considered usable if the origin and destination of the trip are filled in and codable.

Cleaning the data once it is entered begins with range checks. For example, if the possible answers to a question are numbered 1-4 and the non-response is coded as 9, then all answers between 4 and 9 must be erroneous. In addition, certain cross checks must be performed to verify the accuracy of the data. These types of checks are called logic and consistency checks.

8.0 Transit Onboard Surveys

Transit onboard surveys are conducted to collect data for scheduling and operations planning, long-range planning and design, performance analysis, preparation of statistics and reports, and market evaluations. In many areas, transit ridership is a small percentage of total person trips, and data collected in a household travel survey may not have enough responses to adequately represent the trip patterns of transit users. A well designed transit onboard survey provides detailed information, such as ridership and demographic profiles by route, transfer characteristics and fare-class utilization, as well as accurate sample counts of boardings by station or stop.

Transit onboard surveys obtain travel data by intercepting the respondents onboard a surveyed transit vehicle. The intercept method is considered to be an accurate type of data collection since respondents do not have time to forget the characteristics of their trips. The onboard survey data can be used in models for analyzing new transit alternatives or future transit facilities such as intermodal terminals. The transit onboard data allow corridor level analysis of service options such as increased service, limited-stop (express) routes, and priority bus-lane treatments.

Onboard transit surveys may also include attitudinal components to determine how passengers learn about routes and times, to assess the reasons that individuals ride transit, or to explore amenities (such as lighting at bus stops) which may mitigate rider concerns (such as personal security). Data such as these can help determine marketing potential for new fare policies, services, or amenities.

In addition to information on the person trips on the sampled transit routes, total boardings and alightings on each sampled vehicle are directly collected. These data, in conjunction with the total number of vehicle trips on the survey day made on each sampled route by time period and direction, will permit the calculation of average boardings per route per time period by direction. In addition, these data provide the basis for survey sample expansion to represent the entire population of transit users. A few of the data uses and data sources are shown in Table 8.1.

The following discussion focuses on collecting origin-destination and rider characteristics data. Attitudinal questions are sometimes added to the basic data items, but significant care should be applied in designing stated-response, onboard surveys. Stated-response techniques are described in Chapter 13.0. Boarding and alighting counts taken at stations or bus stops,

Table 8.1 Use of Transit Onboard Survey Data

Source of Data	Data Use
Origin-destination and rider characteristics surveys	Determine profile of riders to identify marketing targets, measure growth by market areas, mode of access to transit and usage of park and ride facilities, determine characteristics of pass users and non-users
Attitudinal and stated-response surveys	Identify problems with new fare media, estimate effect of fare modifications, determine perception of services offered, other special studies
Station to station tallies, onboard checks	Section 15 passenger miles and unlinked trips

or onboard checks, use a survey design that is fairly uniform among operators and are used on a continuing basis by many transit agencies to obtain the passenger trip length data mandated by the FTA.

In many transit onboard surveys, the transit operator will be a sponsor or co-sponsor of the survey and will therefore be part of the survey team. Even when the operator is not a survey sponsor, it is advantageous to include the operator as part of the team. This will greatly assist in obtaining data from the agency, coordinating with drivers, etc.

■ 8.1 Background Data

Collecting data for an onboard survey is a labor-intensive process. The first step is to collect information describing the current transit system and to establish the data items to be collected. The baseline data should contain specific information related to the transit system to be surveyed including:

- An inventory of the number of transit routes in the system, and ideally, GIS layers containing the transit system and bus route coverage overlays on the particular highway network of interest;
- Route maps and schedules (bus block logs or runs sheets) which generally contain information on specific roadway, frequency (headways), route start and end points, time periods, bus stop, transfer, and terminal locations, and fares;
- Route and system travel characteristics such as the number of route round-trips by time period, travel mode (local and express bus, light rail, commuter rail), and daily and peak (period and hour) ridership estimates;
- Variables required for typical mode choice travel model estimation such as the location of park and ride and kiss and ride parking locations, typical parking costs in the vicinity of the transit system, and other transit system access information (related to pedestrian, bicycle, transit, and auto access);
- Census data for the population the transit system is intended to serve (see Appendix B of this manual);
- Previous survey data experiences; and
- Sources which are available for geocoding data (see Chapter 14.0 for a discussion of geocoding).

Several of the data items identified above are used to develop the sample of the transit routes to be surveyed. Issues related to the number of estimated survey returns for each route relate directly to the anticipated boardings for sampled routes. To preserve resources, the low ridership routes may be surveyed as one stratum, rather than separately surveying each route.

The design of the survey must also consider the number and types of transit modes to survey. This analysis relates directly to the requirements of the mode choice model specifications and parameters. For example, the survey design and resources are different for analysis of peak travel compared to daily travel. In addition, depending on the access specifications of the mode choice model and transit network, the analyst may be required to gather additional information (parking costs, access times for walk and auto, etc.) beyond the characteristics of the bus trip itself.

Some of the background data identified above can be obtained by interviewing transit operators over the telephone or in person. Through these interviews, the survey designer should outline the specific data required to develop the baseline condition. Formal written requests for this information are often required. The process for obtaining the background data generally contains the following steps:

1. Establish contact with the appropriate staff of the transit operator to be surveyed. The analyst should outline the reasons for the survey and specify the consent of the various client (public) agencies responsible for the study.

2. Outline the specific background data needs in a formal letter of request. This request should be sent to the appropriate transit staff. Include a draft memorandum for the operators to post on the garage bulletin boards informing the drivers/dispatchers about the upcoming survey.

3. Follow the initial contact and formal data request with the telephone interview or in-person interview. The analyst should schedule this interview with the transit operator after a two-week period at a minimum to ensure that the transit operator has enough time to compile the requested data. On the other hand, if block log information is being requested to pull sample routes and/or runs be sure to allow ample time for pulling the full sample (for scheduling) before fieldwork begins.

4. Collect the assembled data, using the most appropriate and convenient method: collect at the in-person interview, or obtain via electronic mail or mail.

The types of available data vary widely depending on transit system characteristics. Some systems have fare structures that monitor each passenger entering and exiting, allowing the potential use of fare collection data to compute maximum passengers loads, number of transfers, trip length, and other operational data. On the majority of systems, fare collection data provide only entrance counts, and in many systems, even with the automated fare collection systems, the counts can be ambiguous. However, there are no transit systems where the fare collection system provides all of the ridership data needed (for example, most systems have pass programs). The gap is typically filled by labor-intensive field surveys that collect information directly from the passengers on board trains and buses or at stops and stations.

It is important that the project sponsor(s) provide ample warning to the transit provider, especially the bus drivers, about the upcoming survey. Drivers should be introduced to the survey supervisors and provided with a general overview of the types of procedures the onboard surveyor will be conducting. Drivers can be asked for recommendations about survey procedures. Since sample bus trips often begin and end at the terminal, the dispatchers and security providers at the bus terminals must be included in the survey process. If the drivers are represented by a union, the union and shop stewards should also be informed of the survey. A letter should be posted on the driver's bulletin board at each terminal at least two weeks before the survey or the survey pretest are scheduled to begin.

■ 8.2 Onboard Survey Design

Design Issues

The old maxim that there is never enough time to do it right, but always enough time to do it over offers a good warning. However, transit surveys present a more ruinous case: resources rarely allow the option of doing the survey again. A survey done wrong simply results in bad data, which are often worse than no data at all.

Time should be made available to structure and design the survey process properly. Time spent in the planning of the survey will prevent problems that cannot be corrected later. A clear statement of the objectives of the data collection and analysis will provide a frame of reference for assessing each element of the survey method, data items, and analysis effort.

The transit onboard survey can be designed as a stand-alone survey or can complement a household travel survey. The onboard survey is implemented to obtain data for the person trips made on the transit system, and most of the ridership survey design characteristics may be used for either bus or rail systems. The procedures and analysis methods are similar, but since most areas are served primarily by bus transit, the remainder of this chapter refers to survey techniques used on bus systems.

The onboard survey also collects accurate boarding information for the sampled buses. Each boarding passenger is surveyed (either by a self-administered questionnaire or an interview) regarding the characteristics of the trip which is intercepted on the sampled transit vehicle.

The principal steps of survey design include:

1. Define the population to be surveyed (e.g., all passengers on the transit system);
2. Select a method to collect the desired data;
3. Specify the data to be collected;
4. Develop a sample plan and determine the appropriate degree of precision and level of confidence;
5. Pretest the survey form(s) and procedures;
6. Organize the fieldwork; and
7. Plan the analysis.

The population to be surveyed may include all passengers on the transit system, peak-period passengers, passengers on specific routes/route branches or express segments on routes carrying a certain percentage of total system ridership (e.g. 90 percent).

Survey Methods

Several types of transit onboard survey methods can be considered, including the following:

- Drivers hand out survey questionnaires to passengers, and passengers hand back or mail back completed questionnaires. This method works for express lines with low boarding/alighting activity and on systems where the bus drivers are fully cooperative with the survey. Generally, the method requires a concentrated driver involvement effort early in the design effort in order to persuade drivers to cooperate fully and willingly. Response rates vary. Accurate boarding counts may not be obtained.
- Surveyors aboard the transit vehicles conduct interviews with boarding passengers, record the passenger responses, and count each boarding passenger. This method is useful where the number of data elements is limited so that the interview time is short. Interviews can be simplified by using a bilingual interviewer, which eliminates the problem of non-response due to poor literacy. The response rate for interviews is

generally higher than for self-administered surveys, typically 30 to 40 percent of all boardings. This method is the most resource intensive, but with training, interviewers can achieve very accurate results. For instance, interviewers can probe for better geographic information or clarify trip frequency questions.

- Surveyors aboard the transit vehicle hand out questionnaires to passengers and collect or allow passengers to mail back completed questionnaires. This method of using a self-administered questionnaire handout with the option of a mail-back response has been the state-of-the-practice for many years. One surveyor can distribute questionnaires and conduct accurate boarding counts of passengers. In addition, each questionnaire is serially numbered to act as a check against the counts and to link it to a specific vehicle, direction, and time period when it is mailed back. Typical response rates are 20 to 30 percent of all boardings. The returns may have to be checked for missing data, illegible data, or erroneous data.

The two self-administered survey methods – where the driver hands out the questionnaires or a trained surveyor hands out questionnaires and counts passengers – usually require survey teams to provide the respondent with the ability to mail back the completed survey form. Only in unusual cases would a hand-out form not include a mailback option. Many agencies already have business reply accounts and post office boxes. The survey planner should always check the size of the post office box since even a modest survey can generate a high volume (spatially) of returned forms.

The 1972 Urban Mass Transportation Travel Surveys manual states that the response rate for an onboard survey can be improved by using extensive publicity prior to the survey day.[1] If extensive efforts are not feasible, modest amounts of publicity can still improve the response rate and are worth the additional effort.

The 1972 Urban Mass Transportation Travel Surveys manual[2] also suggested the following methods for dealing with non-response:

- First, it was expected (and later verified) that the rate of questionnaire return would vary for passengers having different socioeconomic characteristics. To help correct for this, separate expansion factors were developed for each bus route.

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[1] U.S. Department of Transportation, Urban Mass Transportation Administration, *Urban Mass Transportation Travel Surveys*, U.S. Government Printing Office, Washington, DC, August 1972, p.20.

[2] U.S. Department of Transportation, Urban Mass Transportation Administration, *Urban Mass Transportation Travel Surveys*, U.S. Government Printing Office, Washington, DC, August 1972, pgs. 31-33.

Secondly, it was expected that the rate of return for longer person trips might be better than the return for short, inner-city trips. Patrons making longer trips were afforded more time on the bus to complete their questionnaires and did not receive their cards on the inner portion of the route, where congestion mitigated against good survey response. To combat this potential problem and to assist in correcting for socioeconomic differences, each bus route was split into quarters, and a separate expansion factor was prepared for each. The technique for quartering the bus routes was to assign the first 25 percent of all cards handed out on each individual bus trip to the first quarter, the next 25 percent to the next quarter, and so on.

- Since not only trip purpose, but also socioeconomic characteristics of the inbound passengers, might change throughout the day, differing response rates were expected by time-of-day. This third source of bias was again corrected by developing different factors for the a.m. peak, the p.m. peak, and the remainder of the day.

- The net result of the differential factoring required by the preceding three corrections was a set of twelve different subcategories with different factors for each bus route involved. The information on the survey trip report allowed the allocation of both cards handed out and cards coded to the various categories for development of expansion factors.

- A final potential problem anticipated was the fact that a trip involving an origin and destination on opposite sides of the study area would start out inbound on both legs of the round trip. Thus, these passengers might receive two survey cards per round trip, resulting in double counting. This problem was handled by a detailed cell by cell examination of a preliminary trip table to pick out zone interchange movements showing travel in both directions. Survey cards corresponding to the outbound direction were assigned a factor of zero.

The survey method should be carefully chosen based on balancing the required accuracy against the resources available.

■ 8.3 Drafting and Constructing Survey Materials

Data Elements and Survey Forms

Once the survey method has been chosen, the planner should consider data requirements. There are two levels of origin-destination data that eventually require geographic coding and analysis: bus stop-to-bus stop data, and origin to destination data for the passenger's door-to-door trip pattern. Origin-destination surveys are typically designed to obtain other information as well, within the limitations of the questionnaire or the time allotted for the interviews. Interviews should take no longer than 10 minutes to complete, and shorter interviews of three to four minutes result in better responses. The data can be collected for passengers in corridors, by route, by direction, and/or time-of-day. The basic data for an origin-destination survey would include the items presented in Table 8.2.

The last three data items are not specifically for analysis of transit usage, although auto availability and ownership are related to captive transit ridership. The primary purpose of these last items is to link the socioeconomic characteristics of the passenger to similar persons in households collected through the household survey or to information available from the census. These data are required for travel demand modeling. Other information can include questions on fare type and cost, transit pass usage, perceived quality of transit service, advertisement penetration, and the passenger's commuting habits, to name a few.

The wording of questions must be carefully considered and be consistent with other types of travel surveys underway. For example, consistent questions about trip-making are necessary for household travel surveys and vehicle intercept surveys that may be conducted concurrently with the transit onboard survey. This ensures consistent information on travel behavior characteristics of persons within a region that will prove useful in estimating various elements (or model components) of regional travel demand forecasting systems.

In addition, information collected in transit onboard surveys, and, for that matter, all types of travel surveys, should maintain consistency with the current census data specifications. For example, the household, person, and trip information collected in a transit onboard survey should maintain the same categories as specified in the latest census, including breakdowns of income levels, occupation codes, and ethnic status.

The sequence of the questions should follow logically to improve the clarity of the questions. A classic ordering of questions would be the following:

- Where did you get on this bus?
- How did you get to that bus stop?
- Where did you come from? (home, work, school, shopping, etc.)
- What is the location of that place? (geographic location of the origin)
- Where will you get off this bus?
- How will you get from that bus stop to where you are going?
- Where are you going to now? (home, work, school, shopping, etc.)

Table 8.2 Common Data Elements for Transit Onboard Surveys

Data Elements	Information Typically Obtained
Boarding bus stop	Name of bus stop or street intersection.
Trip origin	Street address, as accurately as possible without incurring item non-response.
Arrival and departure times or travel time	Activity start and end times. Travel times are derived from the start and end time data.
Alighting bus stop	Name of bus stop or street intersection.
Trip destination	Street address, as accurately as possible without incurring item non-response.
Activity or travel purpose	Activity or trip purpose categories of sufficient detail to characterize the trip in the travel demand models.
Access mode	Categories designed to exhaust the mode possibilities for the region, plus an "other" category.
Egress mode	Categories designed to exhaust the mode possibilities for the region, plus an "other" category.
Bus route(s) transferred to and/ or from	Description of bus by number or description of path of operation.
Number of buses ridden for this one-way trip	Actual numbers.
Fare Payment Type	Categories designed to exhaust the fare type possibilities for the system.
Trip frequency	Number of trips per week.
Auto ownership	Actual numbers.
Auto availability for this trip	Check yes or no.
Age or year of birth	Actual number or year is usually considered to be preferable to categories with ranges of ages or birth years.
Sex	Check one.
Occupation(s)	Aggregation of U.S. Census categories for each job.
Race, ethnicity, or nationality	Census standardized definitions.
Household size	Actual numbers.
Household income	Income categories based on Census definitions or the agency's standard categories.

- What is the location of that place? (geographic location of the destination)

By asking the name of the bus stop where the person got on before asking the origin of the trip, the respondent understands that 'where are you coming from' is something different from 'where did you get on this bus.' For detailed instructions on collecting and formatting geographic data, the reader should refer to Chapter 14.0.

Figures 8.1 through 8.5 present examples of self-administered onboard surveys.

The first three forms were designed to be passed out on buses from and to which passengers frequently transfer. Therefore, each questionnaire begins by asking whether the respondent has completed a questionnaire yet. This information is needed to properly expand the survey results. After this first question, each of the questionnaires gather origin-destination data, the primary data elements of the surveys. Since item completion tends to drop off as respondents progress through the questionnaire, it is almost always a good idea to put the most important data items first.[3] The questions on the Detroit survey shown in Figure 8.3 are oriented from most important to least important. Note that because of its relative importance, the household income question appears in the middle of the questionnaire, rather than at the end as is usually the case.

The Detroit Bus Survey and the two rail surveys (Figures 8.4 and 8.5) offer respondents a chance to win in an upcoming prize drawing. The drawing acts both as an incentive to participate and a mechanism to obtain information for re-contacting respondents. In the Detroit survey, the telephone information was used to perform clarification follow-up calls. The address information was used to improve the geocoding of the origin and destination data gathered in questions 4 and 8. In the BART survey (Figure 8.4), the telephone numbers were used to develop a contact list for future surveys. The mailing address and telephone numbers gathererd in the LIRR survey (Figure 8.5) were used to perform a telephone-mail-telephone survey of respondents.

In many cases, personal interviews are conducted with boarding passengers. Although this increases the cost of conducting the survey, it ensures sufficient responses and clean and complete data for robust estimates. In a personal interview, the number and wording of questions must be considered carefully since there is no privacy on the bus. For either the interview or self-administered survey, if the origin or destination (boarding bus stop or alighting bus stop may be substituted in some cases) is not complete, the questionnaire is considered a non-response since the data most important to the survey objectives have not been obtained.

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[3] Johanna P. Zmud, Nu Stats International, personal interview April 1996.

Any origin-destination survey method involves the use of a survey form to collect information directly from the passenger, either by a self-administered form or interview form. Other control forms are required to organize and keep a log of field data. A log is used to tabulate boardings and alightings by vehicle trip and to keep track of the questionnaire serial numbers handed out on each trip. In addition, depending on the survey method used, each vehicle trip requires an envelope in which completed questionnaires/interview forms are stored. The surveyor's work shift is delineated on the surveyor's assignment sheet, and quality control necessitates the use of an editor's (or survey administration) log. An example of an administrative form is shown in Figure 8.6.

■ 8.4 Sampling

Survey Population and Sample Selection

Generally, onboard transit surveys employ "two-stage samples." The first sample is a selection of the transit vehicle trips from all the transit trips in the study area. It is important to distinguish between the "vehicle trips" made by the buses and the "person trips" about which passengers are asked to provide information. A vehicle trip is defined as a one-way directional movement of a bus from the beginning of a route to some other point of the route (usually the mid-point). The second stage is the sample of passengers riding a particular sampled bus trip.

In the classic transit onboard survey, each boarding passenger is given a questionnaire to fill out. It is not expected that every passenger will respond. In fact, the completion rate will vary depending on the route, surveyor, and time-of-day. The return rate should be thoroughly tested in the pilot study to determine what response rate can be expected.

Figure 8.1 An Example Self-Administered Transit Onboard Survey Form

1. If you have ALREADY COMPLETED ONE of these forms on another bus, please CHECK HERE ☐ AND CONTINUE FILLING OUT this questionnaire. Thank you.

2. WHERE did you get ON THIS BUS? *(specify nearest intersection)*

   Corner of ____________ and ____________
   (First Street Name) *(Second Street Name)*

3. Where did you COME FROM before you got on this bus? *(check one only)*

   1 ☐ Home 4 ☐ School/College 7 ☐ My Hotel
   2 ☐ Work 5 ☐ Doctor/Dentist 8 ☐ Other
   3 ☐ Shopping 6 ☐ Visiting/Recreation ____________ *(specify)*

4. What is the ADDRESS OF THAT PLACE?

   ______ *Number* ____________ *Street (or intersection or place name)* ____________ *City* ______ *Zip Code*

5. How did you get to THIS BUS? *(check one only)*

   1 ☐ Walking _____ blocks 4 ☐ Having someone drive me
   2 ☐ Driving by myself 5 ☐ Other ____________ *(specify)*
   3 ☐ Transferring from the ____________ bus *(Route Number or Name)*

6. What was your FARE when you boarded THIS BUS?

   1 ☐ 60¢ 3 ☐ Adult Pass 5 ☐ Student Pass 7 ☐ Other
   2 ☐ 25¢ 4 ☐ Transfer 6 ☐ Elderly/Handicapped Pass

7. WHERE will you get OFF THIS BUS? *(specify nearest intersection)*

   Corner of ____________ and ____________
   (First Street Name) *(Second Street Name)*

8. Where are you GOING TO now? *(check one only)*

   1 ☐ Home 4 ☐ School/College 7 ☐ My Hotel
   2 ☐ Work 5 ☐ Doctor/Dentist 8 ☐ Other
   3 ☐ Shopping 6 ☐ Visiting/Recreation ____________ *(specify)*

9. What is the ADDRESS OF THAT PLACE?

   ______ *Number* ____________ *Street (or intersection or place name)* ____________ *City* ______ *Zip Code*

10. How will you get FROM THIS BUS TO the place that you are GOING TO? *(check ANY that apply)*

    1 ☐ Walking ___ blocks 4 ☐ Having someone drive me
    2 ☐ Driving by myself 5 ☐ Other ____________ *(specify)*
    3 ☐ Transferring to the ____________ bus *(Route Number or Name)*

PLEASE CONTINUE →

Figure 8.1 An Example Self-Administered Transit Onboard Survey Form (continued)

11. How MANY BUSES will you ride to get from where you CAME FROM *(Question 4)* to where you ARE GOING *(Question 9)*?

1 ☐ Only one bus 2 ☐ Two buses 3 ☐ Three or more buses

12. How OFTEN do you RIDE the bus ? *(check one only)*

1 ☐ One day/week 4 ☐ Four days/week 7 ☐ Seven days/week
2 ☐ Two days/week 5 ☐ Five days/week 8 ☐ One-three days/month
3 ☐ Three days/week 6 ☐ Six days/week 9 ☐ This is my first time

13. What is the MOST IMPORTANT REASON(S) you ride the bus? *(check ANY that apply)*

1 ☐ Family has no car 4 ☐ Someone else uses car 7 ☐ Parking is a problem
2 ☐ I don't drive 5 ☐ Traffic is bad 8 ☐ Other
3 ☐ Bus is economical 6 ☐ Bus is convenient ________ *(specify)*

14. Do you have a DRIVER'S LICENSE? 1 ☐ YES 2 ☐ NO

15. I am __? 1 ☐ MALE 2 ☐ FEMALE

16. My AGE is __ years: 1 ☐ 6-16 2 ☐ 17-20 3 ☐ 21-64 4 ☐ 65 or older

17. Where is your PERMANENT RESIDENCE?

1 ☐ Oahu 4 ☐ Canada 7 ☐ Europe
2 ☐ Other Hawaiian Island 5 ☐ Asia/Japan 8 ☐ Other
3 ☐ U.S.A. Mainland 6 ☐ Australia/ New Zealand ________ *(specify)*

18. I AM ______? *(check one only)*

1 ☐ Employed full-time 4 ☐ Student in Oahu 7 ☐ Unemployed
2 ☐ Employed part-time 5 ☐ Student elsewhere 8 ☐ Military assigned to Oahu
3 ☐ Housewife 6 ☐ Retired 9 ☐ Military assigned elsewhere

19. How many MOTOR VEHICLES (cars, vans, pick-ups) in running condition are available to members of YOUR HOUSEHOLD? *(check one only)*

0 ☐ None 1 ☐ One 2 ☐ Two 3 ☐ Three or more

20. How many PEOPLE live in your HOUSEHOLD? ______ *(number, including yourself)*

21. The combined TOTAL ANNUAL INCOME of all members of my household is:

1 ☐ Less than $ 5,000 per year 5 ☐ $ 35,000 - $45,000 per year
2 ☐ $ 5,000 - $15,000 per year 6 ☐ $ 45,000 - $55,000 per year
3 ☐ $15,000 - $25,000 per year 7 ☐ $ 55,000 - $65,000 per year
4 ☐ $25,000 - $35,000 per year 8 ☐ More than $65,000 per year

PLEASE PLACE IN RETURN BOXES ON BUS

Figure 8.2 OCTA Onboard Bus Survey Form

1990 BUS PASSENGER SURVEY

IN ORDER TO BETTER PLAN TRANSIT SERVICES, WE NEED TO LEARN MORE ABOUT YOUR TRAVEL PATTERNS. PLEASE FILL OUT THIS SURVEY WHILE YOU ARE ON THIS BUS. THANK YOU.

1. *I have recently filled out one of these questionnaires:*
   1[ ] Yes   2[ ] No

   Please continue.

2. *I got on this bus at:*
   ____________ and ____________ (Major cross streets)

   In the city of ____________

3. *I have just come from: (Check one only)*
   1[ ] Home   5[ ] Work
   2[ ] Shopping   6[ ] Restaurant
   3[ ] Social/Recreation   7[ ] Medical visit
   4[ ] School   8[ ] Other ____________

   Located at:
   ____________ and ____________ (Major cross streets)

   In the city of ____________

4. *I got to this bus by:*
   1[ ] Walking   5[ ] Driving myself
   2[ ] Having someone drive me
   3[ ] Other ____________
   4[ ] Transferring from another bus. Please specify:
   - 1[ ] OCTD Route No. ____
   - 2[ ] Long Beach Transit Route No. ____
   - 3[ ] Laguna Beach Bus
   - 4[ ] RTD Route No. ____
   - 5[ ] Riverside Transit Route No. ____
   - 6[ ] Dial-a-Ride
   - 7[ ] Other ____________

5. *I will get off this bus at:*
   ____________ and ____________ (Major cross streets)

   In the city of ____________

6. *I am going: (Check one only)*
   1[ ] Home   5[ ] To school
   2[ ] Shopping   6[ ] For a medical visit
   3[ ] To work   7[ ] Social/recreation
   4[ ] Out to eat   8[ ] Other ____________

   Located at:
   ____________ and ____________ (Major cross streets)

   In the city of ____________

7. *When I get off this bus, I will get to my final destination by:*
   1[ ] Walking   4[ ] Driving myself
   2[ ] Having someone drive me   5[ ] Another bus
   3[ ] Other ____________

8. *I paid to ride the bus today with: (check one only)*
   1[ ] Cash   4[ ] A fare ticket or coupon
   2[ ] A monthly pass   5[ ] A free ride coupon
   3[ ] Transfer   6[ ] Other ____________

9. *I first started using the OCTD bus:*
   1[ ] Within the past year   4[ ] 3 yrs. ago
   2[ ] 1 year ago   5[ ] 4 yrs. ago
   3[ ] 2 yrs. ago   6[ ] 5 or more yrs. ago

10. *I first heard about OCTD through:*
    1[ ] Friends or family   5[ ] Saw a bus or sign
    2[ ] At work   6[ ] Newspaper
    3[ ] At school   7[ ] Other ____________
    4[ ] A billboard

11. *I usually ride the bus:*
    1[ ] Less than once a week
    2[ ] 1-2 days a week
    3[ ] 3-4 days a week
    4[ ] 5 or more days a week

12. *I use the bus because:*
    1[ ] I don't drive
    2[ ] I don't have a car available
    3[ ] My employer sells passes or gives discount
    4[ ] There's too much traffic
    5[ ] Other ____________

13. *I had an automobile available for this trip TODAY.*
    1[ ] Yes   2[ ] No

14. *The number of people in my household, including myself, is:*
    1[ ] One   3[ ] Three   5[ ] Five or more
    2[ ] Two   4[ ] Four

15. *In my household, the number of vehicles available is:*
    1[ ] None   3[ ] Two
    2[ ] One   4[ ] Three or more

16. *I am ...* 1[ ] Male   2[ ] Female

17. *I am physically disabled.*
    1[ ] Yes   2[ ] No

18. *I am ...*
    1[ ] White   4[ ] Black
    2[ ] Hispanic   5[ ] Asian/Pacific Islander
    3[ ] Other ____________

19. *My main language is... (Check one only)*
    1[ ] English   3[ ] Vietnamese   5[ ] Chinese
    2[ ] Spanish   4[ ] Other ____________

20. *My age is:*
    1[ ] 13 yrs. or younger   5[ ] 35 - 54 yrs.
    2[ ] 14 - 17 yrs.   6[ ] 55 - 64 yrs.
    3[ ] 18 - 21 yrs.   7[ ] 65 or older
    4[ ] 22 - 34 yrs.

21. *The TOTAL YEARLY INCOME of everyone in my household is:*
    1[ ] Less than $5,000   5[ ] $30,000-$39,999
    2[ ] $5,000-$9,999   6[ ] $40,000-$49,999
    3[ ] $10,000-$19,999   7[ ] $50,000 or more
    4[ ] $20,000-$29,999   8[ ] Don't know

22. *My main daily activity is: (Check one only)*
    1[ ] Work
    2[ ] Unemployed at present
    3[ ] Homemaker/housewife
    4[ ] Retired
    5[ ] School ____ Please specify:
    - 1[ ] Elementary   4[ ] College
    - 2[ ] Junior High   5[ ] Adult education
    - 3[ ] High school

23. *If currently employed, my occupation is:*
    1[ ] Clerical, secretarial or other office work
    2[ ] Professional, such as engineer, teacher, or nurse
    3[ ] Service, including food, cleaning and gardening
    4[ ] Sales
    5[ ] Manufacturing, assembly or construction
    6[ ] Military
    7[ ] Other ____________

    8[ ] Not currently employed

Source: Orange County Transit Agency, 1990.

Figure 8.3 Detroit Bus Study Survey Form

Dear D-DOT Customer:

Win $100 cash! Three $100 prizes will be awarded.

Get on board with the Detroit Bus Study! This survey of Detroit bus riders will help D-DOT find out the needs and concerns of its passengers. Your answers will permit D-DOT to plan schedules, routes, and service changes that you need.

It takes only a few minutes to answer the questions while on the bus. It is best if you return this questionnaire to the survey attendant on the bus. You can also mail it as soon as you complete it, but remember— the drawing will be held on October 25, and entries must be received by that date in order to be eligible.

All answers are confidential and are used only in combination with those of other D-DOT passengers.

As our 'Thank You' for helping us, you will be eligible for a drawing of 3 $100 prizes. We are also giving away 4 free monthly bus passes, so you have 7 chances to win! You will also have the opportunity to participate in further opinion surveys. If you do not wish to participate in future surveys, please call 1-800-619-3601 and let us know.

Thank you for helping us make Detroit better.

If you have trouble reading this questionnaire, please call 1-800-619-3601 and ask for Jessie.

NuStats International

4544 S. Lamar Bldg. 200
Austin, TX 78745

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 7473 AUSTIN, TX
POSTAGE WILL BE PAID BY ADDRESSEE

NuStats International
4544 S. Lamar Bldg. 200
Austin, TX 78745

Figure 8.3 Detroit Bus Study Survey Form (continued)

DETROIT BUS STUDY — Nº 37152

If you have already filled one out, please check here ☐ and continue to fill out this form.

A. Register here to win $100 or a free bus pass

Your first name or initials: ____________

Home address: ____________ ____________

Phone number: ____________ ZIP: ____________

B. About your bus ride

1. At which stop did you get on this bus?
CORNER: ____________ AND ____________
Street Name Street Name

2. At which stop will you get off this bus?
CORNER: ____________ AND ____________

3. Where did you come from before you got on this bus? *(check one only)*
1 ☐ Work 5 ☐ Shopping
2 ☐ Home 6 ☐ Recreation/Visiting
3 ☐ School/classes 7 ☐ Public agency office
4 ☐ Medical 8 ☐ Personal/other

4. What is the place you are coming from?
NAME OF PLACE: ____________
CORNER: ____________ AND ____________
CITY: ____________ ZIP: ____________

5. How did you get from there to bus stop? *(check all that apply)*
1 ☐ Transfer from D-DOT route # ____ ____
2 ☐ Transfer from SMART bus
3 ☐ Private vehicle, drove ____ minutes
4 ☐ Walk ____ minutes
5 ☐ People Mover 6 ☐ Other: ____________

6. How long did you wait at this bus stop? ____ minutes

7. Where are you going now? *(check one only)*
1 ☐ Work 5 ☐ Shopping
2 ☐ Home 6 ☐ Recreation/Visiting
3 ☐ School/classes 7 ☐ Public agency office
4 ☐ Medical 8 ☐ Personal/other

8. What is the place you are going to?
NAME OF PLACE: ____________
CORNER: ____________ AND ____________
CITY: ____________ ZIP: ____________

9. How will you get there from this bus? *(check all that apply)*
1 ☐ Transfer to D-DOT route # ____________
2 ☐ Transfer to SMART bus
3 ☐ Private vehicle, drive ____ minutes
4 ☐ Walk ____ minutes
5 ☐ People Mover 6 ☐ Other: ____________

10. How long will it take to get from where you came to where you are going (total time)? ____ minutes

11. How did you pay to get on this bus? *(check one only)*
1 ☐ Transfer 4 ☐ Ticket
2 ☐ Cash ($1.25) 5 ☐ Monthly Pass
3 ☐ Cash (reduced fare) 6 ☐ Other: ____________

12. How often do you ride this route? *(check one only)*
1 ☐ This is the first time
2 ☐ Less than 1 day per MONTH
3 ☐ 1 to 4 days per MONTH
4 ☐ 2 to 4 days per WEEK
5 ☐ 5 or more days per WEEK

13. On what days of the week do you ride this bus route? *(check all that apply)*
1 ☐ Weekdays (Mon - Fri)
2 ☐ Saturday 3 ☐ Sunday

C. About your household

14. Including you, how many people live in your household? ______ people

15. What is the total yearly income before taxes of all persons in your household combined?
1 ☐ under $2,999/year 5 ☐ $15,000-$24,999/year
2 ☐ $3,000-$5,999/year 6 ☐ $25,000-$34,999/year
3 ☐ $6,000-$9,999/year 7 ☐ $35,000-$49,999/year
4 ☐ $10,000-$14,999/year 8 ☐ $50,000 or more

16. How many cars, vans or light trucks are available for use by members of your household?
0 ☐ None 2 ☐ Two
1 ☐ One 3 ☐ Three or more

17. Were any vehicles available to you today for this trip?
1 ☐ Yes 2 ☐ No

D. About you

18. Do you have a valid driver's license?
1 ☐ Yes 2 ☐ No

19. What is your age? _____ years

20. Are you . . .
1 ☐ Male 2 ☐ Female

21. Are you . . .
1 ☐ African American 4 ☐ Hispanic
2 ☐ White 5 ☐ Asian
3 ☐ Arab 6 ☐ Other: ____________

22. Do you have a valid Medicare card?
1 ☐ Yes 2 ☐ No

23. Are you . . .
1 ☐ Employed full-time
2 ☐ Employed part-time
3 ☐ Not employed/student
4 ☐ Not employed/homemaker
5 ☐ Not employed/retired
6 ☐ Not employed

23a. What is your main occupation?
____

24. What would allow you to ride more? *(check all that apply)*
1 ☐ More information about bus schedules
2 ☐ Buses arrive on time
3 ☐ Buses arrive as often as scheduled
4 ☐ Improved access for people with disabilities
5 ☐ Earlier morning service on weekdays
6 ☐ Later evening service on weekdays
7 ☐ More frequent Saturday service
8 ☐ More frequent Sunday service
9 ☐ Improved security on buses
10 ☐ Improved security at bus stop
11 ☐ Buses that go to: ____________
12 ☐ More express service
13 ☐ Other: ____________

25. If a bus were not available, how would you have made this trip today? *(check one only)*
1 ☐ Drive myself 4 ☐ Walk
2 ☐ Someone drive me 5 ☐ Bike
3 ☐ Taxi 6 ☐ Would not go
7 ☐ Other: ____________

Figure 8.4 BART Onboard Survey Form

BART SURVEY & SWEEPSTAKES

FILL IT IN TO WIN

IMPORTANT: Please complete this survey even if you have already completed a survey on a previous trip on BART. Unless otherwise stated, your answers should refer to the BART trip you were on when you received this survey. Please deposit this survey in a collection box as you exit a BART station, or fold and mail back (postage prepaid).

STARTING POINT

1. Which BART station did you enter on this one-way trip?

_______________ (Entry station) (7-8)

2. How did you get to this BART station for this trip?

1 ☐ Walked _____ blocks to BART (10-11)
2 ☐ Taxi
3 ☐ Motorcycle/moped
4 ☐ Bicycle
5 ☐ Car:
- 1 ☐ Drove alone
- 2 ☐ Drove or rode with ___ other person(s) and parked
- 3 ☐ Dropped off by car

Did you park this vehicle: (15)
- 1 ☐ In BART station parking lot
- 2 ☐ Elsewhere and walked ___ blocks

6 ☐ Transit: (16-19)
- 1 ☐ SF Muni
- 2 ☐ AC Transit
- 3 ☐ County Connection
- 4 ☐ SamTrans
- 5 ☐ BART Express
- 6 ☐ Vallejo BART Link
- 7 ☐ Union City Transit
- 8 ☐ Dumbarton Express
- 9 ☐ Martinez Link
- 10 ☐ Benicia Transit
- 11 ☐ Golden Gate Transit
- 12 ☐ Santa Clara County Transit
- 13 ☐ Employer or residence shuttle
- 14 ☐ Other. Specify: ___________

How did you pay that fare? (20)
- 1 ☐ Cash Only
- 2 ☐ Transfer issued at BART
- 3 ☐ Muni Fast Pass
- 4 ☐ BART Plus Ticket
- 5 ☐ Other: ___________

3. Where did you come from? (Specify one) (21-22)

1 ☐ Home	6 ☐ Social, recreational
2 ☐ Work	7 ☐ Personal business
3 ☐ School	8 ☐ Interop Conference/Exhibit
4 ☐ Shopping	9 ☐ Hotel
5 ☐ Medical, dental	10 ☐ Other: ___________

What time did you leave there? ___:___ AM PM
Hour : Min (23-26) (Circle one) (27)

4. What is the location of the place that you came from? (28-32)

_______________ (City) ☐☐☐☐☐ (Zip Code)

_______________ (Street address or nearest intersection)

DESTINATION

5. At which station will you exit the BART system at the end of this one-way trip?

_______________ (Exit station) (33-34)

6. After you exit the BART system on this trip, how will you get to your destination?

1 ☐ Walk _____ blocks to destination (36-37)
2 ☐ Taxi
3 ☐ Motorcycle/moped
4 ☐ Bicycle
5 ☐ Car:
- 1 ☐ Drive alone
- 2 ☐ Drive or ride with ___ other person(s) from parked car
- 3 ☐ Will be picked up by car

Did you park this vehicle: (40)
- 1 ☐ In BART station parking lot
- 2 ☐ Elsewhere and walked ___ blocks

6 ☐ Transit: (43-44)
- 1 ☐ SF Muni
- 2 ☐ AC Transit
- 3 ☐ County Connection
- 4 ☐ SamTrans
- 5 ☐ BART Express
- 6 ☐ Vallejo BART Link
- 7 ☐ Union City Transit
- 8 ☐ Dumbarton Express
- 9 ☐ Martinez Link
- 10 ☐ Benicia Transit
- 11 ☐ Golden Gate Transit
- 12 ☐ Santa Clara County Transit
- 13 ☐ Employer or residence shuttle
- 14 ☐ Other. Specify: ___________

How did you pay that fare? (45)
- 1 ☐ Cash Only
- 2 ☐ Transfer issued at BART
- 3 ☐ Muni Fast Pass
- 4 ☐ BART Plus Ticket
- 5 ☐ Other: ___________

7. Where are you going? (Specify one) (46-47)

1 ☐ Home	6 ☐ Social, recreational
2 ☐ Work	7 ☐ Personal business
3 ☐ School	8 ☐ Interop Conference/Exhibit
4 ☐ Shopping	9 ☐ Hotel
5 ☐ Medical, dental	10 ☐ Other: ___________

What time do you expect to arrive at your destination?
___:___ AM PM
Hour : Min (Circle one)

8. Where is the location of the place that you are going? (53-57)

_______________ (City) ☐☐☐☐☐ (Zip Code)

_______________ (Street address or nearest intersection)

Grand prize is a trip to Cabo San Lucas. Includes airfare and lodging for four days and three nights.
Other prizes include free dinners, tickets to Marine World, BART souvenirs and BART tickets.
To enter the contest, enter your name and a daytime telephone number below:

№ 095770

Name: _______________ Daytime telephone number: (___) _______________

May we contact you in the future to ask your opinion about potential BART service improvements? ☐ Yes ☐ No OVER →

Contest Rules: [illegible]

Source: Bay Area Rapid Transit, 1992.

Figure 8.4 BART Onboard Survey Form (continued)

9. How many one-way trips did you take on BART each day last week ? If you traveled to and from work one day, that counts as 2 one-way trips. Enter the number of rush hour and non-rush hour one-way trips in the boxes below. (58-64)

Time Period	Mon	Tue	Wed	Thu	Fri	Sat	Sun
AM & PM Rush Hours 6-9 AM & 4-7 PM							
Non-Rush Hours Midday & Evening							

(Put total number of one-way trips taken into each appropriate box.) (65-71)

10. What type of ticket did you use to enter the BART system? (72)
   1 ☐ Regular BART ticket (blue):
      What was the value of this ticket when first purchased ? (73)
      1 ☐ $32.00 (high value discount)
      2 ☐ Other. Specify: $ ________ (74-77)
   2 ☐ Muni Fast Pass
   3 ☐ Green ticket (Senior)
   4 ☐ Red ticket → 1 ☐ Youth 2 ☐ Disabled
   5 ☐ BART Plus Ticket (78)
   6 ☐ Other. Specify: ________

11. Does your employer pay for all or part of your ticket ? (79) (80-1)
   1 ☐ No
   2 ☐ Yes → How much per month ? $ ______ (7-9)

12. Was a car, truck or van available to you for this trip?
   1 ☐ No
   2 ☐ Yes
      Why did you choose to use BART rather than a car, truck or a van ? (Check the 2 most important reasons)
      1 ☐ Cost savings of BART (11)
      2 ☐ Traffic congestion (12)
      3 ☐ Inconvenience of parking car
      4 ☐ Safety/Security
      5 ☐ Comfort of BART
      6 ☐ Ecological concerns
      7 ☐ Other. Specify: ________

13. Could you have taken another transit system instead of BART for this trip ? (13)
   1 ☐ No
   2 ☐ Yes
      Why did you choose to take BART instead of another transit system ? (Check the 2 most important reasons)
      1 ☐ BART costs less (14)
      2 ☐ Easier to get to BART (15)
      3 ☐ My trip is quicker on BART
      4 ☐ BART goes closer to my destination
      5 ☐ Safety/Security of BART
      6 ☐ Reliability of BART
      7 ☐ Comfort of BART
      8 ☐ Other. Specify: ________

14. How long have you been riding BART ? (16)
   1 ☐ Less than 6 months
   2 ☐ More than 6 months but less than 1 year
   3 ☐ 1 - 2 years
   4 ☐ 3 - 5 years (Loma Prieta earthquake was October 89)
   5 ☐ More than 5 years

15. During the last 3 months, BART got me to my destination on time _____ % of the time. (17-19)

16. After you boarded the train for this trip, did you stand because seating was unavailable ? (20)
   1 ☐ No
   2 ☐ Yes
      How long did you stand ? (21)
      1 ☐ For whole trip
      2 ☐ For most of trip
      3 ☐ For small part of trip

17. How would you prefer to purchase your BART tickets ? (Check the 2 most favorable to you) (22) (23)
   1 ☐ By mail
   2 ☐ Employer worksite
   3 ☐ Local retail outlet
   4 ☐ Credit card fax order
   5 Machine in station using:
      1 ☐ Cash 3 ☐ ATM
      2 ☐ Credit Card (24)
   6 ☐ Other. ________

18. What is your race or ethnic identification ? (Ethnic categories are consistent with 1990 U.S. Census) (25)
   1 ☐ White
   2 ☐ Black
   3 ☐ Asian or Pacific Islander
   4 ☐ Native American or Eskimo
   5 ☐ Other. ________
      Are you Hispanic or Spanish surnamed ? (26)
      1 ☐ Yes
      2 ☐ No

19. Gender: 1 ☐ Male 2 ☐ Female (27)

20. Age:
   1 ☐ 12 or younger
   2 ☐ 13 - 17
   3 ☐ 18 - 24
   4 ☐ 25 - 34
   5 ☐ 35 - 44
   6 ☐ 45 - 64
   7 ☐ 65 and older

21. What is the total income of all your household members?
   1 ☐ $15,000 or less
   2 ☐ $15,001 - $30,000
   3 ☐ $30,001 - $45,000
   4 ☐ $45,001 - $60,000 (29)
   5 ☐ $60,001 - $75,000
   6 ☐ $75,001 and over

22. This month, how do you rate BART in each area below: *(Excellent - 1, Very Good - 2, Good - 3, Fair - 4, Poor - 5)*
   1. On-time performance ____ (30)
   2. Station cleanliness ____
   3. Train cleanliness ____
   4. BART personnel ____
   5. Parking ____
   6. Security ____
   7. Train announcements ____
   8. Station announcements ____
   9. Telephone transit information ____ (38)

COMMENTS: ________

Printed on recycled paper. THANK YOU Please fasten at bottom

BART

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS MAIL PERMIT NO 7169 OAKLAND CA

POSTAGE WILL BE PAID BY ADDRESSEE

BAY AREA RAPID TRANSIT DISTRICT
PLANNING DEPARTMENT - LMA 4
P.O. BOX 12688
OAKLAND CA 94604-9954

Source: Bay Area Rapid Transit, 1992.

Figure 8.5 Long Island Rail Road Onboard Survey

About the next part of the survey:

To complete this survey, the LIRR will send you some information in the mail, then telephone you at your convenience to ask a few more questions after you've read the mailed information. We think that you will find the survey interesting, and your responses will help us to serve you better.

To thank you for your help in the telephone interview, you will have a chance to win one of ten $100 cash prizes. We will keep your name, address, and telephone number completely confidential, and use them only for the purposes of this survey.

Please print your name:

1 ☐ Mr. 2 ☐ Ms.

Please print your full home mailing address:

Your home telephone number is (_ _ _) _ _ _ - _ _ _ _

The best times to reach you there are: *(Check all that apply)*

1 ☐ weekday mornings
2 ☐ weekday afternoons
3 ☐ weekday evenings
4 ☐ weekend mornings
5 ☐ weekend afternoons
6 ☐ weekend evenings.

Thank you for your help; your participation in this survey is valuable to us. Please hand the form to one of our survey staff, or if you return it in the mail please seal it with adhesive tape.

*Contest rules.

To be eligible to win one of ten $100 cash prizes you must complete both this questionnaire and the telephone interview which will follow in the next few weeks. If this questionnaire is mailed back, it must be postmarked by June 30, 1992. No purchase is necessary.

Only one entry per person. Entrants must be 18 years old or older. This offer is void wherever prohibited. Employees (and their immediate families) of the Long Island Rail Road and of any other MTA agency are not eligible. Winners will be selected at random on September 30, 1992, and will be notified by October 14, 1992.

Contest extended to July 17, 1992.

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NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

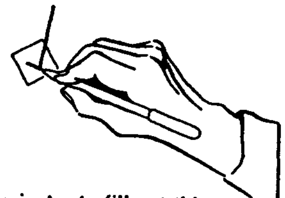
BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 3206 NEW YORK NY

POSTAGE WILL BE PAID BY ADDRESSEE

LONG ISLAND RAIL ROAD SURVEY
PLANNING DEPARTMENT
PO BOX 442
NEW YORK NY 10213-0364

Long Island Rail Road



Dear passenger:

Please take a few minutes to fill out this questionnaire. As we make plans to improve Long Island Rail Road services, we believe that it is very valuable to listen to our customers' views and comments. What you tell us in this important survey (and a follow-up telephone interview) will help us serve you better in the future.

Your train has been selected to be surveyed today. When you have completed this form, please return it to one of our survey staff on the train, or else drop it in the U.S. Mail within two days -- the postage is paid.

Inside you will see that your participation gives you a chance to win a worthwhile cash prize. Thank you for helping us.

105 № 02966

Source: LIRR, 1992.

Figure 8.5 Long Island Rail Road Onboard Survey (continued)

About your train trip today:

1. At which LIRR station did you begin this trip today?

   ______ Print full name of station

2. How did you get to your boarding station? *(Check one only)*
   - 1 ☐ car, parked at or near the station
   - 2 ☐ car, dropped off
   - 3 ☐ bus
   - 4 ☐ subway
   - 5 ☐ walk
   - 6 ☐ by other means (including taxi)

3. What time was your train scheduled to leave that station?

   ☐☐ : ☐☐ (hour : minutes) 1 ☐ a.m. 2 ☐ p.m.

4. At which LIRR station will you end your rail trip?
   - 1 ☐ Penn Station
   - 2 ☐ Flatbush Avenue
   - 3 ☐ Hunterspoint Avenue
   - 4 ☐ Long Island City
   - 5 ☐ Other ______ Print full name of station

5. How will you get from that station to your final destination? *(Check one only)*
   - 1 ☐ car, parked at or near the station
   - 2 ☐ car, picked up
   - 3 ☐ bus
   - 4 ☐ subway
   - 5 ☐ walk
   - 6 ☐ by other means (including taxi)

6. Do you need to transfer between LIRR trains in the course of your train trip today?
   - 1 ☐ no, I use one train only
   - 2 ☐ yes, I need to transfer at:
     - 1 ☐ Jamaica
     - 2 ☐ Babylon
     - 3 ☐ Hicksville
     - 4 ☐ Huntington
     - 5 ☐ Mineola
     - 6 ☐ Valley Stream
     - 9 ☐ other: ______ print station

page 2

7. What type of ticket are you using today? *(Check one only)*
   - 1 ☐ monthly ticket
   - 3 ☐ weekly ticket
   - 4 ☐ one-way peak
   - 5 ☐ one-way off-peak
   - 7 ☐ off-peak ten-trip ticket
   - 8 ☐ senior citizen/handicapped
   - 6 ☐ employee pass
   - 9 ☐ other: ______ specify

8. How did you purchase the ticket you're using today? *(Check one only)*
   - 1 ☐ at a ticket office
   - 2 ☐ ticket vending machine
   - 3 ☐ on the train
   - 4 ☐ by mail

9. If you will be making *another* LIRR trip later today (for example, returning from work), at what time do you expect to board your second train?
   Or if you made a previous LIRR trip earlier today (so that this is your second trip), at what time did you board your first train today?

   Enter time of day of other trip: ☐☐ : ☐☐ (hours : minutes) 1 ☐ a.m. 2 ☐ p.m.

About your travel on the LIRR:

10. How long have you been an LIRR customer?
    - 1 ☐ less than a year
    - 2 ☐ 1 yr. to less than 5 yrs.
    - 3 ☐ 5 yrs. to less than 10 yrs.
    - 4 ☐ 10 years or more

11. In an average month, how many one-way trips do you make in total on the Long Island Rail Road?

    Enter the number of one-way trips (counting each round trip as two trips): ☐☐

12. In the last twelve months, how many *monthly tickets* have you bought to travel by the LIRR?

    Enter number of monthly tickets: ☐☐

13. Do you usually use the LIRR to travel to or from your work or school?
    - 1 ☐ yes → Continue with question 14
    - 2 ☐ no → Please skip to page 5

page 3

About your travel from home to work or school:

14. Please enter the zip code of the place where you report to work or school:

    ☐☐☐☐☐
    - 1 ☐ I don't know it
    - 2 ☐ I work at different places on different days

15. How long in total does it usually take you to travel from your home to your work (or school), door-to-door, using the LIRR?

    Enter total travel time: ☐ : ☐☐ (hours : minutes)

16. And how much of that time do you usually spend traveling on an LIRR train?

    Enter time on the train: ☐ : ☐☐ (hours : minutes)

17. Which of these statements best describes your schedule?
    - 1 ☐ I have no flexibility in the hours I have to be at work/school
    - 2 ☐ I can vary my hours a bit, but not by more than 30 mins.
    - 3 ☐ I can vary my start and finish times by 30 mins. or more

18. When you buy a monthly ticket for the LIRR, how much does the ticket cost?

    Enter cost: $ ☐☐☐
    - 1 ☐ I don't know the cost
    - 2 ☐ I never buy monthly tickets

19. Some companies pay part or all of their employees' commuting costs (sometimes with TransitChek). Does your employer pay anything towards the cost of your rail tickets?
    - 1 ☐ no, my employer doesn't pay anything
    - 2 ☐ yes, on average my employer pays each month $ ☐☐☐

20. Do you have a private car or van available that you could use to travel to work (or school) on a regular basis if you wanted to?
    - 1 ☐ yes
    - 2 ☐ no

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Source: LIRR, 1992.

Figure 8.6 Example of an Onboard Survey Administrative Form

SURVEYOR'S ASSIGNMENT SHEET

ASSIGNMENT NUMBER

REPORT DATE ______________

SURVEYOR ASSIGNED ________________________

REPORT TIME

QUESTIONNAIRES ASSIGNED _______ TO _______

REPORT LOCATION

TRIP NUMBER	ROUTE NUMBER	DIRECTION IN/OUT	BLOCK NUMBER	START LOCATION	DEPARTURE TIME	END LOCATION	ARRIVAL TIME	INSTRUCTIONS

The total number of bus trips which must be sampled will be determined by the response rate on each bus trip.

It should be noted that it is inevitable that some persons will be riding more than one of the bus trips surveyed and will therefore be recruited for the survey more than once. In general, it is best to ask such individuals to complete the survey each time they are recruited. However, all passengers should be asked specifically if they have completed surveys on other bus trips and whether these responses were part of the same person trip (because of transfers or on the same route as part of a round trip). This will provide the necessary information to weight these surveys and to identify any double counting, which could affect survey expansion.

While it would be possible to take a simple random sample of bus trips, it is not the ideal method. First, a random sample would not guarantee coverage geographically. Also, some routes might not be sampled at all, if the number of trips on a route is low compared to the population of trips. A random selection of bus trips is also not cost effective. The sample design calls for a surveyor to ride the sampled bus trip and interview or pass out self-administered questionnaires to passengers as they board the bus. If a single bus trip is selected at random, the surveyor rides that trip, then gets off to go to the start point of a second random trip. This results in as much as half the survey time being spent traveling to and from sampled bus trips.

Instead of taking single bus trips as samples, one can take a cluster of bus trips (several bus trips with common characteristics). If the sample cluster is a cluster of bus trips by route, in effect the sample is stratified by route, which ensures representation by route. If the cluster of trips are in sequence by time-of-day, it also ensures that the sample is representative by time-of-day. To the extent that the clustered bus trips alternate between inbound and outbound one-way direction, a clustered sample ensures representation by direction.

The unit of work for a bus for a particular day is called a block. Typically, bus blocks are selected as the basis of clusters of bus trips. A block of trips is assigned to each surveyor. The surveyor stays on the bus throughout that cluster of trips, riding from the morning peak through the evening peak, inbound and outbound, counting boarding passengers and distributing questionnaires or interviewing passengers. To cover a local route, two-person days would typically be required, and in some time periods/corridors, three to four-person days are necessary.

Most transit onboard surveys are conducted during months when school is in session, i.e. spring and fall. Typically, the survey is conducted onboard the sampled transit vehicles on weekdays for a full operating day. Survey times may vary depending on available project resources and needs. The number of sampled person trips is based on average boardings per bus for the route in the time period and the number of required samples per route. Since ridership varies dramatically by time-of-day, bus trips are further stratified into a.m. peak, off-peak, and p.m. peak-time periods. Finally, the ridership is quite different in the a.m. peak in the inbound direction and the outbound direction, so stratification by direction of the trip is necessary. A typical sample requires a minimum of two bus trips per time period and direction for each surveyed route.

Sample Size

Sample size is a function of the sample error (also referred to as the degree of precision) to be tolerated at a specified level of confidence. The sample size refers to the number of usable response by each stratum, i.e., route, time period, etc. In addition, there is a finite population correction (reduction) in expected sampling error as the ratio of sample size to population size increases. The equation defining sample size requirements is presented below:

$$\sigma_p = \sqrt{pq / n}$$

where:

σ_p = standard error of the proportion p

p = proportion of sample elements having a particular attribute, e.g., sex

q = 1 - p

n = number of completed sample interviews of passenger boardings on a route

m = number of passenger boardings for an average weekday on a route

To maximize the sample size (p=50 percent), this equation leads to the number of required samples shown in Table 8.3. These sample sizes are required for each stratum of the survey, for instance each route. If a greater number of strata are to be used, for instance time periods within a route, then the number of samples increases proportionate to the required strata. Table 8.3 shows that a relative error of ± 10 percent at the 95 percent confidence level would provide good precision at the route level and would require about 384 completed interviews, ignoring the finite population correction. The same precision at the 90 percent confidence level could be achieved with 271 completed interviews per route.

The simplified equations in the right-hand column of Table 8.3 include a finite population correction factor; m is the number of boardings in each stratum (i.e., route). When the number of boardings is high the correction is small. For example, if a route has 20,000 daily boardings, an estimate would have a ± 5 percent error at the 90 percent confidence level based on 267 responses. When the number of boardings is low, the correction may

Table 8.3 Confidence Levels and Sample Sizes

Relative Error	Absolute Error	Confidence Level	Sample Size
± 10%	± .05	95%	$n = \frac{384.2\,m}{m + 383.2}$
± 10%	± .05	90%	$n = \frac{271\,m}{m + 270}$
± 20%	± .10	95%	$n = \frac{96\,m}{m + 95}$
± 20%	± .10	90%	$n = \frac{67.7\,m}{m + 66.7}$

be significant. For example, with 750 boardings, the same precision can be achieved with only 199 responses.

Precision for Each Stratum

To achieve a particular level of confidence for each separate stratum of a bus route the same number of samples are required, leaving off finite correction for the moment. A combination of five time periods and two directions will produce 10 strata. The impact on sample requirements per route is tenfold. For example, using an absolute error of $\pm$ 0.5 at the 95 percent confidence level requires 384 completed interviews per stratum. If a hand-out survey is used, with an expected response rate of 25 percent, a total of 1,536 questionnaires would have to be distributed in each time period and direction for each route (1,536 * .25 = 384). If equal precision is desired for each of the five time periods and two directions (the ten strata), a total of 15,360 questionnaires per route would be distributed. This is clearly beyond the resources of any agency to accomplish.

Survey factoring, including the calculation of precision for each stratum using finite correction, helps mitigate some of the poor hand-out and return rates. The data expansion procedures are explained later in this section. However, factoring procedures should be clearly understood and detailed before the sampling is complete. Otherwise, the procedures and assumptions established during sampling might prove inadequate to control sample bias and provide adequate statistical precision.

Sample Selection

The actual sampling of specific bus routes requires a tabulation of the number of trips each bus on the route makes within the selected time periods. Each bus is numbered, and can be traced through its workday from the first trip to the last. This listing of one-way bus trips for each day is called a block, or sometimes a run, and a full system listing for all buses is called a block log. A simplified example of a bus block is shown in Table 8.4.

As Table 8.4 shows, block 301 begins with bus route 24, branches to bus route 24X for three trips in the morning peak, and then branches to bus route 24B. For sampling purposes, branch routes are included in the main route unless specific conditions related to geographic boundaries and ridership estimates require a separate sample. Therefore, block 301 consists of seven trips – three inbound and two outbound trips during the morning peak (5:00 to 9:00 a.m.) and one outbound trip and one inbound trip in the off-peak period.

Table 8.4 Example Block Log

GARAGE: Sunrise Route: 24

WEEKDAY

				Departure		Arrival	
Trip	**Block**	**Bus**	**Route**	**Time**	**Description**	**Time**	**Description**
001	301	440	24	547A	Sunrise & Lewis	606A	Burk Commute Parking Lot
002	301	440	24	614A	Burk Commute Pk Lot	705A	Sunrise & Lewis
003	301	440	24X	715A	Sunrise & Lewis	808A	Ballston Metro Station
004	301	440	24X	814A	Ballston Metro Station	832A	Sunrise & Lewis
005	301	440	24X	842A	Sunrise & Lewis	903A	Ballston Metro Station
006	301	440	24B	912A	Ballston Metro Station	932A	Sunset Shp Center
007	301	440	24B	945A	Sunset Shop Center	1008	Ballston Metro Station

The survey planner should prepare surveyor assignment sheets once the blocks to be sampled are selected. As specified each block is broken into reasonable surveyor shifts and each trip per shift is tabulated for assignment. Table 8.5 illustrates a typical surveyor assignment sheet. In this case, the surveyor shifts consist of six to eight hours each.

■ 8.5 Organization

Once the survey method and survey design have been established, the survey planner must develop an organization plan to help administer and conduct the transit onboard survey. The organization plan should consider the following elements:

- Staffing;
- Hiring methods;
- Training; and
- Supervision and data collection.

The intent of this organization plan is to provide the planner with proven guidelines to conduct a successful transit onboard survey. Obviously, the scale and magnitude of the survey varies according to available resources, travel demand modeling needs, and size of the metropolitan area and transit system. Therefore, the analyst may choose to emphasize particular elements of the organization plan to suit specific analysis needs. For example, a large system running 5,000 weekday bus trips in a high density urban environment would have different organizational needs than a smaller system running 700 weekday bus trips in a suburban area. The vital differences in field management include the average boardings and headway on each route, and therefore the number of surveyors necessary to conduct the surveys. The required elements of an organizational plan are described in the following sections.

Staffing Analysis

Analysis of the routes to be surveyed, the coverage, headways, and average boardings per time period should be conducted to determine specific survey staffing requirements. For example, the peak boardings may be so high as to necessitate one person simply to count boardings and another to hand out questionnaires. If interviews are being considered, peak loading may be so high as to keep the interviewer from moving freely through the bus to contact passengers. This can be overcome with the placement of interviewers in front and back, or by using a hand-out

Table 8.5 Example Surveyor's Assignment Sheet

Assignment Number: 1
Surveyor Assigned: John Doe
Questionnaires Assigned: 1001 to 1500

Report Date: 11/01
Report Time : 5:15
Report Location: Sunrise Garage

Trip Number	Route Number	Direction In/Out	Block Number	Start Location	Departure Time	End Location	Arrival Time	Instructions
001	24	In	301	Sunrise & Lewis	5:47 a.m.	Burk Commute Parking Lot	6:06 a.m.	Count and Survey Passengers
002	24	Out	301	Burk Commute Parking Lot	6:14 a.m.	Sunrise & Lewis	7:05 a.m.	Count and Survey Passengers
003	24x	In	301	Sunrise & Lewis	8:08 a.m.	Ballston Station	8:08 a.m.	Count and Survey Passengers
004	24x	Out	301	Ballston Station	8:14 a.m.	Sunrise & Lewis	8:32 a.m.	Count and Survey Passengers
005	24x	In	301	Sunrise & Lewis	8:42 a.m.	Ballston Station	9:03 a.m.	Count and Survey Passengers
006	24b	Out	301	Ballston Station	9:12 a.m.	Sunset Shopping Center	9:32 a.m.	Count and Survey Passengers
007	24b	In	301	Sunset Shop Center	9:45 a.m.	Ballston Station	10:08 a.m.	Count and Survey Passengers

Get off Bus at Ballston, take Subway to Sunrise Stop, walk behind Station (Two Blks) to Garage. Your Supervisor will meet you there.

method with mail-back option. If certain routes have very high boarding and alighting volumes, indicating short trips by passengers, a mail-back option must be considered to protect a sample from a bias towards longer trips. For safety reasons, certain routes or certain hours of the day may require more than one surveyor per route.

The basic steps presented below should be followed for this analysis:

1. Identify the number of bus routes to be surveyed and their hours of operation. This information will establish the extent of route coverage of the transit system to be surveyed. It will also provide the analyst with specific surveyor needs associated with each bus route to be surveyed (based on the time each bus is in operation).

2. Use existing GIS mapping (or other bus route maps) of the transit system to overlay on the existing roadway network. This mapping will identify the roadway locations of each bus route and stop locations, and identify potential locations for the survey operation center location.

3. Identify the estimated boardings by time period for each specific bus route (or stratum if smaller than a route). Based on these ridership estimates, the planner can estimate the number of questionnaires handed out and the number of returns given an assumption of return rate. This is generally done in a worksheet file. The total number of questionnaires required to be handed out to achieve the stipulated number of returns is applied to the average boardings per bus trip to estimate how many trips in each time period must be surveyed. Remember that the total number of vehicle trips in each direction and time period should never be less than two.

4. Identify the estimated number of inbound and outbound vehicle trips for each route to be surveyed. The planner should identify the start location (for the first set of a.m. trips this is generally a garage location) and end location for each bus trip. The supervisor can use the garage location as the meeting point and operations center for the early morning trips and as a pick-up point and operations center for the late evening trips. Garage locations are convenient start and end points for surveyors because parking is generally available. Midday relief of surveyors at bus layover locations must be coordinated very carefully so that the correct bus is surveyed.

5. Establish surveyor assignments with unique numbers to cover each one-way outbound or inbound trip for each bus route to be surveyed. The unique numbers will ensure that each one-way direction trip segment will be coded and accounted for separately during fieldwork and data entry.

6. Establish surveyor assignments to cover four- to nine-hour shifts. Using the time periods of the survey that were determined in the

design, the shifts required to cover each route, and therefore the number of surveyors necessary to conduct the onboard survey, can be computed. If the run log or block log is used as the basis of sampling, then the surveyor can take short breaks with the driver. Lunch breaks may be avoided by using a six-hour shift.

7. Establish a survey operations center location for the administration of the survey. Generally, this location is selected to serve as the logical place for the supervision and administration of the survey, and is generally in a central location. The administration center should have 24-hour access, since surveyors will be picking up their survey packs before the first trip in the morning (which may as early as 4:30 a.m.) and dropping off completed survey packs after their last trip in the evening (which may be 10:30 p.m. or later). The field supervisors are best given either morning or evening shifts.

Depending on the scale of the survey to be undertaken and the transit system to be surveyed, slight revisions to the above steps may be required. Through this analysis, the survey planner can determine the staffing requirements for the survey, including the number of surveyors and surveyor hours needed by route and the number of replacement surveyors by route.

Hiring Methods

Based on the staffing analysis conducted above, the survey planner's next task will be to identify the methods for hiring transit onboard surveyors. The first step is to establish the start and end times of the survey period. As stated previously, typical survey schedules include the morning-peak, midday off-peak, afternoon peak, and evening operational periods. This generally covers 12 to 18 hours of the day and is representative of the typical weekday patronage.

The following options are considered:

1. Contract with a (local) data collection firm to conduct and supervise the survey on a turnkey basis. The data collection firm is responsible for all aspects of the survey, including hiring surveyors, conducting, administrating, and supervising the survey in the field.

2. Contract with a (local) data collection firm to conduct the survey fieldwork. The data collection firm is responsible for hiring surveyors and conducting the survey in the field. The project sponsor(s) is responsible for the survey's office administration and for supervision of the data collection firm's fieldworkers.

3. Conduct the survey in-house. The project sponsor(s) has responsibility for recruiting and hiring surveyors, and conducting, administering,

and supervising the survey in the field. In this case, the survey planners schedule interviews with prospective surveyors from various organizations such as college and university employment agencies, planning, and engineering departments; state and local government employment agencies; and private temporary employment organizations. Based on these interviews, the planners select the best qualified personnel who are available at the times required to carry out the survey. A written test is suggested as a way of testing the candidate's ability to code numbers, read, and follow directions.

In most cases, hiring surveyors familiar with the transit system and bus routes to be surveyed is important, although the surveyor may need a car to get to the bus garage before the first bus leaves, or to return home after the last bus has gone back to the garage. If the planning agency contracts the work to a data collection firm, it is always beneficial for the survey planner to be involved in the initial administration and supervision of the survey during the pretest stage to assist, understand the procedures that are carried out, and to ensure that the surveyors and/or contractor are conducting the survey properly.

For information on hiring criteria for contractors, see Chapter 4.0. Sample onboard survey RFPs are shown in Appendix G.

Training Methods

Survey staff training should consist of a project briefing and a demonstration of the surveyor responsibilities. Using a bus during training allows the surveyors to get a feel for where equipment, such as the signs and boxes, belongs. Using other surveyors as surrogate passengers also allows each surveyor to familiarize him or herself with the procedures before real fieldwork begins. In addition, surveyors should be provided with the necessary materials and procedural notes to conduct the survey; an example of a Surveyor's Manual of Procedures is available in Appendix H.

In cases in which data collection firms are hired to conduct the survey, it proves highly useful for the project sponsor(s) to assist in the training of survey administration and surveyor staff. The training generally takes a half-day, including orientation and role playing. Larger systems or surveys with personal interviews may take longer. Typical survey training procedural steps follow:

1. **Project Briefing** – The project sponsor(s) should hold a project briefing for all hired survey staff (or contractor survey staff). This meeting should describe the background and purpose of the survey, as well as the administrative procedures to be followed during the course of the survey. At this point, all surveyors, including the "break" or replacement surveyors should be given their survey assignments and work schedules for the first days of work. Since there is a high turnover

rate, especially in the first few days of surveying, the briefing and training demonstration should be videotaped to train replacement surveyors.

2. **Survey Demonstrations** – The surveyors should be given individual demonstrations on the procedural conduct of the onboard passenger survey at this time. This includes describing the tasks of the surveyor regarding responsibilities for distributing survey materials to boarding passengers, tallying the total number of boardings and alightings at each bus stop location, and collecting the completed questionnaires. The surveyors should also role play the interview/survey distribution process to be certain they feel comfortable with the process and remember each of the steps. In one recent summary, interviewers were videotaped during the role play and asked to identify ways of improving.

3. **Survey Materials** – Each surveyor should be given the appropriate survey materials and supplies at the start of his/her survey shift. Obviously, the materials provided to the surveyors are dependent on the scale of the survey to be undertaken. The materials identified below are intended to provide basic guidelines for surveys of this type:

   - Individual packages containing a given number of questionnaires each;
   - One box (or more) of golf pencils containing 144 pencils each;
   - One (or more) large pencil eraser;
   - One survey assignment sheet;
   - One (or more) manila envelope per one-way bus trip with a survey log file enclosed;
   - Bus route maps and schedules; and
   - One large shopping bag for survey material storage purposes.

4. **Survey Procedures** – The surveyors should be provided with an outline (in writing) of the surveyor procedures described in the previous training sessions. In some cases, several copies of a letter describing the reasons for the survey may be enclosed with this package. The letter should be signed by the project sponsor(s). The purpose of this letter is to provide interested passengers with information about the survey. For specific surveyor tasks and procedures, please refer to the Surveyor's Manual of Procedures in Appendix H. In addition, the surveyor will not be distracted from his/her responsibilities by answering questions about the survey that may be served through this letter.

The training methods identified in this section are intended to provide the basic guidelines to transit onboard survey administrators. In some cases, the planner should revise the parameters outlined above for their given survey situation.

Supervision and Data Collection

At the beginning of each bus route in the morning, the survey planner or data collection contractor should place individual surveyors on the appropriate buses, generally in the bus garage prior to the first vehicle trip. Depending on the scale of the survey, more than one morning and one evening survey supervisor should be scheduled during the course of the survey. Once each morning shift is placed on the correct bus, the morning supervisor is generally available at the administration or operations center to assist the surveyors with problems and other issues that arise throughout the survey day. The field supervisors might want to carry mobile phones to ensure their accessibility. Typical issues include providing surveyors with more questionnaires or pencils, coordinating survey shift changes, dealing with problems such as bus breakdowns, and generally managing the fieldwork throughout the day.

As each one-way bus trip is completed, all survey control (log) sheets and completed questionnaires should be enclosed in the manila envelopes provided to each surveyor. Each manila envelope should contain the specific one-way trip identification number for the given bus route and time-of-day. At the conclusion of the survey, each surveyor should provide all the survey materials and one-way trip manila envelopes to the survey supervisor.

The returned envelopes are taken to the administrative offices to be processed. The questionnaires are edited and coded, and entered into a data file as soon as possible after collection, allowing the monitoring of pass-out rates, response rates, refusal rates, and the completion of the trip log. If a surveyor is not being productive, or is conducting some element of the procedures incorrectly, that surveyor can be retrained or terminated before too many vehicle trips have been incorrectly run. As a result of these checks, low volume routes or time periods, strata with insufficient returns, or bus trips which failed due to surveyor misunderstanding or other problems (the bus broke down for instance), can be rescheduled for the last week of fieldwork.

■ 8.6 Pretesting

The survey procedures and forms should be thoroughly pretested before the full survey is implemented. The survey planner should identify three to five bus routes with unique characteristics to test the survey instrument, surveyor organization, and survey response rates under different conditions. These conditions may include surveying for peak-periods and daily conditions on various bus routes to identify any problems that may arise through the conduct of the survey. Fully implemented survey procedures should be used on at least four one-way vehicle trips, including two outbound and two inbound trips. The pretest staff should include the designers of the survey procedures and forms, survey supervisors, and key surveyors hired to provide support in the fully implemented survey.

The surveyors conducting the pretest use the same procedures and techniques identified by the project analyst during the survey training sessions. For example, the surveyor boards the selected bus, counts the boarding passengers, hands out questionnaires to each boarding passenger, collects the completed questionnaires, encloses the completed questionnaires in the appropriate trip envelope, completes the information for the one-way directional trip, and prepares for the next one-way directional trip.

After completing the pretest, the survey planner(s) should hold a debriefing meeting to jointly identify any discrepancies in the survey procedures. The survey control (log) sheets should be rigorously examined after the pretest for discrepancies and uncontrolled information. The information contained in the returned questionnaires should also be processed immediately to identify any potential problems associated with respondents filling out the survey properly. Frequency distributions should be conducted on each question to determine the validity of the survey instrument. If the valid responses fall below 95 percent, then the question should be reworded. The only questions that should have a significant percentage of blank (or a non-response) responses are the socio-economic questions related to age, sex, ethnic background, and income.

■ 8.7 Administration Issues

As specified above, the organization of the transit onboard survey includes staffing analysis, hiring methods, training methods, and supervision and data collection. Additional administrative support issues should be considered by the project sponsor(s) before the survey is implemented. The requirements for this administrative support are described below:

- Develop the necessary forms such as the questionnaires, bus trip logs, surveyor assignment sheets, and control registers (used to maintain the status of sampled bus trips);

- Provide survey personnel (by making sure surveyors will show up at their scheduled times);

- Develop a manual of survey instructions;

- Develop and conduct the surveyor training program;

- Specify and assemble survey materials sufficient for the field crew anticipated plus 20 percent. Include surveyor badges, pencils and clipboards, envelopes, return boxes and pencil boxes. Provide "Survey Today" signs for the bus window, and shopping bags (or carry-on bags for survey material);

- Conduct the pretest; and

- Acquire the appropriate bus or transit passes for each surveyor.

Daily administrative support is also required, which includes the following:

- Assemble surveyor's equipment for each oncoming shift, disassemble and log in surveyor's equipment with completed questionnaires from each completed shift;

- Organize/review and conduct edits on the completed surveyor's packets from the previous day;

- Keep productivity records for each surveyor, check for cheating, retrain and/or terminate as necessary;

- Check for missed/incomplete/failed trips and reassign such trips for resurveying; and

- Check return rates and completion rates (the number of returns which pass editing) by route and/or stratum to ensure that sample assumptions are being met. Schedule routes with poor returns for resurveying.

■ 8.8 Coding and Data Entry for Transit Onboard Surveys

If mailback or other self-completion survey forms are used in the survey effort, the responses need to be assigned codes for data entry. Closed ended question forms and precoded forms simplify this process greatly, so that the coding and data entry can be performed simultaneously. However, even if precodes are present, a questionnaire with complex questions or open-ended responses should be formally coded prior to data entry. The principles of coding are described in Chapter 2.0

Once all responses have been coded, the data from all self-completion forms and PAPI interview forms should be entered into data files. Survey data are most commonly entered in ASCII flat files, with specified character columns for each coded response. Alternatively, the survey data can be entered directly into database or spreadsheet software packages. The packages can be manipulated to provide user-friendly data entry displays and reasonableness checks on entered data.

It is usually cost-effective to validate all data entry by having different data entry specialists enter the same data. The small additional cost of entering all data twice is almost always preferable to the costs (monetary and time) of sorting out errors during the editing task.

8.9 Cleaning and Editing

The questionnaires for each completed one-way trip should be edited as soon after collection as possible in order to ensure that each surveyor is using proper procedures. At the end of each day, the trip envelopes should be opened and the trip logs edited for completeness. The number of boarding passengers should be compared to the number of questionnaires handed out (using the questionnaire serial numbers). Optimally, this difference should be zero. The project analyst(s) should make certain that the boardings are not lower than the distributed number of questionnaires.

The number of completed questionnaires, refusals, and blanks should be tallied for each trip. Higher than average refusals necessitate a discussion with the surveyor for that trip. There could be a reason one trip had a high refusal rate, or the surveyor may require retraining. Once the editor is satisfied that the trip information is complete, the questionnaires returned for that trip are sorted. Refusals and blanks can be discarded while the completed questionnaires should be sent for data entry. A completed questionnaire may not have all questions answered. Therefore, the rules to identify a usable questionnaire should be given to the editors. Generally, a questionnaire is usable if the origin and destination of the trip are filled in and codable. If the origin and/or destination is blank, but the access or egress made is walking, the boarding bus stop or the alighting bus stop could be substituted as the ultimate origin and destination of the trip. This determination should be made by the survey design staff.

Cleaning the data once it is entered begins with range checks. For example, if the possible answers to a question are numbered 1 to 4 and the nonresponse is coded as 0, then all answers greater than 4 must be erroneous. In addition, certain cross checks must be performed to verify the accuracy of the data. For example, if the answer for the number of buses used to complete the trip is one, then the answer for access or egress mode cannot be bus. Conversely, if the answer to access or egress mode is bus, then the number of buses to complete this trip must be more than one. Similarly, if the fare type is transfer, the access mode must be bus, and the number of buses to complete the trip must be more than one. These types of checks are called logic and consistency checks.

For access mode/egress mode questions that specify transfers to or from a route, checking involves consulting the bus system map to see that a transfer from the bus route(s) listed is possible at the point where the passenger boarded the current bus.

The 1972 Urban Mass Transportation Travel Survey Manual discusses the types of errors usually encountered[4]:

- **Omissions where either the interviewer or the respondent (in a self-administered survey) failed to make an entry** – Sometimes it may be possible for the editor to complete the form, on the basis of other entries on it. For example, if the omission is "the time boarded the vehicle," it may be possible to estimate the time from survey control information. If the survey cards are serialized and specific batches of cards were distributed within a certain known time period, an estimate of the time could be made by analyzing the information related to where the person boarded the vehicle. Great caution must be used when inserting information , to be sure that no guesses are made. The indiscriminate insertion of data could lead to numerous erroneous conclusions. For example, there is no way to determine if the respondent is a male or a female unless that information is recorded. Therefore, no attempt should be made to guess at what the proper entry should be.

- **Impossible entries** – An example of an impossible entry might be the recording of an address in an area that is not within a reasonable distance from the transit boarding place, when the respondent indicated that he walked to the boarding place. In this case, the respondent may have driven to a transit station, but incorrectly identified his means of getting there as "walk," instead of "auto." He may have misunderstood the question, and recorded his home address instead of the actual place where he boarded the vehicle.

- **Inconsistent entries** – These occur when two or more entries must bear a particular relationship to each other, but do not. For example, the addresses recorded for "boarding address" and "alighting address" may be reversed. If the survey is related to "inbound" trips only, a suburban address for "boarding address" is more reasonable than an address close to the central business district.

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[4] U.S. Department of Transportation, Urban Mass Transportation Administration, *Urban Mass Transportation Travel Surveys*, U.S. Government Printing Office, Washington, DC, August 1972, pgs. 33-34.

- **Unreasonable magnitudes of entries which might not necessarily be wrong, but which appear unreasonable** – For example, if the response to the question: "How many autos are available for your use at your home" is recorded as "20," it may be safe to assume that "2" was the intended response.

Before proceeding with data expansion, it is important to spend some time reviewing the results and conducting enough cross-tabulations to insure the data are correct before expanding the sample to reflect the entire population.

9.0 Commercial Vehicle Surveys

Commercial vehicle surveys are used to collect profiles of goods and commodity movements, and truck and commercial vehicle characteristics, within particular areas of study. Surveys of this type have been conducted for several reasons, including for use in statewide, regional, subarea, and local travel forecasting models, in goods movement studies, in management systems (in particular, intermodal and congestion management systems), as well as in international border crossing freight movement studies.

At this point in time, commercial vehicle surveys are not typically performed to support most statewide and Metropolitan Planning Organization (MPO) travel model forecasting efforts. In most cases, states and MPOs estimate commercial and truck travel models outside of the formal travel modeling process. Secondary data sources are often used as post-processors to develop commercial/truck vehicle trip tables and models. However, as the analysis of commercial vehicle travel becomes more important in urban planning, the collection of commercial vehicle survey data will become quite important, as well.

In January of 1995, Samual W. Lau of the San Francisco Bay Area's Metropolitan Transportation Commission (MTC) conducted a literature review of recently conducted commercial surveys entitled "Truck Travel Surveys: A Review of the Literature and State-of-the-Art." This review provides a comprehensive overview and analysis of the types, uses, methods, response rates, and comparisons of recently collected commercial vehicle data in metropolitan areas throughout the United States. It also describes the needs and requirements of commercial/truck data collected to support regional travel models as well as the MPO transportation planning and management system (pavement, bridge, etc.) process. This review provides useful background material associated with the collection of commercial vehicle surveys.

It should be noted that the potential for the use of recent technological advances, such as global positioning systems (GPS), may soon provide reasonable alternatives to the traditional commercial vehicle survey. While GPS is being examined for potential use in other types of surveys, it seems particularly well suited for commercial vehicles. Since the travel patterns of vehicles, rather than persons, are desired, the use of a GPS device on the vehicle is more likely to be accepted by the respondent. GPS also greatly reduces the burden on the respondent since destinations would not have to be recorded. This could be a substantial advantage for vehicles that make many stops per day.

■ 9.1 Assembly of Background Information

Three types of background data are likely to be especially helpful to the survey team:

- Available commodity survey data;
- Data on the commercial vehicle population; and
- Commercial vehicle flow data.

These data are discussed below.

Available Commodity Survey Data

Typically, secondary data sources are used to model and forecast commercial vehicle travel patterns in lieu of collecting new survey data. Although there are a number of sources of data required to support commercial vehicle surveying efforts, there is little information collected by others which can be used directly in the development of truck/commercial travel models. Ideally, available recent survey data should provide information on commercial vehicle trips by origin and destination, vehicle type, commodity type, and time-of-day.

The only potential source coming close to meeting these requirements is the United States Census Commodity Flow Survey (CFS), first conducted in 1993 and scheduled to be repeated every five years as part of the Census of Economics. This survey captures shipment data by all modes from manufacturing, mining, wholesale, and selected retail and service establishments. The sample size – over 200,000 establishments surveyed nationally – is likely to provide a sufficient subsample in the larger metropolitan areas to provide the basis for local commercial vehicle planning and travel modeling efforts.

The major problem in using this information at the local level, however, are disclosure limitations which will likely prevent the general release of detailed origin, destination, and commodity information. Assuming these disclosure limitations could be overcome as they are in the Census Transportation Planning Package (CTPP), the CFS could provide trip tables of truck trips and commodity flows by vehicle type and/or shipment size, and by zip codes of origins and destinations within a metropolitan area.

Unfortunately, the CFS will have the following limitations:

- The level of geographic detail is less than desired because zip codes are typically larger than traffic analysis zones used in travel demand forecasting;

- Vehicle size information is not directly available because the CFS uses four truck types which are not related to vehicle and shipment size (parcel delivery, postal service, private truck, and for-hire truck) from which vehicle size can be inferred;

- There would be no disclosure limitation by commodity type because the CFS is coded to a detailed five-digit commodity code;

- No time-of-day information would be available; and

- The CFS does not include information on truck travel by all types of retail and service establishments; thus, urban area commercial vehicle usage for retail deliveries and service people, for example, would not be included.

At the local level, systematic surveys of truck travel are generally unavailable. The closest to the type of information desired by urban planners and travel modelers are usually the trip logs maintained by many commercial vehicle operators such as delivery services (United Parcel Service and Federal Express), the United States Postal Service, and many on-site repair establishments. Although these trip logs can be used to create limited commercial vehicle trip tables, they are the property of the privately held businesses/establishments, and are therefore difficult to obtain.

Potentially, an aspect of a survey team's commercial vehicle surveying effort could be to request the voluntary provision of these commercial vehicle trip logs for a sample of local establishments. In addition, survey teams could also obtain applicable information from the CFS in order to supplement the primary data collection efforts envisioned for the survey effort.

Data on the Commercial Vehicle Population

Two data sources have typically been used to provide transportation planners and modelers with commercial vehicle population information which can be sampled to obtain commercial vehicle travel data:

- Vehicle registration lists; and

- Commercial establishment lists.

Vehicle registration lists by vehicle type and owner address are generally available to local planners and travel modelers from Departments of Motor Vehicles (DMVs). The vehicle type classifications from these lists may or may not meet the planners' needs, depending on whether or not vehicle weight and type codes are maintained in the files, and on whether or not licenses are differentiated by vehicle type. There may also be problems in identifying passenger vehicles, pickup trucks, and small delivery vans used commercially. This source typically fails to match the population of vehicles actually operating in the study area because commercial vehicle ownership, garaging, and usage often involves two or more locations, some of which may be outside of the study area and therefore impossible to survey.

A second type of data source is an establishment listing. Commercial establishment lists are available in many forms, ranging from telephone listings to publicly maintained lists. Typically, State Departments which administer unemployment and work compensation insurance programs and proprietary databases maintained for sale by private firms, such as Dun and Bradstreet, maintain these listings.

No source will provide perfect data for the survey sampling frame. Potential problems involved with data obtained from these lists include:

- The lack of coverage of branch office operations in employment-based lists;
- The lack of not-for-profit and governmental organizations in the listings; and
- The lack of employers with small numbers of workers.

An additional difficulty in using lists of this type is that they typically include many establishments which do not operate commercial vehicles and can provide only very limited information on trips to and from their locations by vehicles owned by other establishments. For example, an office building with several businesses serviced by a package delivery firm may have a set delivery and pickup schedule. However, the individual businesses within the building may not be aware of the actual types of vehicles and times the trips are being made by the delivery service.

Commercial Vehicle Flow Data

Information on commercial vehicle flows is often valuable for model validation. This information can also be used to monitor commercial traffic into and out of major facilities such as large warehouses, piggyback rail yards, and ports. When state-of-the-art technology is available, classification counts based on the number of axles and length per vehicle can be obtained automatically at traffic count stations. More typically, planners and modelers must rely on available short-term manual classification counts, frequently collected as part of traffic operation and impact studies.

■ 9.2 Commercial Vehicle Survey Design

The most basic design decision for the commercial vehicle survey team is the selection of the appropriate survey population and unit of analysis. Commercial vehicle surveys can be performed by sampling:

- Commercial vehicle trips at certain geographic locations;
- The commercial vehicles themselves; or
- The establishments that commercial vehicles serve.

If the vehicle trip is chosen as the unit of analysis, the commercial vehicle survey is a simple extension to the vehicle intercept survey described in Chapter 7.0.

When the intercept method is insufficient for the anticipated analyses, a general population survey is needed. Often, the population chosen for analysis is the commercial vehicles registered in the study area. In this type of survey, the survey team contacts the owners of a sample of the vehicles, and requests them to provide detailed travel information for the vehicle. Some larger truck fleets have been equipped with GPS tracking devices that allow fleet managers to locate trucks at any given moment. These systems can be used effectively for gathering truck-specific travel data with little effort by respondents.

A major advantage of this approach is that registered vehicle data can usually be obtained from local DMVs at little cost. The major disadvantage is that vehicle registration lists do not typically match the commercial vehicle population in an urban areas since many trucks not registered in the areas will be garaged and operated within the area, and conversely many commercial vehicles registered in the area will typically operate elsewhere.

Because of the problem with using the registered vehicle as the unit of analysis, many commercial vehicle surveys concentrate instead on establishments. The advantage of using employers as the population to be sampled is that nearly all commercial vehicle activity in a region is associated with employment, either of the shipment originator, receiver, vehicle operator, or a combination of the three. Exceptions to this rule of thumb include rare cases of deliveries to households from external study area locations by operators also based outside of the study area. The disadvantages of using employers include the following:

- Many businesses have very limited connections with commercial vehicle trips;

- Establishing a comprehensive population of employers is often difficult;
- Costs of contacting the number of employers necessary to obtain a specified vehicle sample size may be significant; and
- Two-stage, or stratified sampling is required to account for the varying number of commercial vehicles associated with employers of different sizes and types.

The choice of the unit of analysis is likely to depend mainly on the anticipated modeling needs, but also on the schedule and resources available to implement the commercial vehicle survey. A survey based on vehicle registrations can usually be conducted less expensively. However, the primary benefit of a survey based on employers will be that it more accurately represents the entire commercial vehicle population in the particular study area.

General Fieldwork Approach

The fundamental design problem typically faced by surveyors is how to obtain travel behavior information directly from the truck/vehicle operators. In most cases, owners of private trucking and commercial businesses are not willing participants in this type of survey effort, especially if they are asked to provide operational information about their particular business. In addition, the survey design must include a convenient mechanism to obtain travel information directly from the vehicle operator, which is not always evident. Therefore, creative methods for obtaining important travel behavior from the appropriate businesses must be built into the survey design process. Standard design features for the commercial survey include the following steps:

- Contact businesses to obtain approval for survey participation;
- Identify survey method;
- Develop data recording method; and
- Develop survey expansion method.

Recent experience in Chicago, Phoenix, Alameda County (California), and Houston has shown that the following multi-step approach is necessary to conduct and administer a successful commercial vehicle survey:

- **Contact Businesses** – Initial contacts with business owners or employers should be established by telephone. Supplemental contacts should be made by mail and/or in person (particularly for operators of large fleets) to recruit survey participants. Typically, the survey mail-out instrument requests establishment, vehicle, and travel behavior data (trip diary forms) for a single-travel day. Data retrieval is usually conducted either by mailback or telephone contact.

Attempts to simplify this process to a mailout/mailback strategy have been made in at least one recent truck survey (in Phoenix) which was based on vehicle registration data. However, because the response rates were so low in the pretest, the approach was revised to represent the approach described above.

Details and potential refinements of this general fieldwork strategy are discussed in subsequent sections of this chapter. An important issue to address during the survey design is the degree of coordination between the commercial vehicle survey, workplace surveys, and vehicle intercept surveys discussed in Chapters 10.0 and 7.0 respectively. For example, if an employer database is used as the sampling frame, then the procedures used to design the workplace and establishment survey should be combined with those documented below. This will minimize the effort required for meeting data needs and reduce the number of business/employer contacts that have to be made. Similarly, specific truck movements may be well captured by vehicle intercept surveys, reducing the data needs for the commercial vehicle survey.

- **Data Recording Methods** – Typically, the recruitment of businesses/employers to survey is conducted through obtaining vehicle registrations or by contacting businesses directly by telephone. Data retrieval and recording methods for each include the following approaches:

  Vehicle registration information is obtained through the Department of Motor Vehicles. Recruitment of businesses for survey participation are typically obtained through telephone contacts and the use of CATI.

  Retrieval of survey forms is handled by either providing envelopes with return of address and postage or mailback postcard forms. Returned surveys, using either method, are directly input into established computer databases or by using telephone/CATI. CATI is used to directly enter survey responses for several survey types discussed in this manual.

  Employer contacts and subsequent survey recruitment are typically made by telephone and CATI. In some cases, personal contact is made by sending out initial survey participation forms designed to obtain business participation in the survey. Data entry and retrieval use similar methods described above for the vehicle registration approach.

- **Survey Expansion Method** – The survey expansion methods typically used for each approach described above are presented below. For the vehicle registration approach, the sample expansion method includes:

Developing a vehicle factor based on the number of vehicle registrations divided by the number of responses by weight classification or truck type; and

Developing a trip factor based on the total number of trips per truck obtained from the trip diary forms (typically, each vehicle operator is asked for detailed travel behavior information for a limited number of trips, e.g., for a given period, day, or week).

The sample expansion method typically used for the employer contact approach includes:

- Developing an establishment factor based on the number of employers divided by the number of establishments participating in the survey;
- Developing a matrix based on employer size, business type (SIC code), and/or geography (location) in order to define the establishment factor identified above;
- Developing a vehicle factor based on the number of vehicles used by a given establishment divided by the number of employers surveyed (this factor can be truck type-specific); and
- Developing a trip factor using similar methods described above for the vehicle registration approach.

■ 9.3 Organizing the Commercial Vehicle Survey

As specified above, the design of the commercial vehicle survey typically considers the vehicle registration or employer contact approach. If the employer contact approach is used, close coordination with the development and implementation of the workplace and establishment survey is desirable. Similar to the other survey types identified in this manual and once the businesses for surveying have been identified, the following design issues must be determined:

- What is the appropriate survey approach?
- Should the surveys be conducted using telephone interviews or be self-administered?
- What count data are needed for the survey and how can it be obtained?
- Should incentives for participating in the survey be offered?

The fieldwork approach must be identified in the beginning stages of the survey effort. General descriptions of the two typically used approaches, vehicle registrations and employer contacts, are discussed in detail in Section 9.2

Once this approach is identified, the survey design must be determined. The survey design should consider either the initial telephone contact, mail-out, and follow-up telephone contact/CATI approach or the mail-out, self-administered questionnaire, and mail-back approach to obtain the travel behavior information required for analysis and travel modeling. Both designs have been used for surveys of this type, with the higher response rates associated with the telephone interviews. Similar to other survey types, telephone interviews are typically conducted by specialized market research firms. The procedures required for implementation of telephone surveys are discussed in greater detail in Chapter 6.0.

The problematic issue associated with conducting telephone interviews for this type of survey is to identify the appropriate mechanism to directly contact the commercial vehicle operators. As stated previously, this direct operator contact is essential to ensure that the proper level of trip-making and travel behavior data is obtained. Other potential contact persons at employers and businesses include dispatchers and business owners that may be able to answer specific travel behavior questions about their commercial vehicle fleet.

With the self-administered surveys, similar and additional problematic issues must be addressed in order to meet the needs of the survey. For example, a mechanism has to be identified to distribute the survey material from the employer/owner to the appropriate vehicle operators. This must be defined early on in the survey design once the self-administered survey is selected. Typically, the distribution of questionnaire forms is administered by the business employers' owner or fleet dispatcher. Additional issues include ways in which completed survey forms are collected and specific vehicles are identified as survey participants. The self-administered questionnaires are sent directly to the surveyor either by the individual vehicle operators surveyed or by the employer/owner who collects the completed surveys from the individual vehicle operators. Similar to the workplace and establishment surveys, better response rates occur when the employer/owner is responsible for collecting completed questionnaires from operators for mail-back.

The following primary and secondary traffic data can be obtained to supplement the information obtained from the commercial vehicle survey:

- Truck classification counts by weight and activity at cordon and/or screenline locations;
- Truck classification counts at area Truck Centers and Weigh Stations;
- U.S. Census Commodity Flow Survey;

- Vehicle Trip Logs from surveyed businesses; and

- Truck classification counts at permanent station locations on state routes and major highways.

Much of this information can be obtained by using the traditional data collection methods designed for other types of surveys and travel models. For example, the traffic data collected for vehicle intercept surveys can also be used to identify commercial vehicle trucks movements at specific count locations. These data can be used to expand the results of the survey to meet the commercial vehicle demand currently operating on the roadway network. The cordon and/or screenline commercial vehicle data are typically collected at the same locations established for highway network automobile and transit traffic. This ensures consistency with other models developed within the regional travel modeling system such as the development of automobile trip tables by trip purpose using the traditional Four-Step modeling approach.

■ 9.4 Sampling

Sampling strategies are typically conducted in two stages. The first stage involves the selection of the business/employer sample from all the businesses within the study area. The second is the selection of the commercial vehicles (classifications) to be sampled within the businesses selected for surveying. The sampling techniques used for the commercial vehicle surveys can be dependent on other survey efforts taking place, especially the workplace and establishment survey, which use similar methods to define the sample of businesses/employers.

Vehicle registration approach. In order to obtain a reasonable level of information on trips by heavy/large commercial vehicle classifications, sampling should be stratified by vehicle type. Typically, three to four categories are selected for sampling based on weight or the number of axles for each vehicle. Sampling rates are usually established to achieve an equal number of responses by each vehicle type category.

Within each category, vehicles selected for contact should be ordered randomly, by registration number, for example, to avoid geographical and other biases if all vehicles are not contacted.

Employer contact approach. The techniques used to sample workplace and establishment surveys and the issues in identifying the sample of employers are discussed in detail in Chapter 10.0. If the commercial vehicle survey is being conducted independently of the workplace and establishment surveys, then it may be desirable to stratify businesses/employers by SIC code and target the sample on industries most likely to operate trucks and other commercial vehicles. Otherwise, many contacts will be non-productive and inappropriate for surveying because of limited commercial activity. Sampling of vehicles within the businesses will be warranted for establishments with large commercial fleets. This will more than likely be the case for light and medium vehicles because heavy vehicle operators may be difficult to locate and subsequently survey.

■ 9.5 Drafting and Constructing the Commercial Vehicle Survey

Data Elements

Typically, planners design commercial vehicle surveys to determine vehicle owner information such as industry type, number of commercial vehicles, and number of employees; vehicle information such as size, weight, and body type; and information on vehicle usage for a typical travel day. For each commercial trip made on the specified travel day, information to be obtained is typically desired for origin and destination locations, trip start and end times, odometer readings, land use and/or industry type uses at the identified origin and destination locations, activity at the stop locations (loading, unloading, meal stop, etc.), stop location (on- or off-street), and vehicle contents (commodities) during the trip.

The level of detail concerning vehicle contents can vary from simply noting whether the vehicle is empty or loaded, to a detailed commodity description and/or code. Information on the commodities transported is not a necessary element for most urban planning and travel modeling applications, but may be desired for particular urban goods movement studies.

Survey Instruments

Similar to other surveys described in this manual, the survey instrument should be constructed to elicit the appropriate commercial vehicle operator responses to obtain the required data for input into the travel demand modeling process. This includes drafting the appropriate questions and constructing the survey instrument to meet travel modeling needs. The telephone and self-administered survey approaches are typically constructed differently and require different questionnaire designs.

The telephone interview questionnaires are typically more detailed and focus on obtaining other information besides travel behavior. For example, surveyors may obtain commodity flow and other non-related travel behavioral data. Telephone interview questionnaires are also designed to allow for quick interviewer tallying of responses by using personal interview scripts and CATI programs.

The self-administered surveys typically contain fewer questions and are targeted for quick response time. The survey questionnaires must also be clear and easy for respondents to fill out. Generally, a series of instructions are provided directly on the questionnaire form to assist vehicle operators with instructions on how to respond to the questionnaire. Return address and postage are required for a self-administered survey with a questionnaire mail-back option.

In addition, it is recommended that the survey team ask commercial vehicle operators to review and comment on early drafts of the survey questionnaire and materials. This step will ensure that common terminology is used and understood.

Survey questions that might appear on a commercial vehicle survey include:

- Business/employer location and address;
- If appropriate, the Truck Center/Weigh Station location where the survey was completed;
- Ultimate trip origin and destination including state, city, and nearest intersection;
- Interim trip origins and destinations specifying segments/previous stop locations of the entire trip (related to long-haul operators);
- Start and end times of the entire trip (including all trip segments);
- Major routes used for travel on the highway network;
- Frequency of trips using this particular route by day, week, and month;
- Frequency of trips using alternative routes by day, week, and month (including reason for using alternatives such as congestion, time-of-day, etc.);
- Truck classification type and size categories (heavy, medium, light, small commercial);
- Commodity/good that is being transported; and
- If appropriate, locations for pickup and delivery of goods.

The survey instruments from several recent commercial vehicle survey efforts are shown in Figures 9.1 through 9.4.

■ 9.6 Pretesting

As with any survey, pretesting should be carried out prior to the full implementation and administration of the survey. In the case of the self-administered survey, surveyors can rely on surveys already carried out in other locations to reduce the need for extensive pretesting. For telephone interview surveys, it is important that the surveyor test the entire process to ensure each component of the survey is feasible and obtains the appropriate level of information required for analysis and travel modeling purposes.

In some cases, self-administered (mail-back) survey pretesting can be administered on a small scale to persons within your company/agency to identify inconsistencies and other issues associated with the format and wording of the questionnaire. In previous chapters of this manual, procedures and requirements for pretesting are discussed in greater detail.

Figure 9.1 Sample Commercial Vehicle Survey Travel Diary Package from Phoenix

MARICOPA•ASSOCIATION•OF•GOVERNMENTS
Transportation & Planning Office

1739 West Jackson Street
Phoenix, Arizona 85007
(602) 255-7867

Dear Truck Owner,

Enclosed you will find a Vehicle Trip Record designed to study commercial vehicle transportation and travel activity. The survey will play an important part in planning for future transportation needs here in the Valley. **We are interested in learning more about the day-to-day travel behavior of commercial vehicles in Maricopa County.** We need your help. The vehicle with the license plate number listed on the label attached to the survey is the vehicle that should have its travel activity recorded on this Vehicle Trip Record. **By having the driver of that vehicle fill out a travel log for just one day, you will help us learn more about how to help address Arizona's transportation concerns.** We need the travel activity of that vehicle for Tuesday, October 3, 1989.

ABOUT MAG

The Maricopa Association of Governments (MAG) is a voluntary association of local governments that does transportation planning for Maricopa county. Research studies about transportation are conducted so that we can learn more about how to solve traffic problems that affect the Valley. We also maintain computer programs that help us to project future traffic patterns.

ABOUT THE STUDY

This Vehicle Trip Record is being filled out by several hundred commercial vehicle drivers in Maricopa county. Vehicles are randomly selected to participate in the study, and yours is one that has been selected. **The information about the use of your vehicle will enable MAG to understand "a day in the life" of this county's fleet of commercial vehicles.** We want to know what the vehicle is used for and where it goes. We are interested in the vehicle, but we need your help. By filling out the Vehicle Trip Record, your driver will be giving us information that we cannot get anywhere else. Through your record, we will learn more about that vehicle and others like it.

ABOUT THE RESULTS

All information gathered for this study is coming from individuals just like your drivers who are filling out identical Vehicle Trip Records. **All of the information will be treated with the utmost confidentiality. We will use the information only for MAG purposes, to help us prepare future transportation improvement programs.** Programs that we hope will help you.

You really count to us. Can we count on you? In expectation of getting your help with this study, I thank you. If you have any concerns about participating in the research, please call our Survey Information telephone line at 967-4441.

To proceed, the addressee should complete the first page of the Vehicle Trip Record and then forward the record to the driver of the appropriate vehicle as indicated on Page 1.

Yours appreciatively,

Roger Herzog
Roger Herzog
MAG Transportation & Planning
Office Manager

A Voluntary Association of Local Governments in Maricopa County

Figure 9.1 Sample Commercial Vehicle Survey Travel Diary Package from Phoenix (continued)

ADOT COMMERCIAL VEHICLE TRIP RECORD

***** A Personal Message To The Driver Or Drivers *****

If you have any questions, please call our Survey Information telephone line 967-4441.

Who should we contact if we have questions about your Vehicle Trip Record?

NAME ________________________________

TELEPHONE NUMBER ______________________

X X

INSERT LABEL HERE

X X

1. What is the starting address for the vehicle listed on the label above on the survey date (the first Tuesday, Wednesday or Thursday after you received this survey)? Please be specific! Indicate St., Ave., North, South, East or West, nearest intersection if street address is unknown.

Street Address:____

City:______________________________ Zip Code:__________________

2. Please look at Figure 1 and determine which vehicle looks most like this vehicle. In the space provided below, write in the letter next to the picture of the vehicle which looks most like this vehicle. (If this vehicle normally operates with one or more trailers, write in the letter of the most common tractor/trailer configuration usually used.)

Letter of Vehicle From Figure 1: __________

3. If this vehicle, when used as shown in Figure 1, has more than six tires, please write in an estimate of what you think is its gross weight. If the vehicle has six tires or less, go on to Question 4.

Gross weight ______________

4. How will you be using the vehicle today? Please circle "yes" or "no" for each item below to tell us whether you will use the vehicle for that activity today.

a. Transportation between home and work .... YES NO

b. Any work-related purpose other than commuting .... YES NO->COMPLETION OF DIARY IS NOT REQUIRED. RETURN FORM IN POSTAGE PAID ENVELOPE.

YES -> PLEASE COMPLETE TRAVEL DIARY.

Before you go on to the Travel Diary on the next page, we want to give you an idea of what we consider to be a trip or trips to be recorded on these pages. We will use the example of a ten-wheel tractor which is normally used with an eight-wheel semi-trailer to deliver building supplies:

Trip 1 Loaded tractor-trailer goes from warehouse to first delivery site, a new residential development under construction.

Trip 2 Empty tractor-trailer returns to warehouse to drop off for re-loading.

Trip 3 Tractor only goes to truck stop (transportation land use) to be refueled.

Trip 4 Tractor goes to restaurant (retail land use); driver has lunch.

Trip 5 Tractor returns to warehouse to pick up loaded trailer.

Trip 6 Loaded tractor-trailer goes from warehouse to second delivery site, where a hospital is being expanded.

Trip 7 Empty tractor-trailer returns to warehouse where it is parked overnight.

Figure 9.1 Sample Commercial Vehicle Survey Travel Diary Package from Phoenix (continued)

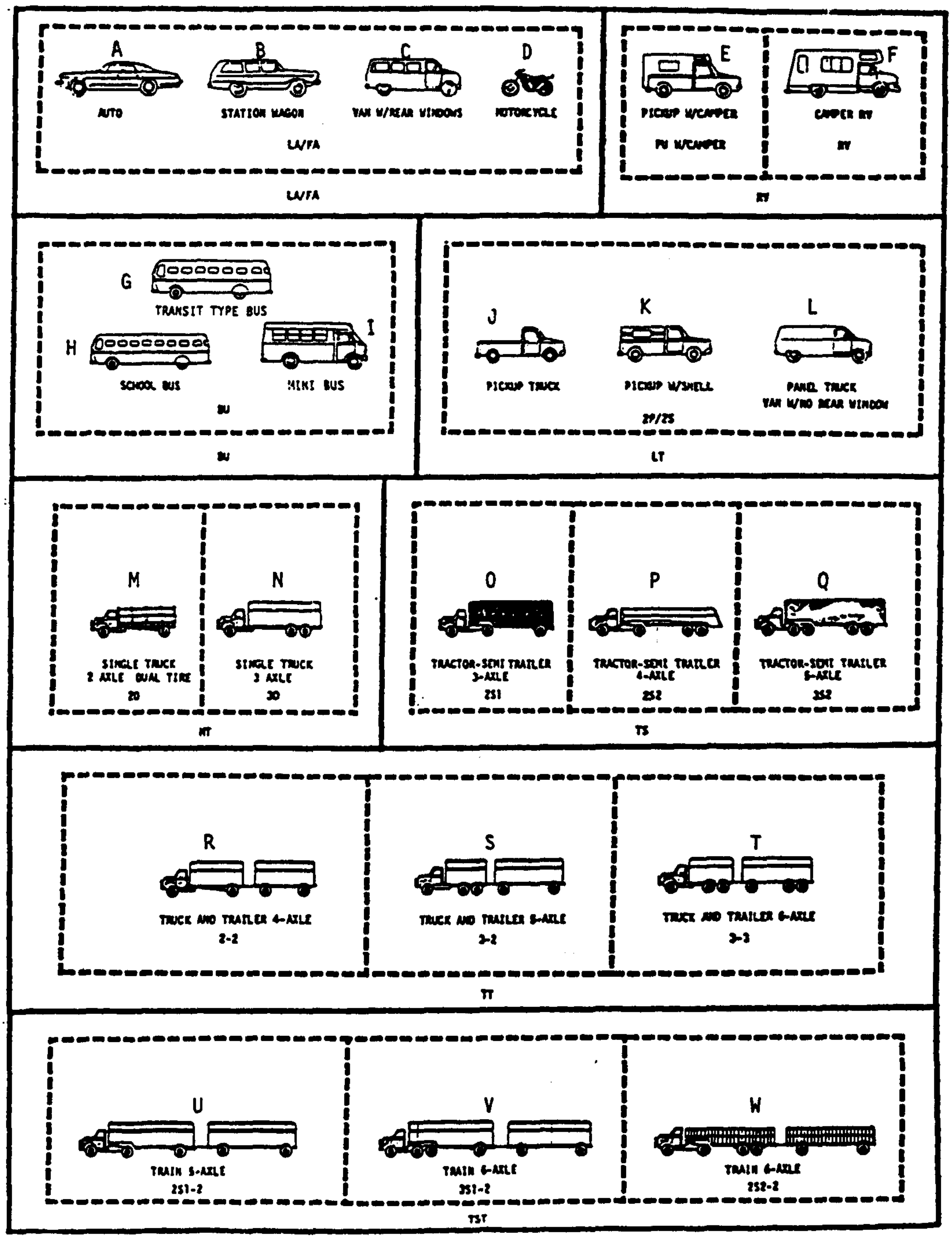

Figure 9.1 Sample Commercial Vehicle Survey Travel Diary Package from Phoenix (continued)

Start time: _____ :__ A.M./P.M.
Start Odometer: __________

TRAVEL DIARY

Please record each trip in the order you make it.

Trip #	Start Time (circle A.M./P.M.)	Stop Time	Stop Odometer	Name & Address of stop Please give EXACT street address, St. vs Ave., etc.	Zipcode of stop	Activity at stop See below.	Stop ON or OFF street	Land Use at stop See below.	Vehicle Type See below.	Total # axles
EXAMPLE TRIP: (TRIP #5 IN PREVIOUS EXAMPLE)										
5	12:45 AM PM	1:15 AM PM	5082.3	1345 N. 10th Street / Warehouse #2, Phoenix	85014	1	ON OFF	3	4	3
1.	AM PM	AM PM					ON OFF			
2.	AM PM	AM PM					ON OFF			
3.	AM PM	AM PM					ON OFF			
4.	AM PM	AM PM					ON OFF			
5.	AM PM	AM PM					ON OFF			
6.	AM PM	AM PM					ON OFF			
7.	AM PM	AM PM					ON OFF			
8.	AM PM	AM PM					ON OFF			
9.	AM PM	AM PM					ON OFF			
10.	AM PM	AM PM					ON OFF			

If your vehicle made more than 10 trips during the day, write in the total number of trips here: __________

Write in your final odometer reading here: __________

What was your final stop address? __________

ACTIVITY AT STOP
1. Pick up, Load
2. Drop off, Unload
3. Load & Unload
4. Service call
5. Gas up vehicle
6. Meal/Other personal

LAND USE AT STOP
1. Residential
2. Retail
3. Manufacturing, Warehousing, etc.
4. Transportation
5. Utilities
6. Communications
7. Hospitals
8. Public/Government
9. Office/Services
10. Other (write in)

VEHICLE TYPE
1. Straight Truck
2. Tractor/semitrailer
3. Tractor/Trailer
4. Bobtail
5. Commercial Auto

At the end of the travel day for this vehicle, please fold and return the Vehicle Trip Record by mail. Postage is paid.

Please return to:

O'NEIL ASSOCIATES, INC.
412 East Southern Avenue
Tempe, AZ 85282

Figure 9.2 Sample Commercial Vehicle Survey Trip Record Forms from Chicago

CATS

CHICAGO AREA TRANSPORTATION STUDY
ILLINOIS DEPARTMENT OF TRANSPORTATION

300 WEST ADAMS STREET CHICAGO, ILLINOIS 60606
TELEPHONE: 793-3464

1986
COMMERCIAL VEHICLE SURVEY
Vehicle Trip Record

THIS TRIP RECORD WILL ACCOMPANY THE ABOVE VEHICLE FOR A PERIOD OF 24 HOURS BEGINNING AT 12:01 AM ON TUESDAY, FEBRUARY 25, 1986.

CONFIDENTIAL
The information obtained from this study will be afforded complete confidentiality, and will be used for statistical/analytical purposes only.

A PERSONAL MESSAGE TO THE DRIVER, OR DRIVERS

YOUR CHANCE TO GIVE US YOUR TWO CENTS WORTH

Please take a minute to read this and to look through the Trip Record before starting out. We need your help but we don't want it to be difficult for you.

About CATS

The Chicago Area Transportation Study (CATS) is a governmental agency that does transportation planning for Northeast Illinois. It does studies of transportation and travel activity, including trucks and buses. CATS also maintains computer programs to project future traffic conditions.

CATS produces two main work items, which are (1) Long Range Transportation Plans (5-year and 20 year projections) and (2) the Transportation Improvement Program, which is a yearly program of specific scheduled improvements such as road surfacing and widening, signalling improvements, grade crossings and separations, etc.

About This Study

This Trip Record will give CATS a "Day in the Life" look at the region's truck fleet - what it does and where it goes. Your help, in filling out the Record, and the information we get from it, will be unobtainable any other way. Please keep a record of the workday of Tuesday, February 25, 1986.

NOTE: If the weather on that day is so bad that the vehicle will be unable to complete a full and normal workday, then please keep the Trip Record on another day later in the same week.

About The Results

All information collected from the Survey will be treated in the strictest confidence. Note that we are only interested in the TRUCK. We will only use the results for CATS' planning work. The information will help us in putting together future Transportation Improvement Programs.

The Commercial Vehicle Survey has been endorsed by the Illinois Trucking Association, and by the Chicago Association of Commerce and Industry.

In expectation of getting your help, I thank you.

YOU COUNT TO US. CAN WE COUNT YOU (IN)?

Yours appreciatively,

F. Gerald Rawling
Chief Freight Planner

We want to give you an idea of what we consider to be a trip, or trips, for the record. We will use an example of a school bus:

TRIP 1: Bus goes from garage to starting point of scheduled route
TRIP 2: Bus goes to grade school at end of route
TRIP 3: Bus goes to high school (pick up party)
TRIP 4: Bus goes to museum
TRIP 5: Bus goes to holding area. Driver has lunch
TRIP 6: Bus goes back to museum
TRIP 7: Bus returns party to high school
TRIP 8: Bus goes to grade school
TRIP 9: Bus works scheduled route (end point ought to be the same as the end point of TRIP 1)
TRIP 10: Bus goes to garage. END OF RECORD

LICENSE PLATE NUMBER: ____________
(This will confirm that the Trip Record is on the vehicle for which it is intended)

If the vehicle's normal work is being conducted by another (that is, different) vehicle, then please send the book out with the substitute vehicle.

LICENSE PLATE OF OTHER VEHICLE: ____________

IF THE LICENSE PLATE HAS RECENTLY BEEN CHANGED, ENTER NEW PLATE NUMBER HERE: ____________

STARTING ADDRESS (12:01 AM, FEBRUARY 25, 1986): ____________

AT MIDNIGHT, THIS VEHICLE WAS (Check which applies):

- ☐ PARKED ON STREET
- ☐ PARKED ON COMPANY PROPERTY OR IN COMPANY GARAGE
- ☐ PARKED ON PERSONAL PROPERTY OR IN PERSONAL GARAGE
- ☐ IN TRANSIT (That is, at work)
- ☐ OUT OF STATE

IF THE VEHICLE WILL NOT WORK ON FEBRUARY 25, 1986 BECAUSE THERE IS NO WORK FOR IT, CHECK THIS BOX ☐

IF THE VEHICLE WILL NOT WORK ON FEBRUARY 25, 1986 BECAUSE IT IS NOT OPERATIONAL (For sale; in for service etc.) Check this box ☐

NOTE: This may take you back to the top of the page to enter the plate number of a substitute vehicle.

CONTACT PERSON FOR CATS TO FOLLOW UP WITH:

NAME: ____________

TELEPHONE: ____________

Figure 9.2 Sample Commercial Vehicle Survey Trip Record Forms from Chicago (continued)

START TIME:

START ODOMETER READING:

		TRIP 1	TRIP 2	TRIP 3	TRIP 4	TRIP 5	TRIP 6	TRIP 7	TRIP 8
STOP TIME									
STOP ODOMETER									
STOP	ON-STREET	☐	☐	☐	☐	☐	☐	☐	☐
	OFF-STREET	☐	☐	☐	☐	☐	☐	☐	☐
ACTIVITY AT STOP (Check one)									
	Pick up, Load	☐	☐	☐	☐	☐	☐	☐	☐
	Drop off, Unload	☐	☐	☐	☐	☐	☐	☐	☐
	Load and Unload	☐	☐	☐	☐	☐	☐	☐	☐
	Gas Up Vehicle	☐	☐	☐	☐	☐	☐	☐	☐
	Meal or other personal	☐	☐	☐	☐	☐	☐	☐	☐
LAND USE AT STOP (Check one)									
	Residential	☐	☐	☐	☐	☐	☐	☐	☐
	Retail	☐	☐	☐	☐	☐	☐	☐	☐
	Manufacturing	☐	☐	☐	☐	☐	☐	☐	☐
	Transportation/Utilities/ Communications/Warehousing, including Wholesale	☐	☐	☐	☐	☐	☐	☐	☐
	Public & Government, incl. Museums, Schools, Libraries	☐	☐	☐	☐	☐	☐	☐	☐
	Office & Services, incl. Finance Real Estate, Insurance, Hospitals	☐	☐	☐	☐	☐	☐	☐	☐
	Other (Write In)								
TRUCK TYPE (Check one)									
	Straight Truck	☐	☐	☐	☐	☐	☐	☐	☐
	Tractor + Semitrailer	☐	☐	☐	☐	☐	☐	☐	☐
	Tractor + Trailer	☐	☐	☐	☐	☐	☐	☐	☐
	Bobtail	☐	☐	☐	☐	☐	☐	☐	☐

TRIP	NAME AND ADDRESS OF STOP (Please Include Zip Code)
1	
2	
3	
4	
5	
6	
7	
8	

Figure 9.2 Sample Commercial Vehicle Survey Trip Record Forms from Chicago (continued)

START TIME:.

START ODOMETER READING:

	TRIP 9	TRIP 10
STOP TIME		
STOP ODOMETER		
STOP ON-STREET	☐	☐
STOP OFF-STREET	☐	☐
ACTIVITY AT STOP (Check one)		
Pick up, Load	☐	☐
Drop off, Unload	☐	☐
Load and Unload	☐	☐
Gas Up Vehicle	☐	☐
Meal or other personal	☐	☐
LAND USE AT STOP (Check one)		
Residential	☐	☐
Retail	☐	☐
Manufacturing	☐	☐
Transportation/Utilities/ Communications/Warehousing, including Wholesale	☐	☐
Public & Government, incl. Museums, Schools, Libraries	☐	☐
Office & Services, incl. Finance Real Estate, Insurance, Hospitals	☐	☐
Other (Write in)		
TRUCK TYPE (Check one)		
Straight Truck	☐	☐
Tractor + Semitrailer	☐	☐
Tractor + Trailer	☐	☐
Bobtail	☐	☐

TRIP	NAME AND ADDRESS OF STOP (Please Include Zip Code)
9	
10	

IF THE VEHICLE MAKES MORE THAN 10 TRIPS FOR THE DAY, WRITE IN THE TOTAL NUMBER OF TRIPS HERE:

FINAL STOP ADDRESS

FINAL ODOMETER READING:

WHAT IS THE MOST COMMON COMMODITY THAT THIS VEHICLE HAULS?

THANK YOU FOR TAKING PART IN THIS IMPORTANT STUDY OF COMMERCIAL VEHICLE ACTIVITY.

IN THE SPACE PROVIDED, WHICH FOLLOWS, PLEASE TAKE THE OPPORTUNITY TO MAKE COMMENTS.

Figure 9.3 Sample Commercial Vehicle Survey Forms from Houston-Galveston

HGAC

COMMERCIAL PASSENGER CARRIER CONTROL FORM

Telephone Number

Company Name: ______________________

Address: ______________________

Attention: ______________________

License Plate Number

Screening Call

Respondent Name

Call	Date	Time	Int	Result
1				
2				
3				

First Follow-Up (Day Before Survey)

Respondent Name

Call	Date	Time	Int	Result
1				
2				
3				

Second Follow-Up (Day Before Survey)

Respondent Name

Call	Date	Time	Int	Result
1				
2				
3				

Responses

1. Willing to Participate? ☐ Yes ☐ No — Comments

Responses 1st Follow-Up

1. Was questionnaire received? ☐ Yes ☐ No — Comments
2. Was a second survey mailed? ☐ Yes ☐ No

Responses 2nd Follow-Up

1. Was questionnaire mailed back? ☐ Yes ☐ No — Comments

Result Codes:

01 - Terminated	03 - Over Quota	06 - Call Back	09 - Disconnected	12 - Not Qualified
02 - Refusal	04 - Completed	07 - Busy Signal	10 - Business/Gov't	13 - Spanish
	05 - No Answer	08 - Ans. Machine	11 - Deaf/Language	

Figure 9.3 Sample Commercial Vehicle Survey Forms from Houston-Galveston (continued)

HGAC

Houston-Galveston Area Council

Office of the Executive Director

PO Box 22777 • 3555 Timmons • Houston, Texas 77227-2777 • 713/627-3200

Dear Commercial Vehicle Survey Participant:

Thank you for agreeing to participate in the Houston-Galveston area one-day travel survey. The Houston-Galveston Area Council, assisted by Wilbur Smith Associates, is conducting this survey to help plan for future transportation needs in our area. Your vehicle(s) was randomly selected in the sample of commercial vehicles registered in the Houston-Galveston area, and we need your assistance.

We are enclosing a copy of the one-day travel survey form for your or your truck driver's use in identifying trip information. We would like the truck driver to complete the form for all travel performed by the selected vehicle on the designated date. It is really quite simple and will assist us in studying the way commercial vehicles get around the Houston-Galveston area.

It is important that you complete and return this form even if no trips were made in the Houston-Galveston area on the selected date, as we need to know this information to estimate overall travel characteristics. Please note that this information will be treated confidentially, and will only be used in summary form.

Your cooperation and assistance in providing information for this important survey is greatly appreciated. If you have any questions, please call Wayne Holcombe at 465-7800. Thank you.

Sincerely,

Jack Steele

Figure 9.3 Sample Commercial Vehicle Survey Forms from Houston-Galveston (continued)

COMMERCIAL PASSENGER CARRIER SURVE

ATTENTION PASSENGER CARRIER DRIVER!

Here is your chance to participate in decisions about highway and transportation improvements ir the Houston-Galveston area. Roadway modifications will be based upon your survey answers. This survey applies to every trip made in your passenger carrier on the designated travel day.

Thank you for your participation!

PART 1 VEHICLE INFORMATION

1) Record Type: 23

2) Day of Travel: ______________ (Month) ______________ (Day)

3) Company Name: ______________________________

4) Address: ______________________________

OFFICE USE ONLY:
5) Census Tract Number: __________ 6) Traffic Serial Zone Number: __________

7) License Plate Number: ______________

8) Make of Vehicle: ______________ 9) Model of Vehicle: ______________

10) Vehicle Year: ______________

11) Vehicle Fuel Type:
- ☐ 1. Unleaded Gasoline
- ☐ 2. Unleaded Gasoline
- ☐ 3. Diesel
- ☐ 4. Propane
- ☐ 5. Compressed Natrual Gas
- ☐ 6. Other ______________ (Specify)

12) Maximum number of passengers vehicle can carry: ______________

The next part of the survey asks that you record the following information after each trip made by this passenger carrier vehicle on the designated travel day. A trip is any time the vehicle stops and you or someone else gets into or out of the vehicle.

Figure 9.3 Sample Commercial Vehicle Survey Forms from Houston-Galveston (continued)

COMMERCIAL PASSENGER CARRIER SURVEY

OFFICE USE ONLY
Record Type: 24
License Plate:

PART 2
TRIP DIARY

00 My Trip Began At:
Location:
Place, Address, or nearest intersection, City/State/ZIP

OFFICE USE ONLY | CENSUS TRACT | ZONE NUMBER
Odometer Reading
Departure Time am pm
Number of Passengers

Please indicate the purpose of the trip:
- ☐ 1. Base Location / Return to Base Location
- ☐ 2. Delivery
- ☐ 3. Pick-Up
- ☐ 4. Vehicle Maintenance (fuel, oil, etc.)
- ☐ 5. Driver Needs (lunch, etc.)
- ☐ 6. Other ______

Please describe this location:
- ☐ 1. Residential
- ☐ 2. Educational
- ☐ 3. Industrial
- ☐ 4. Government
- ☐ 5. Medical
- ☐ 6. Office
- ☐ 7. Retail
- ☐ 8. Other ______

01 Then I Went To:
Location:
Place, Address, or nearest intersection, City/State/ZIP

OFFICE USE ONLY | CENSUS TRACT | ZONE NUMBER
Odometer Reading
Arrival Time am pm
Departure Time am pm
Number of Passengers

Please indicate the purpose of the trip:
- ☐ 1. Base Location / Return to Base Location
- ☐ 2. Delivery
- ☐ 3. Pick-Up
- ☐ 4. Vehicle Maintenance (fuel, oil, etc.)
- ☐ 5. Driver Needs (lunch, etc.)
- ☐ 6. Other ______

Please describe this location:
- ☐ 1. Residential
- ☐ 2. Educational
- ☐ 3. Industrial
- ☐ 4. Government
- ☐ 5. Medical
- ☐ 6. Office
- ☐ 7. Retail
- ☐ 8. Other ______

02 Then I Went To:
Location:
Place, Address, or nearest intersection, City/State/ZIP

OFFICE USE ONLY | CENSUS TRACT | ZONE NUMBER
Odometer Reading
Arrival Time am pm
Departure Time am pm
Number of Passengers

Please indicate the purpose of the trip:
- ☐ 1. Base Location / Return to Base Location
- ☐ 2. Delivery
- ☐ 3. Pick-Up
- ☐ 4. Vehicle Maintenance (fuel, oil, etc.)
- ☐ 5. Driver Needs (lunch, etc.)
- ☐ 6. Other ______

Please describe this location:
- ☐ 1. Residential
- ☐ 2. Educational
- ☐ 3. Industrial
- ☐ 4. Government
- ☐ 5. Medical
- ☐ 6. Office
- ☐ 7. Retail
- ☐ 8. Other ______

03 Then I Went To:
Location:
Place, Address, or nearest intersection, City/State/ZIP

OFFICE USE ONLY | CENSUS TRACT | ZONE NUMBER
Odometer Reading
Arrival Time am pm
Departure Time am pm
Number of Passengers

Please indicate the purpose of the trip:
- ☐ 1. Base Location / Return to Base Location
- ☐ 2. Delivery
- ☐ 3. Pick-Up
- ☐ 4. Vehicle Maintenance (fuel, oil, etc.)
- ☐ 5. Driver Needs (lunch, etc.)
- ☐ 6. Other ______

Please describe this location:
- ☐ 1. Residential
- ☐ 2. Educational
- ☐ 3. Industrial
- ☐ 4. Government
- ☐ 5. Medical
- ☐ 6. Office
- ☐ 7. Retail
- ☐ 8. Other ______

04 Then I Went To:
Location:
Place, Address, or nearest intersection, City/State/ZIP

OFFICE USE ONLY | CENSUS TRACT | ZONE NUMBER
Odometer Reading
Arrival Time am pm
Departure Time am pm
Number of Passengers

Please indicate the purpose of the trip:
- ☐ 1. Base Location / Return to Base Location
- ☐ 2. Delivery
- ☐ 3. Pick-Up
- ☐ 4. Vehicle Maintenance (fuel, oil, etc.)
- ☐ 5. Driver Needs (lunch, etc.)
- ☐ 6. Other ______

Please describe this location:
- ☐ 1. Residential
- ☐ 2. Educational
- ☐ 3. Industrial
- ☐ 4. Government
- ☐ 5. Medical
- ☐ 6. Office
- ☐ 7. Retail
- ☐ 8. Other ______

05 Then I Went To:
Location:
Place, Address, or nearest intersection, City/State/ZIP

OFFICE USE ONLY | CENSUS TRACT | ZONE NUMBER
Odometer Reading
Arrival Time am pm
Departure Time am pm
Number of Passengers

Please indicate the purpose of the trip:
- ☐ 1. Base Location / Return to Base Location
- ☐ 2. Delivery
- ☐ 3. Pick-Up
- ☐ 4. Vehicle Maintenance (fuel, oil, etc.)
- ☐ 5. Driver Needs (lunch, etc.)
- ☐ ______

Please describe this location:
- ☐ 1. Residential
- ☐ 2. Educational
- ☐ 3. Industrial
- ☐ 4. Government
- ☐ 5. Medical
- ☐ 6. Office
- ☐ 7. Retail
- ☐ 8. Other

Figure 9.4 National Truck Trip Information Survey Power Unit Description and Survey of Day Trips

State __ __ (1, 2)   Selection No. __ __ __ (3, 4, 5)   Date Code __ __ (6, 7)

NTTIS COMPANY & POWER UNIT DESCRIPTION

COMPANY DESCRIPTION

OPERATING AUTHORITY:

Is this a daily rental truck? YES [ ]7
Is this truck govt. owned? YES [ ]6
(city/county/state/federal) 8

→ *SKIP to Power Unit Description below.*

Do any of your trucks ever carry goods interstate (across state lines)?

[ ]1 YES → Are you
- PRIVATE [ ]1 → [ ]1
  (Carry own goods)
- FOR HIRE [ ]2 → ICC Authorized [ ]2 (common/contract); Exempt [ ]3 → Is the owner also the driver? YES [ ]1 NO [ ]2
  (Carry other people's goods)

[ ]2 NO → Are you
- PRIVATE [ ]1 → [ ]4
  (Carry own goods)
- FOR HIRE [ ]2 → [ ]5 (11) → Is the owner also the driver? YES [ ]1 NO [ ]2
  (Carry other people's goods)

[ ]9 UNKNOWN (9) →
- PRIVATE [ ]1
- FOR HIRE [ ]2 (10) → Is the owner also the driver? YES [ ]1 NO [ ]2 (12)

POWER UNIT DESCRIPTION

Verify the make, model year, and VIN, and ask for the model name and company unit number.

1. Make __________ Year: 19__ __ VIN __________
2. Model Name __________ Company Unit Number __________
3. *EDITOR:* Code the base state of operation __ __ (13, 14)
4. POWER UNIT TYPE
   - Tractor [ ]8
   - Straight Truck [ ]1 (15)

   STRAIGHT TRUCK BODY STYLE:
   - Van [ ]1
   - Flatbed [ ]2
   - Tanker [ ]3
   - Refrig. [ ]5
   - Dump [ ]6
   - Refuse [ ]7
   - Other [ ]8 (16)

   __________ *(Specify)*
5. NUMBER OF AXLES
   - Two [ ]2
   - Three [ ]3
   - Four + [ ]4 (17)
6. CAB STYLE
   - Cab Forward [ ]1
   - Cab Over [ ]2
   - Short Conventional [ ]3
   - Med. Conventional [ ]4
   - Long Conventional [ ]5 (18)
7. FUEL
   - Gas [ ]1
   - Diesel [ ]2
   - Other ________ [ ]3 (19)
     (Specify)
8. Power Unit EMPTY WEIGHT: __ __ __ __ __ __ (20, 21, 22, 23, 24, 25)
9. Power Unit LENGTH: __ __ __ (26, 27, 28)
10. Estimated Annual Mileage *for this power unit:* __ __ __ __ __ __ (29, 30, 31, 32, 33, 34)
11. Percent of annual mileage for each trip type *for this power unit:*
    - Local *(Pickup and delivery, with 50 mile radius)* __ __ __% (35, 36, 37)
    - Short Haul *(Intercity, one-way, distance 50-200 miles)* __ __ __% (38, 39, 40)
    - Long Haul *(Intercity, one-way, distance 200+ miles)* __ __ __% (41, 42, 43)

    (Total=100%)
12. Does this power unit ever pull twin trailers?
    - [ ] Yes   Percent of annual mileage with twin trailers: __ __ __% (44, 45, 46)
    - [ ] No   *(Enter 000.)*

Figure 9.4 National Truck Trip Information Survey Power Unit Description and Survey of Day Trips (continued)

Selection No. ___ ___ ___ ___ Date Code ___ ___ Quarter ___ Survey Date ___ ___/___ ___/___ ___

NTTIS SURVEY DAY TRIPS

TRIP ___ ___

VEHICLE, CARGO, AND DRIVER

1. OPERATING AUTHORITY (Private Carriers only)
   Were you operating for-hire (e.g., on backhaul)?
   [ ]1 No
   [ ]2 Yes Was it as? ICC (common/contract) [ ]2
   Exempt (interstate hauling only) [ ]3
   Intrastate for-hire [ ]5

2. DRIVER AGE: ____ Yrs. 3. DRIVER YEARS WITH COMPANY: ____ Yrs.

4. CONFIGURATION: Any trailers? No [ ]1 Yes [ ]2

	Power Unit	1st Trailer	2nd Trailer	3rd Trailer
Type:		Semi [ ]1		
		Full [ ]2	Full [ ]2	Full [ ]2
		Utility [ ]3	Utility [ ]3	Utility [ ]3
		Other [ ]4	Other [ ]4	Other [ ]4
		None [ ]5	None [ ]5	None [ ]5
Body:		Van [ ]1	Van [ ]1	Van [ ]1
		Flatbed [ ]2	Flatbed [ ]2	Flatbed [ ]2
		Tank [ ]3	Tank [ ]3	Tank [ ]3
		Auto C. [ ]4	Auto C. [ ]4	Auto C. [ ]4
		Dump [ ]6	Dump [ ]6	Dump [ ]6
		Other [ ]8	Other [ ]8	Other [ ]8
		(Specify)	(Specify)	(Specify)
No. Axles Used:	____	____	____	____
Lengths (Ft):	____	____	____	____
Empty Wts (Lbs):		____	____	____

5. CARGO:

	Power Unit	1st Trailer	2nd Trailer	3rd Trailer
CARGO:	____ [ ]	____ [ ]	____ [ ]	____ [ ]
Cargo Wt (Lbs):	____	____	____	____
Hazardous Cargo	Yes [ ]1 No [ ]2	Yes [ ]1 No [ ]2	Yes [ ]1 No [ ]2	Yes [ ]1 No [ ]2

6. GROSS COMBINATION WEIGHT for the trip (Lbs): ____________ [1]

MILEAGE

1. Starting Point ____________ (City) ________ (State) Time: ________ AM[ ] PM[ ]
2. End Point ____________ (City) ________ (State) Time: ________ AM[ ] PM[ ]
3. Via ____
   (Describe route/give road nos., etc.)
   ____
4. Total Miles for Trip: ____________
5. Breakdown of Mileage:

	LIMITED ACCESS		US/STATE/MAJOR ARTERY		OTHER	
	Day (6am-9pm)	Night (9pm-6am)	Day (6am-9pm)	Night (9pm-6am)	Day (6am-9pm)	Night (9pm-6am)
Rural:	14-17	18-21	22-25	26-29	30-33	34-37
Sm Urban: (Pink & Orange)	38-41	42-45	46-49	50-53	54-57	58-61
Lg Urban: (Yellow)	62-65	66-69	70-73	74-77	78-81	82-85

6. Specific Large Urban Area: ___ ___ [1]

(Over)

■ 9.7 Training and Interviewing

Similar methods for survey training described in other chapters of this manual can be used to train and brief the surveyor (telephone interviewer) staff designated to conduct the commercial vehicle survey in the field. For example, the training methods described for the household travel survey can be used for the telephone interview approach described in this chapter. In addition, the training methods for the *Roadside Handout Survey* described in Chapter 7.0 and the workplace and establishment surveys in Chapter 10.0 are very similar to the self-administered (mail-back) survey described in this chapter.

Interviewer and surveyor courtesy and persuasiveness in getting cooperation from employers and owners is essential to the successful completion of the commercial vehicle survey. Identifying the 'path' from the initial business/employer contact to the appropriate decision maker who will agree to participate and permit the survey to continue is also essential. This 'path' also provides the reliable link between the employer and vehicle operator.

In most cases, survey training is conducted prior to the pretest and the implementation of the overall survey with all participating surveyors and interviewers. The training session is typically conducted several days before the scheduled pretest and overall survey dates. Surveyors are briefed on the purpose and procedures on how to conduct the survey. Items generally covered by survey administrators include:

- Project briefing describing the background and purpose of the survey and a description of survey assignments for all surveyors;
- Demonstrations of the procedures of the survey administration describing surveyor/interviewer responsibilities for distributing questionnaires, survey schedules, etc.; and
- Survey procedures checklist provided to the surveyors and/or interviewers during the initial briefing session, including authorization letters and background material.

In commercial vehicle surveys designed for administration at Truck Center and Weigh Station locations, it is important for the survey administrator to coordinate with the surveyors to ensure that they have been distributed all of the necessary survey materials required to successfully carry out the survey. These survey materials may include:

- Survey forms;
- Record keeping forms;

- Writing instruments; and
- An authorization letter describing the intent of the survey and the request for survey participation.

The survey administrators must also provide additional instructions to the surveyors about the distribution of forms to dispatchers and employers, as appropriate. If the survey questionnaires have serial numbers, surveyors will be able to track the Truck Center/Weigh Station, and employer locations and times of survey distribution.

Variations of interviewing procedures can be used depending on the survey method selected and the sample of commercial vehicles to be surveyed. Also, survey notices should be distributed among businesses/ employers and Truck Centers/Weigh Stations according to the survey method chosen.

9.8 Coding

Commercial vehicle survey coding is conducted using similar procedures used for other surveys described in this manual. Similar techniques are used to code both the self-administered (mail-back) and telephone interview surveys. The survey questionnaires are typically designed to be self-coding (except for the origin-destination information), where each survey response can be coded to correspond to its answer check box number. Data coding can either be completed manually by the surveyors conducting the telephone interviews, by CATI, or by vehicle operators completing the self-administered survey.

Typically, as with other surveys, data are punched into a numerical ASCII data block for a specified width and length as determined by the number of questions/responses and sample size of the survey. Individual survey questionnaire responses are typically given an identification number to track the responses for each business/employer and vehicle operator surveyed. Survey origins and destinations must be geocoded to identify the geographic locations of the commercial vehicle trips surveyed. Chapter 14.0 provides a detailed discussion of survey geocoding techniques.

■ 9.9 Cleaning and Editing

Similar data cleaning and editing techniques used for other surveys described in this manual are also conducted for the commercial vehicle survey. As stated in previous chapters, completed questionnaires should be edited as soon after collection as possible to ensure that the proper surveyor techniques have been used and the appropriate information has been obtained. Range checks should be conducted to identify any data inconsistencies that may occur in the coding process and to verify the accuracy of the data.

10.0 Workplace and Establishment Surveys

Workplace and establishment surveys are conducted to collect data on the characteristics of trips made to non-residential establishments. The people who go to non-residential, or commercial, establishments can be divided roughly into two classes: workers and visitors. An establishment survey may be directed toward either or both groups, or may concentrate on a specific type of establishment, e.g., shopping center, school, hospital, etc. Many types of analyses, especially those related to studying rezoning, traffic impacts, congestion management, and trip reduction programs, require information on the number and types of trips attracted to various facilities.

The most exacting collection procedures belong to the workplace survey specifically designed for obtaining data needed for the calibration of the trip attraction models. In model development, the trip attraction data are used to help balance the production data collected during a household travel/activity survey, and to provide more detailed origin-destination data for specific types of facilities or for specific geographic locations. Attraction rates, such as person trips per employee by industry type, are commonly sought. Using secondary sources of data, such as State Employment Commission establishment data, it is possible to apply the survey-derived attraction rates to make small area estimates of trip attractions for home-based work trips, home-based non-work trips, and non-home-based trips.

In the past, trip attraction data were obtained from household travel surveys, external vehicle surveys, and commercial vehicle surveys. However, as the focus of household surveys shifted from providing zone-to-zone trip tables (requiring large sample sizes) to providing travel model input data with acceptable precision levels (requiring smaller sample sizes), the trip attraction data became inadequate in many cases. The sampling variability of trip attraction rates based upon small sample household travel surveys is enormous. Providing estimates of home-based work attractions from a household survey requires aggregation across the entire planning region, which masks any variability by geographic location. If, for instance, one wishes to estimate hospital trip generation, it is more helpful to count the arriving trips at a sample of hospitals, rather than estimating the trips to all hospitals in the region by a small sample of households.

In the mid-1980s, planning agencies began to obtain workplace and establishment survey data as part of their regional modeling data collection efforts. Since that time, the increased interest in employer-based TDM measures has led to the implementation of several other workplace and establishment surveys throughout the country.

The workplace/establishment survey can incorporate up to five separate data collection efforts for each sampled workplace:

- Collection of employer information;
- Survey of employees;
- Survey of visitors;
- Person and/or vehicle count; and
- Survey and count of delivery people and/or a count of delivery vehicles.

■ 10.1 Assembly of Background Data

Two types of background information are typically assembled for workplace and establishment surveys:

- Data on employers in the study area; and
- Available information on people's journeys-to-work.

The key information needed for the design and implementation of workplace/establishment surveys is a comprehensive inventory of establishments within the study area. The survey team needs to develop a database that contains the name, address, and key characteristics of each establishment, such as:

- Number of employees at each site;
- Type of business (usually based on Standard Industry Classification (SIC) codes);
- Type of area that the establishment is in (employment density classes or a standard agency classification);
- Name of manager to contact in seeking permission to conduct the survey; and
- Name of manager to work with in implementing the survey.

The primary use of the database is as the sampling frame for the survey; the establishment characteristics that are needed for a particular survey effort will depend on the survey team's data needs.

- Commercial firms, such as Dun & Bradstreet Information Services, and American Business Information, maintain files of commercial establishments primarily for purposes such as providing data on the credit worthiness of firms and to provide marketing prospects for clients. Some commercial database vendors attempt to maintain establishment databases that contain a great deal of business information for each establishment within a region. For instance, the Dun & Bradstreet database can provide more than 50 data items about each establishment, including:

  - Company name;
  - Trade name;
  - Street address and mailing address;
  - Telephone number;
  - Total employees;
  - Employees on-site;
  - Names of key staff;
  - Year business was started;
  - Line of business;
  - Up to six SIC codes;
  - Number of employees three years ago; and
  - Number of employees five years ago.

  Dun & Bradstreet updates the establishment database on a continuous basis. The database generally provides a fairly comprehensive listing for larger employers, but is not as reliable for a full listing of small employers because the lifespan of small businesses can be short, and because these businesses are harder to locate. The accuracy of the location of the site and the number of employees must always be verified.

- Each state collects employment and wages data from most establishments for the purposes of administering unemployment insurance. In addition, the states and the federal government maintain current employment data for measuring labor force participation and unemployment. Some state employment divisions will share with planners disaggregate employment data (employment information on an establishment-by-establishment basis) provided that confidentiality considerations are addressed. These state employment databases include the Federal Identification Number, the SIC code, the number of employees, and an address, usually keyed to where the payroll is prepared. The address must be carefully verified along with the number of employees, since franchises and branch offices are often combined in a listing under one main office. In addition, up to half of the employers list post office boxes as the address of record. Provided that establishment data are available from state sources, these files are usually available to a planning agency or survey team free of charge.

- The Polk Directory is available through many libraries, and offers a rather comprehensive listing of household and employment data sorted by name and address. For business establishments, the address, owner's name, telephone number, and type of business – including listings for associations, libraries, and organizations which may not be available from state sources – can be determined.

- The telephone directory, which lists the businesses in the area by street address, is a rich source of data because most businesses are listed. However, no information on type of industry or number of employees is available through telephone directories; these data would need to be developed by the survey team.

Since the data sources have been compiled for different reasons, none is totally accurate or comprehensive for use in travel surveys. The survey team needs to evaluate the costs and benefits of each data source before selecting the best sampling frame inputs.

Often, a multiple-source data system will provide the survey team with a comprehensive and reliable database which can also be regularly updated. Sometimes, survey teams use State Employment Commission data as a base, and then verify the address and number of employees with the Dun & Bradstreet file for the same area. Telephone calls can be made to settle any differences in data between the two sources, and to verify certain data.

Once the employer database has complete data for the base year, updates can be made by simply using updated state data and matching the Federal Identification Number to update the number of employees. Non-matches in the original file are establishments that have gone out of business, and non-matches in the new state file are new businesses (which must be verified as to location and number of employees).

If the survey team has the capability to store the establishment data in a GIS database, then the verification and updating of information is greatly facilitated. In addition, this data format allows survey team members and agency staff to conduct field checks of establishments to ensure that the database matches actual conditions.

In addition to assembling the establishment data, the survey team will usually benefit from analyzing the Census Journey-to-Work data. These data will help define the likely range of responses to survey questions at given locations. For instance, the Census data will tell the survey team whether transit is a viable access mode for a particular location. The survey team can then customize response categories to reflect this infor-mation. The Journey-to-Work data can also help verify the data on the number of employees at establishments within counties, county sub-divisions, and traffic analysis zones. The Census Journey-to-Work data are discussed briefly in Appendix B.

■ 10.2 Survey Design

The survey team faces several survey design issues with regard to workplace and establishment surveys, including:

- What is the relevant survey population, employees and visitors or employees only?
- What survey method(s) should be used?
- Given the chosen survey method, what data collection techniques should be employed?
- What accuracy-enhancing (bias-reducing) measures should be used?

These four issues are described below.

Survey Population

Based on the survey data needs, the survey team must determine the relevant population for the workplace and establishment survey. For most modeling analyses, survey teams will be interested in obtaining information about trips to and from the establishment, regardless of whether they are made by employees or visitors to the establishment. This information is needed for developing trip attraction rates. However, for some analyses, especially those related to potential employer-based transportation demand management (TDM) measures, the most appropriate survey population includes only on-site employees. This decision about the survey population guides the selection of survey methods and techniques, and the organization and fielding of the survey.

A second survey population decision for the survey team that is interested in collecting both employee and visitor information is the determination of how commercial trips and freight movements to and from the site should be considered. Sometimes, if the workplace survey is being conducted in conjunction with a commercial vehicle survey, it is easier to leave commercial trips out of the workplace survey population. On the other hand, it is not always possible to distinguish these trips from visitor trips, and by not considering these trips, the survey team loses some potentially useful data.

Survey Methods for the Workplace/Establishment Survey

Three general survey methods for conducting workplace/establishment surveys are used. Since there is really only one way to identify and sample the universe of visitors to the establishment, the methods differ only in how employees are surveyed. In the first approach, the employee and visitor surveys are conducted together by intercepting a random sample of all people entering and/or leaving an establishment. The second method involves implementing only a centralized employee survey. No data are collected from visitors. In the third method, visitors are intercepted as they enter and/or leave the establishment, but employees are surveyed separately through some centralized means, such as an employer-distributed self-administered mailback survey. Each method requires a small amount of information to be gathered from the employer, such as survey day employee attendance, and information on any special activities occurring during the survey period.

Tables 10.1 through 10.3 summarize the different survey methods.

The two methods that have a personal intercept component require counts of people entering and/or leaving the establishment to be conducted for weighting purposes and for trip attraction calculation. The counts are the most important aspect of many workplace surveys. An accurate count of persons entering the workplace allows for the calculation of attraction rates for that establishment. Without an accurate count, no rate calculations are possible. This is stressed because no other activity at the site should be allowed to interfere with the accuracy of the counts.

Two methods for counting people can be used. First, fieldworkers can be asked both to count (and record) people and administer the survey. This is feasible if fieldworkers are simply handing out self-administered survey forms, especially for lower volume entrances or times of day. The second method for counting is to assign multiple fieldworkers to each entrance, one of whom simply counts people while the others administer the survey. This method is desirable for very busy entrances and for surveys in which personal interviews are to be conducted. If multiple entrances to the workplace exist, an accurate count is needed of each. If an entrance is not visible from the counter's location, an additional counter should be

Table 10.1 Workplace/Establishment Survey Methods: The Joint Employee/Visitor Survey

Procedures

1. After selecting an establishment for the sample, contact the employer to verify that the attributes used for survey sampling are accurate, and request permission to conduct the workplace/establishment surveys at one or more of their sites.
2. If permission is received, identify on-site contacts, and interview them to obtain background employer information. Obtain exact street location and the number of entrances, and establish a date and time for field inspection.
3. Conduct a field inspection, and observe each of the entrances, estimating the needed number and placement of fieldworkers. Define a cordon line for the site (usually the building itself, but sometimes the property lines or other boundary). Diagram the site, noting the location of each entrance and the proposed stationing of personnel and equipment along the cordon.
4. Develop detailed logistical plan for the site that details the proposed fieldwork, and obtain approval from the on-site contact person.
5. On the designated day, station fieldworkers and equipment. Conduct interviews with or handout surveys to all people crossing the cordon line in one direction.

Advantages and Disadvantages

1. The method minimizes the amount of work that employers need to do, which may improve their willingness to agree to allow the survey.
2. All elements of the data collection can be supervised (and therefore controlled, to some extent).
3. At many locations, employees arrive and depart according to schedules, so fieldworkers may experience extremely busy periods where they can only reach a small percentage of people crossing the cordon.
4. The survey team must deal with multiple responses from employees who enter and leave the establishment frequently, and with the likelihood that response rate will diminish over the course of the day for these people.

Usage of this Method

1. The method is useful for establishments with separate employee and visitor entrances and predictable high-activity time periods. If the survey team can be prepared for the surges in activity, and is able to identify visitors and employees before contacting them, then the disadvantages of the method can be avoided.
2. However, in general, this method is not recommended.

Table 10.2 Workplace/Establishment Survey Methods: The Employee Survey

Procedures

1. Obtain the same permissions and background data from the employer as for the Joint Employee/Visitor Survey.

2. Recruit the assistance of the on-site contact person in distributing survey forms to on-site employees.

3. On the day before the designated survey day deliver survey forms to the contact person, who then distributes them to all employees or a sample of employees. Forms are commonly distributed along with company newsletters or with paychecks. Forms can be centrally collected by the employer, or they can be mailback questionnaires.

Advantages and Disadvantages

1. Minimal/fieldworker requirements. No personal intercept contacts.

2. Respondents receive survey materials from their employees, rather than from strangers. Respondents are more likely to feel the survey is important and legitimate, and they may feel more compelled to participate if their employers are involved.

3. No information is gathered from non-employees, so calculating total trip attraction rates is not possible.

Usage of this Method

1. This is the preferred approach for survey efforts requiring information only from employees.

2. A variation of this method is to obtain permission from employers to interview employees, rather than to distribute self-completion forms. This approach is extremely useful for conducting stated response surveys and other specialized surveys, but it is typically difficult to perform a random sample survey of the employees. Usually, a convenience or quota sampling approach is used at a central location, such as a lunch room.

Table 10.3 Workplace/Establishment Survey Methods: Separate Employee and Visitor Surveys

Procedures

1. An employee survey is performed as outlined in Table 10.2.

2. An intercept survey along a pre-established cordon is performed as described in Table 10.1. When potential respondents are contacted, they are asked whether they are on-site employees. Only those who are not employees are asked to participate in the intercept survey.

Advantages and Disadvantages

1. This method mitigates many of the problems of the other two methods. Both employees and visitors are included in the survey, employees are required to complete only one questionnaire, and the difficulty of responding to high employee travel periods is avoided.

2. The method requires a great deal of cooperation from employers.

3. The method requires two different data collection instruments – one for visitors, one for employees.

Usage of this Method

1. This method is likely to be the best approach for most survey efforts, but because it combines the two previous approaches it is more difficult and expensive than the others. If the survey team's data needs can be met with one of the other approaches without significant loss of data quality, then that approach should be used. However, in most cases, this approach will be necessary.

assigned. If the arrival rate is too high for a single counter to achieve an accurate count, additional counters should be scheduled. When more than one counter is used for a high-volume area, they should work back-to-back if possible, to lessen the chance of double counting.

Sometimes, in special circumstances, fieldworkers alternately perform the surveying and counting functions at particular locations. For instance, for the first 15 minutes of an hour, the fieldworker interviews or distributes forms to people, then for the next 15 minutes, she or he counts people, then switches back to surveying. Provided that people arrive and/or leave the establishment randomly throughout each hour, the partial count results can be factored to the full hour, and a single fieldworker can successfully complete both assignments. However, it is generally not a good assumption that people arrive or depart randomly, and so this approach should only be used in certain situations.

Counts which are conducted in one direction are generally easier for the field personnel to keep straight. If entrance counts and surveys are used, better time of arrival data is obtained, but data on how long a respondent stays at that destination is missing (or needs to be derived from survey questions). Some businesses, generally restaurants, prefer interviews to be conducted as the patrons leave. The decision to count and/or survey only the entering or the exiting people can be made for all survey locations, with exceptions made on a case by case basis. The only rule is that ALL PERSONS MUST BE COUNTED, in order to establish the base rate of trips to or from the establishment.

The last issue related to counting is whether vehicle counts should be taken in addition to the person counts. The answer to this question will depend on the modeling needs of the survey team, on whether questions on mode of arrival and auto occupancy are asked on the survey, and on the desire of the analyst to have independent checks on survey results. Technically, with the person count data and with detailed survey data on access mode and vehicle occupancy, the survey team will be able to estimate vehicle trips to and from the site with a high degree of accuracy. Vehicle count data, however, can sometimes provide assurance that the survey is accurately capturing travel to and from the site, especially at sites with drive-through facilities, such as fast food restaurants, banks, and dry cleaners.

If several sites with independent parking facilities are to be included in the workplace/establishment survey, the use of more automatic traffic recorders may be cost-effective. Care should be taken in placing tube counters in driveways to parking facilities, however. The slow speeds and angles of approach of vehicles can impair the accuracy of the vehicle counts, and a manual verification count for two or more hours is recommended where these locational barriers are a potential problem.

Data Collection Techniques for the Workplace/Establishment Survey

If a separate employee survey is to be conducted (either by itself or as part of a employee/visitor survey), it is recommended that the survey team rely on centralized employer distribution of self-completion surveys with on-site return, rather than mailback return, where possible. Of course, if on-site return is logistically difficult or impossible, a mailback survey is the only option. Personal interviews of employees (other than when they are entering or leaving an establishment) are usually infeasible. To draw a random sample of employees requires the employer to either provide the survey team a complete list of employees with home contact information, or to provide the survey team with the opportunity to contact employees during work hours. Most employers would refuse either option.

The survey team has three data collection options for the intercept portion of the workplace/establishment survey:

- Personal distribution of self-administered survey forms;
- Personal interviews using pencil and paper methods; and
- Computer-assisted personal interviews (CAPI).

The advantages and disadvantages of self-administered surveys and personal interviews are described in Chapter 3.0. For workplace/establishment surveys (as for transit onboard and vehicle intercept surveys), the primary tradeoff between the two methods is between the better response rates (and, therefore, lower potential for bias) of the interview method and the quicker distribution and the lower level of intrusiveness of the self-completion method.

If the survey team chooses to conduct interviews, they next need to decide whether the interviews will be recorded by conventional techniques or by CAPI techniques. As discussed in Chapter 3.0, CAPI systems have the following advantages:

1. They can be designed to permit the entry of only legal codes in any particular field (prevents data entry errors).

2. They can be used to check entries to make sure that they are consistent with other previously entered data (prevents data inconsistencies).

3. They automatically route interviewers through the interview (ensures respondents are asked all the relevant questions and are not asked ones that should be skipped).

4. They can use information from previous questions or previous interviews to make interview questions or the sequencing of questions specific to a particular respondent.

5. The survey team is able to use the computer screen as a means of communicating with respondents. With CAPI, the survey team is able to present visual information to which respondents can respond, including:

   - The interview questions (some types of questions, such as rating scales, can be presented graphically);

   - The interview answers so that respondents can check to ensure that the interviewer is recording the proper response;

   - Information commonly shown to respondents on show cards such as household income-level categories;

   - Computer graphics (including video) to illustrate particular questions; and

   - Geographic representations of information provided by the respondent.

However, CAPI systems also have the following disadvantages compared with standard PAPI interviews:

1. A great amount of programming time and effort is needed before the survey. The CAPI program needs to be nearly perfect before the survey is fielded, because interviewers will not generally be able to fix it in the field.

2. They require interviewers with more skills (or, at least, different skills).

3. There are no source records for the interview. The survey team must rely on the interviewer to enter information correctly.

Accuracy-Enhancing Measures

Like other travel surveys, a potential source of bias in workplace/establishment surveys is usually non-response, but, if anything, the issue is more difficult to deal with for the workplace/establishment surveys. Workplace survey non-response can occur at two levels, in asking employers to participate and in asking employees and visitors to complete the survey.

The first and most important step for the survey team in reducing non-response is to effectively "sell" the survey effort to the employers in the sample. It is often very difficult to persuade employers to participate in the effort. Survey teams should consider the following strategies to obtain the necessary support:

- Before contacting employers, contact local political officials and the Chamber of Commerce (or some other local business organization) to solicit support for the survey effort. Recent survey experience has shown that employers are more willing to participate in the workplace/ establishment survey if the first contact letter is sent from one of these organizations.

- Contact the most senior managers as possible at the sample firms. Even though contacting them is more challenging and time consuming than talking to mid-level managers, the senior managers may be more willing to "see the big picture," and they should be able to provide a decisive response one way or the other immediately.

- Be prepared to provide a detailed proposal of how the survey team would like to proceed, including the survey methods, survey dates, and likely questionnaire content. Also, be ready to compromise with the proposed plan. If a manager sees that the survey team is willing to work toward an acceptable arrangement, he or she is more likely to see that the participation of the particular firm is important.

- Finally, concentrate resources on the largest firms in the sample. Large firms are far more likely to be in sampling strata with fewer establishments; so failing to obtain a large firm means losing a significant proportion of a stratum's employees, with limited hope of substitution.[1] Note that this does not mean large firms should be oversampled, but that every effort should be made to secure their participation.

The survey team faces many of the same challenges as in other intercept surveys. Since the contact takes place while the respondent is going somewhere, persuading him to cooperate can be difficult. In addition, unlike some surveys, nothing is known of the potential respondent prior to contacting them; it is difficult or impossible to either pre-notify them of the survey or to follow-up with them later. On the other hand, the in-person request is usually the most effective approach, and so respondents who have time will usually agree to either be interviewed or to take a self-administered questionnaire.

The most effective approach for persuading employees to complete centrally-distributed survey forms is usually to stress that their employer supports the effort and believes it to be important. This message is best

[1] Michael Kemp, *Downtown San Francisco Workplace Travel Survey: Field Procedures Plan and Manual,* April 24, 1989.

sent by having the employer distribute the surveys. A cover letter explaining the survey effort from the employer to employees is usually a very effective approach for building response.

■ 10.3 Sample Design

Workplace and establishment surveys typically employ a two-stage sample design. The first stage is a sample of non-residential businesses in the area, and the second stage is either a sample of persons arriving at the establishment or a sample of the employees at the establishment.

The first-stage sample element is the business or establishment. Once the establishment sample frame is developed from available data sources, a representative sample of establishments to survey can be drawn. The establishments are typically stratified into a relatively small number of fairly homogenous groups. Usually, the four stratification criteria are:

- Area type or location within the study area;
- Industry type (type of business);
- Number of employees; and
- Freestanding versus non-freestanding establishments.

These criteria are discussed below.

The location and/or area types of workplaces are likely to affect the number and types of trips attracted to a site. Area type is generally a surrogate measure for development density and land use form. Typically, non-work trips per employee are different in amount and type (trip length, mode) in densely developed areas than in sparsely developed areas. Trip rates per employee or per square feet vary as one moves from the CBD to the suburbs to rural areas. In addition, the available travel choices are likely to be substantially different between the different types of areas. A simple delineation of area types is to break up the study area into CBD/urban, suburban, and rural areas. Other categorizations could be based directly on densities or more subjective measures related to urban form, like the presence of sidewalks. GIS is a very useful tool for developing area types of this nature.

The area types used should be applicable to the total population of commercial establishments in the study area. The borders of the areas should be contiguous with Census Tracts, TAZs, or Municipal boundaries in order to enumerate how many total employers and employees are in each area type.

Since different types of businesses attract different types and numbers of trips, establishments are generally classified into different categories based on Standard Industrial Classification (SIC) codes. SIC codes classify virtually all economic activities into a standardized set of codes, based on the type of industry or business activity. SIC codes can be quite detailed, but the most commonly reported set of codes is the two-digit classification shown in Table 10.4. For purposes of travel demand modeling, these codes are commonly combined into a manageable number of categories, such as retail, basic, service, and government.

In this four-industry type classification, basic industry includes agriculture, mining, manufacturing, construction, wholesale trade, transportation, communications, and utilities, including postal workers (SIC 1-51). Retail includes general merchandise and food stores, restaurants, gas stations, and all miscellaneous retail establishments (SIC 52-59). The service sector includes banks and insurance agencies, real estate offices, health, education, legal, engineering and accounting firms, research and business services, and recreation and amusement services such as hotels, motion pictures, and museums (SIC 60-87). The government sector includes all executive, legislative and judicial branches, administration, taxation and public order employees; for instance schools, post offices and police stations (SIC 90-98). Alternatively, the government sector could be combined with the service sector for three employment types; basic, retail, and service.

The main reason for stratification by industry type is to reduce the variance in trip rates by trip type per employee within each category. Home-based work trip rates vary slightly across all business types, but other types of trips can be much different between categories. For instance, home-based shopping trips per employee in a basic industry should be close to zero, while home-based shopping trips per employee for a retail industry should be relatively high.

There is evidence that work trip travel behavior is affected by the size of the workplace, particularly for considering the effects of TDM measures. Larger employers are able to offer transit subsidies, carpool/vanpool matching, special parking facilities or costs, on-site daycare and/or cafeterias, and other amenities that can modify the characteristics of employee trips.

The number of employees in an establishment can range widely from very small businesses with fewer than 10 employees, to huge workplaces with a thousand employees or more. The frequency of workplaces by employment size is skewed toward the smaller businesses while the distribution of total workers is skewed toward the larger businesses. As a general rule, the largest 20 percent of the businesses in an area account for 80 percent of the employees, whereas the rest of the businesses (80 percent) employ 20 percent of the work force.

Recent work in workplace/establishment surveys has shown that there are differences in travel behavior between "freestanding" and "non-freestanding"

Table 10.4 Two-Digit SIC Codes

SIC	Description
01-09	**Agriculture, Forestry & Fishing**
01	Agricultural Production – Crops
02	Agricultural Production – Livestock
07	Agricultural Services
08	Forestry
09	Fishing, Hunting & Trapping
10-14	**Mining**
10	Metal Mining
12	Coal Mining
13	Oil & Gas Extraction
14	Mining & Quarrying of Nonmetallic Minerals
15-17	**Construction**
15	Building Construction – General Contractors
16	Heavy Construction, Except Bulding Construction
17	Construction – Special Trade Contractors
20-39	**Manufacturing**
20	Food & Kindred Products
21	Tobacco Products
22	Textile Mill Products
23	Apparel, Finished Products from Fabrics
24	Lumber & Wood Products, Except Furniture
25	Furniture & Fixtures
26	Paper & Allied Products
27	Printing, Publishing & Allied Industries
28	Chemicals & Allied Products
29	Petroleum Refining & Related Industries
30	Rubber & Miscellaneous Plastics
31	Leather & Leather Products
32	Stone, Clay, Glass, & Concrete Products
33	Primary Metal Industries
34	Fabricated Metal Products, Except Machinery & Transportation Equipment
35	Industrial & Commercial Machinery
36	Electronic, Electrical Equipment & Components
37	Transportation Equipment
38	Measuring, Analyzing & Controlling Instruments; Photo, Medical, & Optical Goods; Watches & Clocks
39	Miscellaneous Manufacturing Industries
40-49	**Transportation, Communication & Utilities**
40	Railroad Transportation
41	Local, Suburban Transit & Interurban Transport
42	Motor Freight Transportation
43	United States Postal Service
44	Water Transportation
45	Transportation By Air
46	Pipelines, Except Natural Gas
47	Transportation Services
48	Communications
49	Electric, Gas & Sanitary Services
50-51	**Wholesale Trade**
50	Wholesale Trade - Durable Goods
51	Wholesale Trade - Nondurable Goods
52-59	**Retail Trade**
52	Building Materials, Hardware, Garden Supplies
53	General Merchandise Stores
54	Food Stores
55	Automotive Dealers & Gasoline Stores
56	Apparel & Accessory Stores
57	Home Furniture, Furnishings & Equipment
58	Eating & Drinking Places
59	Miscellaneous Retail
60-67	**Finance, Insurance & Real Estate**
60	Depository Institutions
61	Nondepository Credit Institutions
62	Security & Commodity Brokers, Dealers
63	Insurance Carriers
64	Insurance Agents, Brokers, & Services
65	Real Estate

Table 10.4 Two-Digit SIC Codes (continued)

SIC	Description
70-89	**Services**
70	Hotels, Rooming Houses, Camps, & Other Lodging
72	Personal Services
73	Business Services
75	Automotive Repair, Services & Parts
76	Miscellaneous Repair Services
78	Motion Pictures
79	Amusement & Recreation Services
80	Health Services
81	Legal Services
82	Educational Services
83	Social Services
84	Museums, Art Galleries & Botanical Gardens
86	Membership Organizations
87	Engineering, Accounting & Research Services
88	Private Households
89	Services, necessary
91-97	**Public Administration**
91	Executive, Legislative & General Government
92	Justice, Public Order & Safety Courts
93	Public Finance, Taxation & Monetary Policy
94	Administration of Human Resource Programs
95	Administration of Environmental Programs
96	Administration of Economic Programs
97	National Security & International Affairs
99	**Nonclassifiable Establishments**

sites.[2] Freestanding sites are those which do not share facilities such as parking with other establishments. Besides the cited differences in travel behavior, the two types of sites require different survey methods since in a non-freestanding site, persons who are visiting one of the other establishments may be counted or intercepted. There is also the potential for "double-counting" persons who visit more than one site. It may be a good idea to add a question asking how many establishments were visited in the group of establishments.

Once the establishments have been categorized, the survey team should determine the number of establishments and employees in each stratum. For some survey efforts, a random sample of establishments in each stratum will then be drawn. However, if the sampling unit is the establishment, then small employers and large employers have an equal probability of being selected – a "mom and pop" grocer with three employees has the same chance of being chosen as a 3,000-employee complex.

For most analyses, an approach that considers the number of employees is more desirable. One way to resolve the potential imbalance is to weight employee and workplace frequencies. If one were to weight them equally, then:

$$N_k = .5n\left[\frac{E_k}{E} + \frac{F_k}{F}\right]$$

where:

n_k = number of samples in class k;

n = total sample size;

F = total number of establishments;

F_k = total number of establishments in size class k;

E = total number of employees; and

E_k = number of employees in size class k.

For example, say that in employment class k there are 10 establishments with 1000 employees. For all classes, there are 100 establishments with

[2] David E. Pearson, *An Evaluation of the Pilot Workplace Survey in Beaumont-Port Arthur*, presentation to the Fifth National Conference on Transportation Planning Methods Applications, Seattle, April 1995.

5000 employees. If a total of 20 establishments are to be surveyed, then the number of establishments in class k will be

$$N_k = 0.5\,(20)\left[\frac{10}{100}+\frac{1000}{5000}\right] = 3 \text{ establishments}$$

Another method of setting the number of samples is as a proportion of the universe.[3] Briefly, these steps are:

1. Determine the distribution of worksites by area type and industry type.

2. Allocate the number of employees by area type and industry type.

3. Calculate the average number of employees per worksite by area type and industry type.

4. Compute the distribution percent of all workplaces by area type and industry type.

5. Define the total sampled employees in each industry type by calculating the sample percent for employees.

6. Determine the number of employees to be sampled by industry type by applying these rates to the total employment by type.

7. Distribute the total sampled employees by industry across area types based on the portion found in the universe. This number of employees to be sampled by area type and industry type is the minimum desired.

8. Calculate the number of worksites to be sampled by dividing this desired sample of employees by the average number of employees by site.

9. The minimum number of sites in a cell should be set (for instance 10 sites), so if the number of sample sites is less than the minimum in any cell the number is adjusted. A maximum may also be set.

The recommended percent of total employees (Step 6) should take into account the variation in the amount and types of trips of employees and visitors to various activity types. For instance, the trips to a Basic establishment are accounted for primarily by the employees of that establishment, and the variation between different Basic establishments is low. The highest variation in terms of the amount of trips is in the Retail sector, where the majority of trips are from visitors. For instance, two retail

[3] Texas Transportation Institute Research Report 1235-10.

establishments each have 10 employees in attendance on the survey day. One is a fast food restaurant and generates 90 trips per employee. One is a plumbing supply shop and generates 10 trips per employee. The Service sector contains some sites which are similar to Retail in terms of the number of trips generated per employee, such as a busy clinic or a DMV office, and also includes sites where the number of trips is quite low, such as a quiet office. Given these variations, the survey team set the percent of Retail and Service employees higher than that of Basic employees.

The most simple and direct method of developing the sample is to select every *n*th employee, and therefore the establishment in which that employee falls. For example, if there are 1,000 employees in the CBD Service sector, and a two percent sample of Service employees is desired, every 50th employee becomes the sample indicator. One would first rank order the establishments by size from largest to smallest. Then a random digit lower than the interval of 50 is chosen as the start (say 3). The 3rd employee indicates the first sampled establishment (the business in which that employee works). The second sampled establishment is the one containing the 53rd employee (3 + the interval of 50), and the third is the one containing the 103rd employee (53 + the interval of 50), etc. until 20 employers have been selected. The sum of the employees in the selected 20 (or fewer) businesses should be about two percent of the total employees.

The number of establishments that will need to be contacted in order to achieve the number of samples required is based on the survey team's expectations about:

- The employer refusal rate;
- The employee response rate; and
- The completion (versus attempted) rate for the employee questionnaires.

In some survey designs, not every employee at larger establishments is required to complete a questionnaire: a subsample of employees would be adequate. One method to accomplish this is to give every employee a questionnaire, sort the returns by serial number, and then sample out (remove) each form that ends in a random digit(s) chosen beforehand, or every *n*th form. This method is simplest for the establishment to administer, but more costly for the survey team since there is a cost for printing the extra questionnaires. A second method of subsampling employees is based on employee number (if sequentially assigned). If one-third of the employees are to be sampled, three random digits can be chosen (such as 2, 5 and 6) and all employees whose employee number ends in one of the digits becomes a sampled employee. This method is more work for the establishment, and requires a commitment by the employer to succeed.

■ 10.4 Drafting and Constructing the Survey Materials

In order to develop the necessary survey instruments for workplace and establishment surveys, the survey team must address the following issues:

- What data are needed from the surveys?
- How should survey questions be worded and presented?
- What survey instruments are needed, and how should they be designed?

Data Elements for the Workplace and Establishment Survey

Workplace/establishment surveys collect three broad types of data:

- Establishment information;
- Employee information; and
- Visitor information.

The survey team needs to carefully determine all of the data elements that are likely to be needed from the survey effort. Specific survey efforts will seek many of the elements described in Tables 10.5, 10.6, and 10.7, as well as other elements.

Some potential establishment data elements are shown in Table 10.5. Most of these data are typically obtained from interviews with the employer contact person. The count information must be collected by the survey team through direct observation.

Table 10.6 lists some employee data elements that can be collected with workplace/establishment surveys. In general, if the survey design relies on intercepting employees as they travel in or out of the establishment, the data elements that are sought focus on the trip being made at the time of the intercept, but if employees are contacted through a centralized means while they are at work, then questions about multiple trips or about general travel are more commonly used.

Table 10.7 shows some visitor data elements. Generally, visitors are intercepted as they travel to and from the establishment, and so visitor data tend to focus on the specific trip.

Table 10.5 Establishment Data Items

Data Elements	Information Typically Obtained
Name of employer	Official name, as well as any d.b.a. names.
Key manager	Name and title of "highest-ranked" staff member at the site.
Location	Specific street address and mailing address for the establishment. Classification of the establishment into an area type category, if establishments are being stratified that way.
Telephone numbers	Direct number of contact person, security personnel, and key managers.
Type of business	One or more SIC codes for the establishment.
Employees	Number of on-site employees (by shift, if applicable).
Site size	Square footage or acreage of the establishment.
Volume of business at site	Annual sales or other transferable measures of business activity and output.
Parking availability	Number and proximity of parking spaces for employees and visitors.
Parking policies	Cost of parking for employees and visitors; employer subsidy policies.
Transit availability	Location of nearest transit facilities. Transit service levels and fares; employer fare subsidy policies.
Bicycle and pedestrian amenities	Availability of bike lockers and showers at the site. Assessment of the quality of pedestrian amenities at, and around, the site.
Employer TDM measures	Description of all TDM programs being sponsored by the employer or other employer-sponsored agency (such as a TMA).

Table 10.6 Workplace and Establishment Survey Employee Data Elements

Data Elements	Information Typically Obtained
Travel activity to and from establishment	Number of trips to and/or from the establishment on the survey day.
Names of places where each trip started or ended	Name of locations in employee's words.
Type of place or land use of each trip end	Variations on categories like private home, place of business, hotel/motel, other.
Address of each trip end	Street address or nearest intersection.
Start and end time of all travel	Usually, collecting start and end times is preferable to asking travel times.
Travel group size for each trip	Number of people traveling together.
Travel mode for each trip	Categories designed to exhaust the mode possibilities for the site, plus an "other" category.
Parking information for each trip to the establishment	Location of parking and cost (excluding any subsidies).
Personal information about the employee	See Table 6.14 for a representative list.
Household information for the employee	See Table 6.13 for a representative list.
Attitudinal and stated response questions related to employer-based transportation measures	Stated preference, rating and ranking questions.

Table 10.7 Workplace and Establishment Survey Visitor Data Elements

Data Elements	Information Typically Obtained
Name of place where incoming trip started, or outgoing trip will end	Name of location in visitor's words.
Type of place or land use of the trip end	Variations on categories like private home, place of business, hotel/motel, other.
Address of trip end	Street address or nearest intersection.
Start and end time of trip	Will need to be estimated for outgoing trips. One of the times will be known from the time of the interview or the time of the survey distribution.
Travel group size for the trip	Number of people traveling together.
Travel mode for the trip	Categories designed to exhaust the mode possibilities for the site, plus an "other" category.
Parking information	Location of parking and cost (including and excluding any subsidies).
Specific trip purpose	Categories describing likely reasons for visiting an establishment, plus an "other – please specify" category.

Development of Questions from the List of Needed Data Elements

Guidelines for developing survey questions from the list of data elements are provided in Chapters 6.0 through 8.0 of this manual.

Survey Instruments and Materials for the Workplace and Establishment Survey

Depending on the chosen survey method, the survey team could need to design and construct any of the following:

- Letters of introduction requesting permission to conduct the survey work;
- A draft cover letter for an employer's manager to sign that would accompany the distribution of the centralized employee survey;
- An interview script for the employer contact interview;
- A self-completion employee survey;
- Collection boxes for the self-completion employee surveys;
- Control sheets for employer distributed surveys;
- Site diagram to help fieldworkers and supervisors station themselves at the establishment;
- Person and/or vehicle count forms;
- Self-completion survey forms to be distributed at the establishment cordon;
- An interview script or CAPI program for interviewing people as they cross the establishment cordon; and
- Control sheets for interviewers and fieldworkers distributing forms.

The survey team should draft a letter requesting permission from employers to conduct the survey at their establishment. As noted above, it is desirable to have the letter be sent from a third party, such as the Chamber of Commerce or the Mayor's Office, but the survey team should produce the first draft of the letter to ensure that the survey procedures and uses are described accurately. The letter should stress the importance of the survey effort and the need to have the cooperation of the specific establishment in question. The letter should also explain the confidentiality of the survey data.

The survey team will also need to produce a draft cover letter for the employer to attach to each employee survey form. This letter should reiterate the information supplied in the permission letter, clearly indicate that the survey has been approved by the employer, and explain any special survey retrieval procedures (such as the location(s) of survey collection boxes). The letter should also identify the principal contact person for the employer, so that he or she can answer any questions about the survey effort.

Once the survey team has obtained tentative permission to conduct the survey at a particular site, the employer's contact person or other knowledgeable staff should be interviewed about the establishment.

These interviews are commonly conducted informally as the survey arrangements are being completed, but it is much better to take a few minutes to conduct a formal or semi-formal interview with a pre-established script or questionnaire. Informal data gathering often causes interviewers to forget to ask particular questions that might be important in analysis. The survey team should consider providing the contact person with a list of questions or a discussion guide prior to the interview so that related files can be ready at the time of the interview.

The self-completion employee survey questionnaires can actually be quite detailed, because they may ask about each trip made to or from the establishment. The forms may be presented on standard size and weight paper since they may not need to be mailed back, or they can be distributed with business reply envelopes. Examples of two recent employee surveys are shown in Figures 10.1 and 10.2. If the forms are to be re-collected by the employer contact person, it is also helpful to supply one or more collection boxes with accompanying signage to ease the return process. To help the contact person with their efforts, it is also helpful to provide written instructions and to ask them to record their progress on a control form. The instructions and log form for a recent Illinois survey are shown in Figure 10.3.

When one or more survey team members visit the establishment prior to the survey, a site plan should be obtained or developed. This plan should show the proposed cordon and all potential exits. In addition, the plan should note any special circumstances and survey design issues. For instance, the site plan should include the fact that certain exits are not available at certain times of the day. Often a common site plan form, such as that shown in Figure 10.4, is used by survey team members to record the site information.

Because counting people entering or leaving an establishment is usually an integral part of the survey effort, standard count forms should be used to record the information. An example form is shown in Figure 10.5. Usually, the counts are collected on an hourly basis. If hand-held tabulators are used, it is suggested that the counters not turn them back to zero

Figure 10.1 The Lake-Cook Corridor Employee Transportation Survey

DEERFIELD AND NORTHBROOK

Lake-Cook Transportation Survey

Employee

Thank you in advance for your time and participation in this important survey. The purpose of this survey is to better understand the transportation needs of employees in the Lake-Cook Corridor and in the Deerfield and Northbrook area. Please answer each of the questions below and return this to the person who gave it to you. Your answers will be kept confidential and will only be used to produce statistical data needed to improve transportation services in the area.

1. **What is your zip code at *home*?**

   ____ ____ ____ ____ ____

2. **What is the nearest *major* intersection to your home?**

   ________________ and ________________

3. **Do you usually work in the Lake-Cook Road area?**

   ☐1 Yes ☐2 No

4. **Do you work full-time or part-time? (Less than 30 hours each week.)**

   ☐1 Full-time ☐2 Part-time

5. **Did you work in the Lake-Cook Road area yesterday? (or your last regular work day.)**

   ☐1 Yes ☐2 No

6. **What day of the week was that?**

   ☐1 Monday ☐3 Wednesday ☐5 Friday
   ☐2 Tuesday ☐4 Thursday

7. **At what time did you arrive *to* work yesterday?**

   _____ : _____ ☐1 A.M. ☐2 P.M.
   (hour) (minutes)

8. **How many *minutes* did it take you to get from home to work yesterday?**

   ____________________ (minutes)

9. **Approximately how many *miles* do you live from your work place in the Lake-Cook Road area?**

   ____________________ (miles)

10. **How did you arrive at your work site yesterday?**

    ☐1 Driver of auto, truck, or van (including carpool)
    ☐2 Passenger of auto, truck, or van (including carpool)
    ☐3 Public bus (Route No. __________)
    ☐4 Metra
    ☐5 Other ____________________

11. **If you arrived at your work site by auto, truck, or van, how many people were in the vehicle (*including yourself*)?** No. of people __________

12. **If you did *not* drive to work, was an auto available for this trip?**

    ☐1 Yes ☐2 No

13. **If you came by Metra, how did you get *to* the station?**

    ☐1 Drove auto ☐3 Walked ____ (minutes)
    ☐2 Dropped off ☐4 Bus (Route No. _____)
    ☐5 Other ____________________

14. **If you came by Metra to the Lake-Cook Road area, how did you get *from* the station?**

    ☐1 Drove auto ☐3 Walked ____ (minutes)
    ☐2 Dropped off ☐4 Bus (Route No. _____)
    ☐5 Other ____________________

15. **At what time did you leave work yesterday?**

    _____ : _____ ☐1 A.M. ☐2 P.M.
    (hour) (minutes)

16. **If a midday shuttle were available to and from Northbrook Court or Deerbrook Mall, would you use it?**

    ☐1 Yes ☐2 No

Source: Lake-Cook Corridor Transportation Survey, 1994.

Figure 10.1 The Lake-Cook Corridor Employee Transportation Survey (continued)

If "yes," how many times per week? ________

Lake-Cook Transportation Survey—Employee—2

17. Do you usually use your own car for trips during work hours?

☐1 Yes ☐2 No ☐3 Not applicable

The following questions relate to your travel to work.

18. In your commute to and from work, do you make stops on the way?

	Yes	No	If "yes," how many stops per week
1. To Work	☐1	☐2	________
2. From Work	☐1	☐2	________

19. What factors do you consider when choosing your means of transportation to work? (Check up to three.)

☐1 Travel time
☐2 Cost
☐3 Convenience
☐4 Flexibility
☐5 Comfort and safety
☐6 Reducing pollution/conserving energy
☐7 Ability to make stops enroute

20. What kinds of things do you think would make shuttle bus service attractive in the Lake-Cook Road area?

☐1 Bus shelters
☐2 Crosswalks
☐3 Placement of bus stops close to my building
☐4 Sidewalks
☐5 Other ________________

21. If you drive alone to work, what are the *three* most important reasons why you don't regularly use public transportation to commute to the Lake-Cook area?

☐1 Public transportation is not convenient to my home
☐2 Public transportation is not convenient to my work site
☐3 Work late/irregular hours
☐4 Public transportation is too time-consuming
☐5 Cannot get home in an emergency
☐6 Public transportation is too costly
☐7 Other ________________

Now we would like to ask you a few questions for statistical purposes only. This information will be grouped for sample verification and travel demand estimation and is completely confidential.

22. What is your age? ________

23. Are you male or female?

☐1 Male ☐2 Female

24. Which of the following best describes your current job classification?

☐1 Professional/Technical/Clerical
☐2 Managerial/Administrative/Sales
☐3 Skilled Craft
☐4 Laborer
☐5 Service Worker
☐6 Equipment Operator/Trucker
☐7 Other ________________

25. What is your annual income?

☐1 Less than $10,000
☐2 $10,000-19,999
☐3 $20,000-29,999
☐4 $30,000-39,999
☐5 $40,000-49,999
☐6 $50,000-59,999
☐7 $60,000 or more

Do you have any comments about transportation in the Lake-Cook Road area?

____
____
____
____
____
____
____
____
____

Thank you for your assistance!

Source: Lake-Cook Corridor Transportation Survey, 1994.

Figure 10.2 The NCTCOG 1994 Employee Travel Survey

E 10453

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS
1994 EMPLOYEE TRAVEL SURVEY

The North Central Texas Council of Governments is sponsoring a survey of travel in the Greater Dallas-Fort Worth area. Please help by participating. Your answers will be kept confidential and will be summarized with others for analysis.

1. Company Name (write in): ______________________

2. Do you work here (check one): 1☐ Full-Time (40 hrs or more/wk) 2☐ Part-Time (less than 40 hrs/wk)

3. What time did you arrive at work today? ____:____ 1☐ AM 2☐ PM

4. Where did you LEAVE FROM to get to work today? (Check one) 1☐ Home 2☐ Other

5. What is the address of that PLACE?

______________________ Address (or nearest intersecting streets) ____________ (City) ____________ (Zip Code)

6. How did you get to work today? (Check one)

1☐ I drove a car, pickup, truck, or van
2☐ Passenger in a car, pickup, truck, or van
3☐ By motorcycle
4☐ By taxi
5☐ By DART or "T" bus
6☐ By another type of bus
7☐ Walked
8☐ Biked
9☐ Other (Specify)____________

7. If you traveled to work by CAR, PICKUP, TRUCK, VAN, or MOTORCYCLE today, HOW MANY PEOPLE were in the vehicle, including yourself and children? ____________ (enter number)

8. If you traveled to work by CAR, PICKUP, TRUCK, VAN, or MOTORCYCLE today, HOW MUCH did/will YOU pay to park?

I paid/will pay $__________ . ______ (If no parking cost paid, enter 0)

1☐ Daily 2☐ Weekly 3☐ Monthly 4☐ Other (Specify)____________

9. If you traveled to work by BUS, how did you get to the place where you boarded the first bus? (Check one)

1☐ By car, pickup, truck, motorcycle, or van 2☐ Walked 3☐ Other (Specify) ____________

10. If you traveled by BUS, what method of payment did you use to board the bus? (Check one)

1☐ I paid cash of $ ____.____ 2☐ I used a pass (weekly or monthly) 3☐ Other (Specify)________

11. How MANY MINUTES did it take to walk to your workplace from the place you got out of the last vehicle that brought you there? If you walked the entire trip, enter that time. (Check one)

1☐ Less than 1 Minute 2☐ 1-5 Minutes 3☐ 6-10 Minutes 4☐ 11 Minutes or More: ______ (write minutes)

Please answer questions 12-17 at the end of your work day today.

12. While you were at work today did you ever LEAVE for any reason and then return to work?

1☐ NO (Skip to Question 18 on back.) 2☐ YES (Continue with Questions 13-17.)

13. How many times did you leave work today and then return to work? (Write in total #.) ____________

14. What was your main reason for leaving? (Check one for each time you left.)

	1st Time	2nd Time	3rd Time	4th Time	5th Time	6th Time
Break (Smoke, Walk, Bathroom...)	1☐	1☐	1☐	1☐	1☐	1☐
Work Related	2☐	2☐	2☐	2☐	2☐	2☐
Other	3☐	3☐	3☐	3☐	3☐	3☐
15. How did you get there?						
Auto, Pickup, Truck, Van, Motorcycle	1☐	1☐	1☐	1☐	1☐	1☐
Bus or Transit	2☐	2☐	2☐	2☐	2☐	2☐
Walk	3☐	3☐	3☐	3☐	3☐	3☐
Bike	4☐	4☐	4☐	4☐	4☐	4☐
Other (Specify)	5☐ ____	5☐ ____	5☐ ____	5☐ ____	5☐ ____	5☐ ____
16. What TIME did you arrive back at work? (Circle AM or PM)	____ AM PM	____ AM PM	____ AM PM	____ AM PM	____ AM PM	____ AM PM
17. If Auto, Pickup, Truck, Van, Motorcycle: Enter number of people in vehicle on trip back to work (including yourself):	____	____	____	____	____	____

(PLEASE CONTINUE ON BACK)

Source: NCTCOG Employee Travel Survey, 1994.

Figure 10.2 The NCTCOG 1994 Employee Travel Survey (continued)

18. On your way in to work today, did you make any STOPS? (Check yes or no)

- N☐ No, I traveled directly to work. (Skip to Question 20.)
- Y☐ Yes (Answer Question 19.)

19. If you made any stops on your way in to work today, why did you stop? (Check as many as apply.)

- 1☐ Attend School
- 2☐ Work Related
- 3☐ Eat a Meal
- 4☐ Recreational, Social
- 5☐ Shopping, Buy Gas,...
- 6☐ Personal Business (Bank, Doctor,...)
- 7☐ Pick-Up/Drop-Off a Passenger
- 8☐ Other (Specify)________

20. What time did you leave work yesterday (or your previous weekday at work)? ____:____ 1☐ AM 2☐ PM

21. After you left work yesterday (or the last weekday you worked), did you make any stops?

- N☐ No (Skip to Question 22.)
- Y☐ Yes - WHY did you stop? (check as many as apply)

- 1☐ Attend School
- 2☐ Work Related
- 3☐ Eat a Meal
- 4☐ Recreational, Social
- 5☐ Shopping, Buy Gas,...
- 6☐ Personal Business (Bank, Doctor,...)
- 7☐ Pick-Up/Drop-Off a Passenger
- 8☐ Other (Specify)________

22. After you left work yesterday (or the last weekday you worked), what was your final destination? (check one)

- 1☐ Home
- 2☐ Other Place

The following questions are for statistical purposes only:

23. How many total CARS, PICKUPS, TRUCKS, VANS, or MOTORCYCLES are available for use by members of your household, including your own vehicle? ________ (enter number)

24. Are you a licensed driver? 1☐ Yes 2☐ No

25. In total, how many licensed drivers are in your household, including yourself? (Write in number) ________

26. In total, how many members of your household work either full-time or part-time, including yourself? (Write in number) ________

27. How many PEOPLE live in your household (including yourself)? ________ (enter number)

28. What is your AGE? ________ (enter years)

29. What is your GENDER? 1☐ Male 2☐ Female

30. What was your total annual household income last year before taxes, including all the members of your household? (Check box)

- 01☐ Less than $10,000
- 02☐ $10,000-$14,999
- 03☐ $15,000-$19,999
- 04☐ $20,000-$24,999
- 05☐ $25,000-$29,999
- 06☐ $30,000-$34,999
- 07☐ $35,000-$39,999
- 08☐ $40,000-$49,999
- 09☐ $50,000-$74,999
- 10☐ $75,000-$99,999
- 11☐ $100,000 and above

THANK YOU FOR YOUR PARTICIPATION! PLEASE RETURN COMPLETED FORM
TO SURVEY DROP BOX OR YOUR SUPERVISOR.

For Office Use Only: CBA #: ________

Source: NCTCOG Employee Travel Survey, 1994.

Figure 10.3 Employer Contact Person Instructions and Control Log for the Lake-Cook Transportation Survey

Employee Survey Instructions

Please complete the surveys and Employer Control Log using the following steps.

Step 1

- Select a random sample of employees to be surveyed. The employees to be surveyed should be selected by matching the random digit(s) identified on the "*Deerfield/Lake Cook TMA—Employer Control Log*," item 5, with the last number of the employee's social security number. Every employee with a matching social security number should be asked to fill out a survey form.

- Inform all selected employees of the survey and ask for their participation. Explain to them that this survey will be used to collect information on the transportation needs and concerns of the people who work in the Lake Cook Road Corridor. Furthermore, the survey responses will be used to determine the feasibility of alternative transportation systems (i.e., Shuttle bus service). All survey responses are confidential and will only be used for this study.

- Distribute survey forms to employees on the date identified on the "*Deerfield/Lake Cook TMA—Employer Control Log*," item 4. The survey should take approximately 10 minutes to fill out and should be completed right away. The survey questions are self-explanatory, and both sides of the survey should be completed. Pen or pencil may be used to fill out the form.

- The survey should be distributed and collected on one day only. It is important that the surveys are done in this manner to improve the accuracy of the data. Please do not have employees fill out the survey on different days.

Step 2

- Collect all survey forms. Check for completeness as they are returned.

- Fill out the "*Deerfield/Lake Cook TMA—Employer Control Log*" included in the package that was mailed to you. This information is necessary to assist in data entry.

  Fill out items 6 thru 9 and review the existing information already entered on the form for completeness and accuracy. If you have conducted your survey on a different date other than that indicated under on item 4, please correct this information on the form.

Step 3

- Package the Employer Control Log and all survey forms (both completed and unused) into the return envelope. Contact either Glen Phillips or Cindy Fish at Barton-Aschman (708-491-1000) to schedule a date and time for the forms to be picked up.

Thank you for your assistance in completing this survey.

Source: Lake-Cook Corridor Transportation Survey, 1994.

Figure 10.3 Employer Contact Person Instructions and Control Log for the Lake-Cook Transportation Survey (continued)

Deerfield/Lake Cook TMA—Employer Control Log

Sample Number ________
Class Number ________

1. **Establishment Information**
   Company Name ______________________ Telephone __________
   Type of Business ______________________________________
   Address ____
   City ______________________ Zip Code __________

2. **Contact Person Information**
   Name ______________________ Department ______________
   Title ______________________ Telephone ______________

3. **Employee Questionnaires Delivered:** __________ to __________

4. **Survey Day** ____________ **Date** ______________

5. **All employees to be surveyed.**

Contact Person, please complete items 6 through 8 before returning.

6. **Number of Employees by Shift**
   ____:____ AM/PM to ____:____ AM/PM Employees: full-time _____ part-time ______
   ____:____ AM/PM to ____:____ AM/PM Employees: full-time _____ part-time ______
   ____:____ AM/PM to ____:____ AM/PM Employees: full-time _____ part-time ______

7. **Employee attendance on survey day:** Full-time ________ Part-time ________

8. **Estimated amount of time/cost to conduct the survey:** _____ hours
   _____ estimated hourly rate

Source: Lake-Cook Corridor Transportation Survey, 1994.

Figure 10.4 An Example Site Plan Evaluation Form

Dallas Establishment Survey

Prepared by CBA- Sept 1994

SITE PLAN EVALUATION FORM

CBA ID #:

SITE/COMPANY NAME:

INTERVIEWER:

SITE/COMPANY STREETADDRESS:

DATE:

INTERVIEWER: PLEASE WRITE ANY COMMENTS/DIRECTIONS ON BACK OF THIS FORM

__ FREESTANDING
__ NON-FREESTANDING

__ SHOPPING CENTER/MALL
__ MULTI TENANT BUILDING
__ STAND ALONE BUSINESS

__ Separate parking
__ On street parking
__ Shared parking
__ Cut through

Source: NCTCOG Establishment Survey, 1994.
Note: See Appendix I for a completed example.

Figure 10.5 Example Person Count Form

Site Name ____________ Site # ________ Location Number ______

Time	Number of Persons Entering (Including Employees but not Delivery Personnel)	Number of Delivery Personnel
6 AM - 7 AM		
7 AM - 8 AM		
8 AM - 9 AM		
9 AM - 10AM		
10AM - 11AM		
11AM - 12PM		
12PM - 1 PM		
1 PM - 2 PM		
2 PM - 3 PM		
3 PM - 4 PM		
4 PM - 5 PM		
5 PM - 6 PM		
6 PM - 7 PM		
7 PM - 8 PM		
8 PM - 9 PM		
9 PM - 10PM		
10PM - 11PM		
11PM - 12AM		

TOTAL: ____________

Source: NCTCOG Establishment Survey, 1994.

each hour, but let the daily total run, and simply record the current total at the beginning of the hour.

The visitor survey instrument may be either an interview script of a self-completion questionnaire. If the self-completion approach is used, the survey forms are likely to be shortened forms of the employee survey forms. The interview scripts, whether pencil and paper or CAPI, should be designed to be administered quickly and with minimal perceived effort by the fieldworker. An example interview form is shown in Figure 10.6. This form actually allows the interviewer to record two interviews on one form in order to reduce the number of forms that they will need to complete. Both interviewers and fieldworkers distributing self-completion questionnaires are also usually asked to complete simple control logs on an hourly basis.

Pretesting

A pretest of the developed forms and procedures should be conducted on several sites in various area types and industry types. No matter how straightforward the forms or procedures, the pretest invariably surfaces one or more problems or constraints that were overlooked, from a typographical error on the forms to low response rates for one or more industry type. Knowing the potential problems before full-scale fieldwork begins is invaluable, and can avoid insurmountable difficulties or bad data later in the survey process.

In a pretest, generally several sites are recruited, surveyed, and analyzed. Personnel involved in the pretest should include the survey planners and field staff who are slated to become field supervisors during actual fieldwork, but where possible, actual fieldworkers should be used for the pretest. Personally going through the procedures allows the field supervisors and fieldworkers a greater understanding of the strengths and weaknesses of the survey design. Depending on the complexity of the survey, the number of sites could be from five to 30. Sufficient employee and visitor returns should be recovered to make estimates of the validity of the data, usually at least 30 to 50 returns of each.

Each question is typically analyzed with one of three outcomes: valid, invalid, or blank. A valid response means that the respondent understood the question and gave a logical response within the data range expected. An invalid response means the respondent did not understand the question or gave an illogical response outside of the expected range. For example, an invalid response often arises when a question on mode of access to transit is worded "If you used transit,...," but individuals whose mode was auto answer the question. An out-of-range example is a written answer of 600 for the number of minutes traveled to the worksite. A blank response is self-explanatory, and often arises as a non-response in demographic questions (age/sex/income). One would expect a non-response

Figure 10.6 The NCTCOG Visitor Travel Survey Interview Form

NORTH CENTRAL TEXAS COUNCIL OF GOVERNMENTS
1994 VISITOR TRAVEL SURVEY INTERVIEW FORM

(ONLY IF NECESSARY) The North Central Texas Council of Governments is sponsoring a survey of travel in the Greater Dallas-Fort Worth area. Please help by participating. Your answers will be kept confidential and will be summarized with others for analysis.

CBA #: ____________

Date: ____/____/94

Location: ____________________

Int: ____________________

Questions	Person 1	Person 2
A. Are you a visitor or do you work here at [illegible]?	[illegible]	[illegible]
B. RECORD time (circle AM or PM):	___:___ AM PM	___:___ AM PM
C. Where did you come from to get to [illegible] today?	☐ Home ☐ Other ________ (work, shop,...)	☐ Home ☐ Other ________ (work, shop,...)
D. What is the address of that location? (or nearest intersecting streets, city & zip) (or place name and street, city & zip)	________ (Place Name) ________ (Address) ________ (City) ________ (ZIP)	________ (Place Name) ________ (Address) ________ (City) ________ (ZIP)
E. WHY did you come to [illegible] today? (See Code List E)	Code/Specify: ______/______	Code/Specify: ______/______
F. How did you travel here to [illegible] today? (See Code List F)	Code/Specify: ______/______	Code/Specify: ______/______
IF WALK, SKIP TO QUESTION N.		
G. How long did it take you to walk from where you got out of the vehicle?	Minutes: ______	Minutes: ______
If by Car/Pickup/Truck/Van/Motorcycle ask:		
H. HOW MANY PEOPLE were in the vehicle, including yourself and all children?	Enter #: ______	Enter #: ______
I. HOW MUCH did/will you, yourself, PAY TO PARK to visit [illegible]? (If no parking cost paid, enter 0)	Paid/will pay: $_____._____ (amount) ☐ By Meter ☐ Hourly ☐ Other ______ ☐ Daily ☐ Monthly	Paid/will pay: $_____._____ (amount) ☐ By Meter ☐ Hourly ☐ Other ______ ☐ Daily ☐ Monthly
J. How much of the parking cost you just mentioned was or will be REIMBURSED by someone else? (If none, enter 0)	$_____._____ (amount)	$_____._____ (amount)
If by Bus ask:		
K. HOW did you get to your first bus stop? (See Code List K)	Code/Specify: ______/______	Code/Specify: ______/______
L. HOW did you PAY? (Show card on back of clip board)	Code/Specify: ______/______	Code/Specify: ______/______
M. How much of the transit cost you just mentioned was or will be REIMBURSED by someone else? (If none, enter 0)	$_____._____ (amount)	$_____._____ (amount)
If by Walk ask:		
N. How many minutes did it take you to walk from your last destination?	Minutes: ______	Minutes: ______
O. How many other businesses did you visit within this building/center before arriving here? (If none, enter 0)	Enter #: ______	Enter #: ______

Code List E - Trip Purpose

1) Work related
2) Eat a meal
3) Shopping, buy gas...
4) Social, recreational
5) Personal business (Bank, Doctor, Mail, Legal)
6) School
7) Pick up/drop off passenger
8) Pickup/drop off delivery/parcel
9) Other ____ (Specify)

Code List F - Mode

1) Drove car, pickup, truck, van
2) Passenger in car, pickup, truck, van
3) Motorcycle
4) Taxi
5) DART/"T" bus
6) Other type of bus
7) Delivery vehicle
8) Walked
9) Biked
10) Other ____ (Specify)

Code List K - Bus Mode

1) Walked
2) Biked
3) Motorcycle
4) Taxi
5) Car, pickup, truck, van and was dropped off (Specify number in vehicle)
6) Car, pickup, truck, van that parked near the bus (Specify number in vehicle)
7) Other ____ (Specify)

Source: NCTCOG Establishment Survey, 1994.

rate of over 10 percent for an income question, but if the questionnaire is eliciting item non-response of more than five percent on any other questions, the survey team should check the wording, font size, and placement on the form to see if response can be improved.

Once the pretest forms have been analyzed and corrected, the procedures should be examined. The surveyors, counters, and supervisors should be debriefed on the procedures to ensure that each member of the survey team understood and followed the correct guidelines. Individual surveyor's interview sheets and control forms should be analyzed to uncover any coding problems before fieldwork begins. Often, the surveyors need to be reminded to get full and complete geographic detail for the origin information. Changes to the procedures should be documented carefully. If procedures are modified to a great extent, it is a good idea to pretest the new procedures before going into the field with the final survey.

■ 10.5 Training and Briefing Survey Personnel

After the survey pretest, the surveyors should be trained in the fieldwork procedures. A Manual of Procedures should be prepared that will describe to each surveyor the method for conducting the intercept surveys, and a formal training session should be required of each fieldworker. The training session should cover the following issues:[4]

1. **Overview** – This is information on the nature of the study - why it is being undertaken, how the findings can be used, and its important implications that may benefit the people or the problem under study. This information is useful to motivate interviewers, and to allow fieldworkers to address respondents' questions.

2. **The Sponsor** – Fieldworkers should understand the survey sponsorship so they can provide respondents with the correct answer. In government sponsored research the sponsorship is not kept secret, as is more common in commercial marketing research.

3. **The Population** – Training should describe the people being studied (such as whether visitors and employees, or only visitors) so that fieldworkers know whom they should be talking to.

4. **Survey Methodology** – If fieldworkers are inexperienced, the training session and manuals should introduce fieldworkers to some of the theory and practice of survey research. This is especially useful for

[4]Charles Backstrom and Gerald Hursh-Cesar, *Survey Research*, 2nd edition, John Wiley & Sons, 1981, p. 246.

fieldworkers who are challenged by potential respondents to justify the survey process.

5. **Sampling** – Fieldworkers also must know enough about sampling to understand the principles of randomness and the sources of sampling biases.

6. **Consistency (standardization)** – Training must convince fieldworkers of the importance of standardized behavior in the workplace/establishment surveys. Fieldworkers must understand the reasons for consistency in approaching respondents, introducing the study, asking questions, and recording responses.

7. **Interviewer Biases** – A large part of the training sessions should be devoted to showing fieldworkers how their own personality and characteristics can bias questionnaire data. They should learn to identify the major sources of interviewing biases, both generally and for themselves specifically, and should be made aware of the devices for protecting against their own behavior influencing respondents' answers.

8. **Respondent Biases** – Training should deal with respondent motives for not participating in survey efforts, and for evading or falsifying interview responses.

9. **Selection Procedures** – Trainers should demonstrate how to read building layouts so fieldworkers can properly position themselves. In addition, fieldworkers should be taught how to select individuals for the survey. Often, this is most easily conveyed by actually simulating the field conditions.

10. **Interviewing or Questionnaire Distribution Procedures** – The training session should show respondents how to administer the questionnaire (either by conducting an interview or by distributing a self-administered form), and how to record the respondent contacts or serial numbers on quota sheets or time logs. Role playing during training is invaluable in surfacing any misunderstanding about the questions or procedures.

11. **Supervision and Problem Solving** – This is straightforward information about who supervises the fieldwork, which supervisors work with which fieldworkers, what their responsibilities are, why supervisors are required to carry out checking and monitoring activities, and so on. The intention is to improve fieldworkers' understanding of the managerial role of the supervisor in coordinating the survey effort, and to encourage fieldworkers to seek assistance from supervisors, rather than hide their problems. The supervisors can conduct the role playing sessions in small groups of five to 10 surveyors to assert the supervisors authority and to open the channels of communication.

12. **Verification** – Without implying distrust, the training session should address the criteria and procedures that will be used for verifying interviewers' work, including recontacting respondents, supervision, debriefing, and data and records analysis.

13. **Scheduling and Logistics** – At the training session, fieldworkers should be told of the time and timing of the survey, the number of forms to be distributed or interviews to be conducted, the assignment locations, procedures for getting assistance, and the use of field instructions and other materials and forms.

14. **Administrative Procedures** – In some cases, the training session may need to be used for detailing fieldworkers' conditions of employment, including wages, tax withholding, benefits, insurance, dates of payment, etc.

Appendix I provides a recent Survey Fieldwork Manual that was developed for establishment surveys in the Dallas-Fort Worth area.

■ 10.6 Conducting the Survey

General Procedures

Once the sample of workplaces has been determined, the actual survey procedures can be implemented. The following procedures are usually followed when employee and visitor data are obtained separately.

1. Call each sampled establishment to determine if the establishment is still in operation, verify the address and get the CEO/owner/manager's name and title. A brief explanation, if any at all, is all that is needed for this call.

2. Send a recruiting letter to each sampled business. This first contact letter should have a number that the business owner can call to verify that the survey is legitimate.

3. Interview/recruit employer and establish contact person. The first recruiting call should be made two to three weeks after an individually addressed and personally signed letter has been sent. The CEO/owner/manager is the first contact to garner the businesses' participation. When contact is made with him or her, the importance of that businesses' participation in the survey will be explained as well as the procedures; agreement to participate will be obtained. Generally, a contact person will be designated to assist in distribution and pick-up of the employee questionnaires; this person is often an administrator, human resources, or secretarial staff person. A full explanation of the

procedures during the recruitment call – the employee survey, the visitor survey, the counts and the employer information required – helps reduce late drop-outs which waste resources and time.

Determine number of employees, hours of operation and hours that counters may have to be in place, exact street location, square footage, and number of entrances. Conduct as much of the employer information interview as is feasible to allow the site to be properly scheduled. Keep track of the outcome of each call in the employer contact log.

4. Schedule the survey day. If the sample consists of many sites, or the survey is to be conducted over a long period of time, scheduling of sites should take into account the geographic proximity of sites scheduled for the same day. Plotting the sampled sites using a GIS, and recruiting and scheduling sites in the same area for the same day saves on oversight and supervisory time, and allows surveyors and counters to carpool even though they may work at separate sites. If the sites are close together, one supervisor can manage oversight and relief of three to five sites (depending on the size and complexity). The survey day is tentative until the site visit is complete, and any special qualities of a particular site are understood.

5. Schedule a personal site visit. Set up a time for a personal visit, for field inspection, and to deliver employee questionnaires (one or two days to a week or more before survey day). A personal visit to the employer to drop off questionnaires and conduct the interview makes a large positive difference in completion rates for each establishment. It is recommended personal visits be used at least for the larger establishments.

   During the personal visit, conduct field inspection and observe the number of entrances, estimate the number of visitor surveyors required, and the number and placement of counters. Define a cordon around the establishment. It is always a good idea to check the site plan with the contact person before completing the survey design to ensure that all doors are noted and covered by counters, and that a door that is not operational is not scheduled to be counted. In larger buildings and more secure sites, a copy of the site plan with surveyor/counter positions shown should be left with the security or personnel director. The scheduled survey day can be confirmed unless peculiarities of the site require rescheduling.

6. On the designated survey day, station surveyors should remind the contact person to deliver employee questionnaires. Counters should be in place 15 minutes before the first person arrives on the site, and surveyors placed 15 minutes before the scheduled business hours begin. The site supervisor is responsible for complying with the instructions and placement shown on the site diagram.

7. Count commercial vehicles going to the establishment during working hours on the survey day. The delivery personnel may be surveyed as visitors, or may be surveyed separately (if at all – delivery persons generally are rushed and often refuse to be interviewed or fill out a questionnaire).

The purpose of the personal visit to the site, although resource intensive, is threefold: to provide the employee questionnaires to the employer; to complete the data needed on the employer and to answer any remaining questions the employer may have; and to review the survey site. While the first two could be accomplished by telephone and mailout/mailback of questionnaires, experience has shown that a personal visit to each site has a positive impact on completion rates. A site visit, however, to review the site and develop a strategy is necessary.

The Site Strategy

Review of the survey site consists of two parts:

- Externally touring the site and diagramming the layout of the buildings, the locations of parking, and the locations of driveways and doorways; and

- Interviewing the senior person or contact person.

For more complex sites, the site review consists of a third component: internally touring the building(s), and externally retouring the site. The reason for sometimes undertaking such an elaborate site review procedure is to develop a survey strategy. Just as there is no standardized company layout or business operating practice, there is no clean and neat survey strategy that can be applied equally well to all surveyed establishments. Each establishment has its own peculiarities that will affect the way counts are conducted and how visitors are intercepted. Thus a strategy should be developed during the course of the inspection of the site, based on the specifics of the site and its operations.

To obtain a true count, it is absolutely essential to station the survey personnel in the proper locations. The fieldworkers assigned to count entering and exiting people are generally instructed only to count, not to make decisions or judgments about what people were actually doing or why they were making a trip. Interviewers obtain that information on a sample basis. The accuracy of the counts therefore depends almost entirely on the soundness of the strategy for stationing survey personnel. Counting only entrances to the establishment requires excluding from the count the traffic that was internal to the operation, e.g., trips between offices/departments within the establishment or trips to the restrooms and lunchrooms. Excluding internal traffic from the count generally requires developing establishment cordons at the outer boundaries of the site.

Isolating trips to the surveyed establishment sometimes requires distinguishing between trips to the surveyed business and trips to other businesses. Some sample establishments will adjoin or share space with other establishments that are not being surveyed. To reduce the possibility of mistakenly counting trips to other businesses, the survey planner may wish to establish count stations as close as possible to the activity center(s) of the surveyed business and away from the outer boundaries. This would focus the count on the surveyed business only.

These contrasting approaches are suited to different building layouts and modes of operation. For many of the surveyed establishments, the correct strategy can be determined only after interviewing the employer and touring the site.

Car dealerships are a prime example of the potential problem of counting internal traffic. The area of activity extends beyond the walls of the showroom to include the adjacent car lots. Salespersons come and go between the buildings and the lots many times each day, but it is all in the course of their work on the site. In order to avoid falsely counting this internal traffic as trips to the establishment, an outer cordon approach can be used. With this method, inbound trips are counted at the driveways leading into the site rather than at the doorways leading into the buildings on the site. These counts can be vehicle counts, and the person-trip equivalents estimated from the survey data, or for consistency with other sites the counters can count persons entering in vehicles.

This method is clean and efficient but will yield an accurate count only under certain conditions. The driveways must be used only by persons going to the surveyed establishment (a strip shopping center would almost never qualify, for example). Also, all traffic to the surveyed establishment must use the driveways into the site. If some trips to the site use a parking lot outside of the cordon area, or do not arrive by auto, then those persons entering on foot need to be accounted for. In that case, survey personnel need to count persons in cars at driveways and also count persons on foot entering at locations other than at the driveways.

For many establishments, a large amount of the person traffic in and out of the building is made up of employees taking short breaks. The prevalence of the smoke-free workplace complicates the counting of persons entering the site by creating a greater incidence of employee trips. The survey team has three options for properly accounting for employee break trips, like smoking trips. The first possibility is to determine during the employer interview if the establishment provides an internal smoking area and if all smokers use it. If the answers to both were yes, then the smoking trips would never be observed and, therefore, never counted. The second possibility is to conduct the cordon count, outside of where employees are likely to take their breaks, in which case the smoking trips would not be counted. The third possibility is to specifically ask employees on the employee questionnaire the number of times they left the building for incidental trips such as smoking.

The incidental trips will ultimately be subtracted out of the total count on the basis of responses on the employee questionnaires. It is recommended that incidental trips be accounted for on the employee questionnaire, since so many buildings are smoke-free and cordon counts cannot be guaranteed at each site, but the survey team needs to remember the difficulty of getting respondents to remember short, incidental trips.

Five special reminders:

- Trips made by the employee in and out of the worksite must be accounted for on the employee form.
- Incidental trips, such as leaving the building to smoke, must be accounted for as well.
- Every door through which a person may enter MUST BE COUNTED. Contact the security personnel if the door is locked during the site visit to verify that the door in question is never opened.
- Have the same wording on questions that will allow comparison with the Household Travel Survey, such as the same income ranges, auto ownership, and employment status definitions.
- Be sure to contact all agencies which will be involved in participation, such as security personnel, building management, all building tenants, etc.

The visitor survey will be undertaken by survey staff at the entrances of each establishment on the scheduled survey day. The counters and surveyors are generally placed at their stations 15 minutes before the first person arrives, which is often much earlier than the posted business hours for a site. The times for placing the counters should be discussed with the contact person. Each entering person, or if a subsample approach is taken each *n*th person, will be asked if they are visitors to the site, and if they are, they will be handed a questionnaire. If an interview technique is used, every person is approached and the completed interviews are subsampled in the editing phase. For counts that include only entrants, the field personnel will stay on-site until 15 minutes after the posted close of business.

Delivery trucks and taxis arriving at the sample establishments may also be counted by survey staff to estimate truck trip attractions. These counts are generally performed by the hour, similar to the person counts. Entering trucks may be classified by counting the axles, or by a silhouette form as shown for the commercial vehicle surveys. The classification of these vehicles should be consistent with classification counts taken on the roadways in the same time period or DMV classification of vehicles by type.

■ 10.7 Editing and Cleaning the Data

When a survey at a particular site is complete, the returned visitor and employee questionnaires, employer information sheet, and person and truck count sheets should be edited as soon as possible. This ensures that each site supervisor and each surveyor is using proper procedures, and missing forms can still be located or information that was not filled in (such as attendance) still obtained with a phone call. The day after the survey day the site envelope should be opened and the employer information sheet edited for completeness. The number of entering persons should be totaled for the survey period and entered on the employer information sheet.

An accuracy check to verify the counts if they seem low or high is to double the entrance count and divide by the number of employees at the site. This person trip rate would be comparable to the ITE Trip Generation person trip rate for the same size and type of industry. General ranges can be established as the survey progresses to check these rates by the locally collected data. For instance, the first fast food restaurant in the survey might be checked against ITE, but the fifth can be checked against the first four. This reasonableness check is vital to ensure that the counts for each sampled site are accurate.

Once the editor is satisfied that the employer and count information is complete, the questionnaires returned by employees and the questionnaires or interviews of visitors are examined. Refusals and blanks can be discarded, and the completed questionnaires sent to data entry. Not every questionnaire will have every question answered, and rules to identify a completed questionnaire should be determined in the survey design and given to the editors. Generally, whether the employee or visitor came from home, the mode, and whether employee trips were made during working hours are used as the primary pieces of data. The critical questions that define a completed questionnaire should be identified during the survey design phase.

After each employee questionnaire and each visitor interview or questionnaire is edited for completeness, the number of completes should be tallied for each site on a master control log. This acts as a control log for data entry.

Cleaning the data once it is entered into computer files begins with range checks. For example, if the possible answers to a question are numbered 1-4 and non-response is coded as 99, all answers between 4 and 99 must be erroneous. In addition, certain cross checks must be performed to verify the accuracy of the data. If the employee was an auto passenger then the auto occupancy cannot be less than two. If the employee responded that the mode to work was auto, but also checked a fare type for transit trip, then the questionnaire should be examined to determine if the employee took an auto or transit.

10.8 Data Expansion

The factoring of the visitor and employee data to represent the total person arrivals at the establishment is accomplished by expanding the survey sample to equal the arrival counts. The derivation of these expansion factors follow:

$$C = C_w + C_{n_w} \tag{1}$$

That is, total person trip arrivals is equal to the sum of arrivals by employees (C_w) and arrivals by non-employees (C_{nw}). C_w and C_{nw} can not be counted separately and are therefore not known. However, attendance (A) is known so that the expansion factor (F_w) for employee questionnaires can be calculated from the attendance and the number of completed employee questionnaires (Q_w):

$$F_w = \frac{A}{Q_w} \tag{2}$$

Now, an employee may enter the building once, twice, or three or more times. Each time he or she will be counted. The number of trips to an establishment by worker i is equal to one plus the number of additional trips made by the employee to the establishment during the day (K). That is, it is the sum of first trip to work plus subsequent trips by employee throughout the day. Since that information is only known for those employees who filled out a questionnaire, the sample sum must be multiplied by the expansion factor for employees, F_w, to estimate the total arrivals by employees:

$$C_w = F_w \sum_{i=1}^{n} (1 + K_i) \tag{3}$$

Where K_i is the number of return trips to an establishment for the employee of an establishment. Now one can obtain the number of arrivals of visitors at the establishment:

$$C_{nw} = C - C_w \tag{4}$$

The expansion factor for non-employee questionnaires (F_{nw}) can be completed given the number of completed visitor surveys (Q_{nw}):

$$F_{nw} = \frac{C_{nw}}{Q_{nw}} \tag{5}$$

This description of the establishment survey factoring process underscores the importance of an accurate count of arrivals at the establishment, and the necessity of obtaining the attendance of employees at the establishment. If the trips made by employees during working hours were recorded by time-of-day, it would be possible to calculate expansion factors by time-of-day exactly. If they are not, temporal assumptions regarding these trips will have to be made in order to obtain time-of-day factors.

The trip numerator of the attraction rate will be the number of employees (or attendance if attendance is to be forecast instead of employment). There may be a tendency on the part of the workplace person designated to complete the form to be somewhat casual in reporting employment. It is imperative that the data on number of employees and the number of employees in attendance on the day of the survey be as accurate as possible. It is awkward to have more employee interviews than workers in attendance for a workplace.

The final conversion to an attraction rate requires nothing more than the division of trip arrivals by the actual employment. For example, the rate of non-work arrivals per worker, a major independent forecast variable for future trip attraction predictions, is the rate of non-work arrivals to total employment.

For example, say that an establishment has 500 employees attending work on the survey day, and 250 completed surveys were obtained. Assume that these 250 surveys showed a total of 125 additional trips by employees (0.5 per employee). There were 50 completed visitor surveys, and the count showed 1000 arrivals.

Then:

$$F_w = \frac{500}{250} = \mathbf{2.0}$$

$$C_w = (2.0)\,(375) = 750$$

$$C_{nw} = 1000 - 750 = 250$$

$$F_{nw} = \frac{250}{50} = \mathbf{5.0}$$

So the expansion factor for employee surveys would be 2.0, and the factor for visitor surveys 5.0.

11.0 Visitor Surveys

The hotel/visitor survey provides unique and useful information about non-resident travel in areas where visitors make a significant contribution to the overall traffic. Some metropolitan areas draw thousands of visitors who travel for sightseeing, business, amusement, and sports events. None of the travel surveys described in previous chapters is likely to provide much information about visitor travel; the visitor survey collects information on the mode of travel and the geographic and temporal movements of non-residents.

Hotel/visitor surveys are designed to gather information about the characteristics of non-residents who stay at hotels or other places of lodging. (The term "hotel" will be used throughout this chapter to refer to all public lodging for hire, including hotels, motels, bed-and-breakfast establishments, etc.) Specific information about the number and type of trips is also obtained. These data can be used to develop visitor trip generation rates (i.e. trips/occupied hotel room). This type of survey is *not* used to gather information about specific tourist or recreational attractions such as theme parks. In those cases, a special generator or establishment survey, as described in Chapter 10.0, is the appropriate means to collect the data.

Data collected from hotel/visitor surveys can be used to estimate the potential visitor demand for new service modes, particularly specialty modes such as people movers or streetcars that are designed to appeal to visitors. The potential demand for travel to new destinations that would draw tourists can also be estimated. The trip information from the hotel/visitor survey can also be used to help estimate the effects of new development.

The hotel/visitor survey can be used to collect travel data for out-of-area visitors who stay at hotels in the area. The surveys usually will not account for visitors staying with resident friends (which could be accounted for in the household travel survey) or for visitors staying at non-commercial lodgings such as clubs, association facilities, or school dormitories. In addition, the hotel-based survey will not provide information on travel of visitors who do not stay overnight.

The format of a hotel/visitor survey is similar to that of a household travel survey. Instead of a dwelling unit, the hotel room is used as the sampling unit. Data can be expanded to the estimated number of occupied rooms in the same way in which household survey data are expanded to occupied dwelling units. Location within the study area may also be a predictive variable in estimating the number of trips by mode and purpose. Combined with the occupancy rates by hotel size class and location collected from the sample of hotels, the rates can be used to estimate the number of visitor trips generated by mode and purpose for an estimate of all occupied hotel rooms in each size-class and (if applicable) by area-type for the entire study area.

■ 11.1 Assembly of Background Data

The main type of data required for initiating a hotel survey is a listing of hotels in the study area. Common sources for this listing include:

- Tourist trade or hotel associations (these vary depending on location);
- Chambers of Commerce; and
- Telephone directories.

It is a good idea to use one source to compile an initial list and another to check the list for completeness. Hotel associations or chambers of commerce can also be helpful in gaining cooperation from member hotels.

The listing of hotels can provide not only part of the sampling frame for the survey, but also information about the hotels. Information needed will include the name of a contact person, telephone number, hotel address, and the number of rooms.

■ 11.2 Hotel/Visitor Survey Design

The survey team faces several survey design issues regarding hotel/visitor surveys. Given that the survey population for the hotel/visitor survey is the set of registered guests at all area hotels, these issues include:

- What survey method(s) should be used?
- Given the survey method, what data collection techniques should be employed?

These issues are described below.

Survey Method

There are two main options for the survey method. These are:

- Centrally distributed self-completion surveys; and
- In-person intercept interviews, usually in the hotel lobby.

In the self-completion survey, forms can be distributed to pre-selected rooms. The in-person interviews can be conducted as guests are checking out or as they pass through the lobby. The advantages of each method are shown in Table 11.1. In general, the self-completion method is preferred by many surveyors because of its lower cost, greater amount of information that can be gathered, and better ability to target the desired sample population. However, this method is also characterized by low response rates, and it will not be available if hotels do not permit the survey forms to be delivered.

Data Collection Techniques

For the self-completion survey, the only issues concerning data collection techniques are the methods for distributing and retrieving the survey forms. For the most part, these are dictated by what the hotels will allow. Distribution methods include having hotel staff leave the survey forms in the rooms, sliding the forms under the room doors, or handing the forms out at the check-out desk. It is preferable to collect the forms at the hotel, but a mailback option can also be provided.

There are three data collection options for the intercept survey method:

- Personal distribution of self-administered survey forms;
- Personal interviews using pencil and paper methods; and
- Computer-assisted personal interviews (CAPI).

The advantages and disadvantages of self-administered surveys and personal interviews are described in Chapter 3.0. The primary tradeoff between the two methods is between the better response rates (and, therefore, lower potential for bias) of the interview method and the quicker distribution and the lower level of intrusiveness of the self-completion method.

If the survey team chooses to conduct interviews, they next need to decide whether the interviews will be recorded by conventional techniques or by CAPI techniques. CAPI systems have the following advantages:

Table 11.1 Comparison of the Self-Completion and In-Person Interview Methods

Advantages of the Self-Completion Survey

1. Minimal fieldworker requirements.
2. Since there are no personal intercept contacts, the survey is less intrusive.
3. Since respondents can fill out the forms at their leisure, more information (such as daily trip diary data) can be gathered than in an in-person interview, where respondent time constraints can limit the survey.
4. All guests staying in a room can be surveyed on a single form.
5. There is no bias toward guests who may pass an intercept survey site frequently.

Advantages of the In-Person Intercept Survey

1. The response rate for self-completion hotel surveys is very low (10% or less), leading to the need for a large distribution and questions about non-response bias.
2. Required hotel cooperation and participation is less for intercept surveys since hotel staff generally must distribute self-completion surveys.
3. Hotels may be reluctant to allow survey distribution in rooms because of sensitivity to guest privacy (initial selection is non-voluntary).

1. They can be designed to permit the entry of only legal codes in any particular field (preventing data entry errors).

2. They can be used to check entries to make sure that they are consistent with other previously entered data (preventing data inconsistencies).

3. They automatically route interviewers through the interview (ensuring respondents are asked all the relevant questions and are not asked ones that should be skipped).

4. They can use information from previous questions or previous interviews to make interview questions or the sequencing of questions specific to a particular respondent.

5. The survey team is able to use the computer screen as a means of communicating with respondents. With CAPI, the survey team is able to present visual information to which respondents can respond, including:

   - The interview questions (some types of questions, such as rating scales, can be presented graphically);

   - The interview answers so that respondents can check to ensure that the interviewer is recording the proper response;

   - Information commonly shown to respondents on show cards such as household income-level categories;

   - Computer graphics (including video) to illustrate particular questions; and

   - Geographic representations of information provided by the respondent.

However, CAPI systems also have the following disadvantages compared with standard PAPI interviews:

1. A great amount of programming time and effort is needed before the survey. The CAPI program needs to be nearly perfect before the survey is fielded, because interviewers will not generally be able to fix it in the field.

2. They require interviewers with more skills (or, at least, different skills).

3. There are no source records for the interview. The survey team must rely on the interviewer to enter information correctly.

■ 11.3 Sample Design

Hotel surveys typically employ a two-stage sample design consisting of a sample of hotels in a region and a sample of guests at those specific hotels. The sample of hotels is a method which allows fieldwork to concentrate on specific sites; the hotels are simply a way in which to reach a cluster of tourists. The sampled hotels are typically stratified by area type and by size (number of rooms or units). The stratification of the sampled hotels is based on the assumption that guests of large hotels may travel differently than those of small hotels, and visitors staying downtown may travel differently than visitors staying near the airport. The second stage of the sample consists of guests who stay in the selected hotels. Each occupied room consists of a visitor or group of visitors, and like the household travel survey, data is collected for each member of an occupied room.

For most analyses, an approach that considers the number of occupied rooms (or guests) is desirable. One way to resolve the potential imbalance between large and small hotels is to weight employee and workplace frequencies. If one were to weight them equally, then:

$$N_k = .5n\left[\frac{E_k}{\sum E_k} + \frac{F_k}{\sum F_k}\right]$$

where:

N_k = number of samples in class k;

n = total sample size;

F_k = total number of hotels in size class k;

E_k = number of occupied rooms in size class k.

This provides an equal weighting of incidence of rooms and hotels.

Another method of setting the number of samples is as a proportion of the universe. Briefly, these steps are:

1. Determine the distribution of hotels by area type and industry type.
2. Allocate the number of occupied rooms by area type.
3. Calculate the average number of occupied rooms per hotel by area type.
4. Compute the distribution percent of all hotels by area type.

5. Define the total sampled rooms by calculating the sample percent for rooms.

6. Determine the number of rooms to be sampled rooms, applying these rates to the total number of hotels.

7. Distribute the total sampled rooms across area types based on the portion found in the universe. This number of rooms to be sampled by area type is the minimum desired.

8. Calculate the number of hotels to be sampled by dividing this desired sample of rooms by the average number of occupied rooms by site.

9. Set the minimum number of sites in a cell so that if the number of sample sites is less than the minimum in any cell, the number is adjusted. A maximum may also be set.

The most simple and direct method of developing the sample is to select every *n*th room, and therefore the hotel in which that room is located. For example, if there are 1,000 rooms in the CBD and a two percent sample is desired, every 50th room becomes the sample indicator. One would first rank order the hotels by size from largest to smallest. Then a random digit lower than the interval of 50 is chosen as the start (say 3). The 3rd room indicates the first sampled hotel (the hotel in which that room is located). The second sampled hotel is the one containing the 53rd room (3 + the interval of 50), and the third is the one containing the 103rd room (53 + the interval of 50), etc. until 20 hotels (or fewer since some hotels might contain multiple selected rooms) have been selected. The number of rooms in the selected 20 (or fewer) hotels should be about two percent of the total rooms.

The number of hotels that will need to be contacted in order to achieve the number of samples required is based on the survey team's expectations about:

- The hotel refusal rate;
- The guest response rate; and
- The completion (versus attempted) rate for the guest questionnaires.

In self-completion surveys where forms are delivered to rooms, not every guest at larger hotels is required to complete a questionnaire; a subsample of rooms is adequate. One method to accomplish this is to give every guest a questionnaire, sort the returns by serial number and then sample out (remove) each form that ends in a random digit(s) chosen beforehand, or every *n*th form. This method is simplest for the hotel to administer, but more costly for the survey team since there is a cost for printing the extra questionnaires. A second method of subsampling rooms is based on room number. If one-third of the rooms are to be sampled, three random digits can be chosen (such as 2, 5, and 6) and all rooms whose number ends in one of the digits becomes a sampled rooms. This method is more work for the hotels, and requires a commitment from the hotel to succeed.

In order to properly weight the interviews, it is necessary to have a count of occupied rooms by number of occupants for the sampled hotels. This count can be used to estimate the total occupancy rate for all rooms in all hotels, and the number of total visitors for the study area for the travel date(s).

Like the workplace survey where a small number of employers can account for the majority of the work force, in most areas the largest hotels (over 500 rooms) account for a disproportionate amount of the total rooms available. The greatest number of hotels, on the other hand, are generally in the smaller size-class (less than 100 rooms). Because of the difference in travel characteristics between the large hotels, which may provide shuttle service and host conventions, and smaller hotels, which may attract different types of visitors, the sample must carefully represent the types of hotels available to a visitor.

Once the sampling frame has been established, a representative sample can be drawn. Typically, hotels in the study area are stratified into size categories. For example, the categories might be: *small* (less than 100 rooms), *medium* (100-500 rooms), and *large* (500 rooms and greater). In addition, the geography of an area might lend itself to stratification by area type such as downtown, tourist district, remaining city, and airport area or suburbs. This allows a sample matrix stratified by size and area type. In addition, the nightly room rate could be used to stratify the properties. All of these strata should be examined with the objective of achieving a reasonable distribution of observations in each category.

■ 11.4 Drafting and Constructing Survey Instruments and Materials

Survey Instruments

Depending on the chosen survey method, the survey team could need to design and construct any of the following:

- Letters of introduction requesting permission to conduct the survey work;
- An interview script for the hotel contact interview;
- Site diagram to help fieldworkers and supervisors station themselves at the hotel;

- A self-completion visitor survey form;
- Collection boxes for the self-completion surveys;
- Control sheets for hotel distributed surveys;
- An interview script or CAPI program for interviewing people at the survey sites; and
- Control sheets for interviewers and fieldworkers distributing forms.

The survey team should draft a letter requesting permission from hotels to conduct the survey. It is desirable to have the letter be sent from a third party, such as the Chamber of Commerce or the Mayor's Office, but the survey team should produce the first draft of the letter to ensure that the survey procedures and uses are described accurately. The letter should stress the importance of the survey effort and the need to have the cooperation of the specific hotel in question. The letter should also explain the confidentiality of the survey data.

Once the survey team has obtained tentative permission to conduct the survey at a particular site, the hotel contact person or other knowledgeable staff should be interviewed about the hotel. These interviews are commonly conducted informally as the survey arrangements are being completed, but it is much better to take a few minutes to conduct a formal or semi-formal interview with a pre-established script or questionnaire. Informal data gathering often causes interviewers to forget to ask particular questions that might be important in analysis.

When one or more survey team members visit the hotel prior to the survey, a site plan should be obtained or developed. This plan should note any special circumstances and survey design issues.

The self-completion visitor survey questionnaires can actually be quite detailed because they may ask about each trip made. The forms may be presented on standard size and weight paper since they may not need to be mailed back, or they can be distributed with business reply envelopes. It is desirable to supply one or more collection boxes with accompanying signage to ease the return process. To help the contact person with their distribution efforts, it is also helpful to provide written instructions and to ask them to record their progress on a control form.

The in-person intercept survey instrument may be either an interview script or a self-completion questionnaire. If the self-completion approach is used, the survey forms are likely to be similar to what would have been distributed to rooms. The interview scripts, whether pencil and paper or CAPI should be designed to be administered quickly and with minimal perceived effort by the fieldworker. Both interviewers and fieldworkers distributing self-completion questionnaires are also usually asked to complete simple control logs on an hourly basis.

In general, the following guidelines are useful to keep in mind while developing data collection forms and interview scripts:

- Self-administered questionnaires should be clear and self-explanatory.

- Multiple languages should be considered if using a self-completion questionnaire for visitor surveys. The tourist bureau can give the survey planners a sense of the languages most likely to be spoken by visitors.

- A written form should be available for individuals (hearing impaired or non-English speaking) who can fill out a form but not be verbally interviewed.

- Interviewers can be trained to use skips, but the flow of the interview can be disrupted if the questions are not in logical and clear order. The forms typically request general information about the visitor's trip to the study area, e.g., mode, purpose, arrival day/time, etc., and then specific data about the trips made yesterday. Socioeconomic information is collected at the end, with income generally being the last question.

In addition to the collection forms, a separate form will be used for the hotel information; that is: the name and location of the hotel, the total number of rooms, and the occupancy rate for the night before the survey day, along with the name and title of the manager, in case follow-up data is required.

Data Items

The data items to be obtained can be classified into three categories:

General Visit Data

- Number of persons occupying the respondent's room (for most survey efforts, all should be interviewed);

- Purpose of the visit, for example:

  - Tourist, Convention, Business, Visiting friends, Special events (football game, etc.)

- Local area auto availability:

  - Owned, Rented, Borrowed

- Number of nights stayed;

- Mode of arrival into the area (Private Vehicle, Airplane, Bus, Train, Ship);
- Mode of departure from the area; and
- Frequency of visits during past year.

Travel Data (for each trip)

- The address of the starting point of the trip;
- The starting time of the trip;
- The name and address of the place visited, or where the trip ended;
- Arrival time at destination, or what time the trip ended;
- Purpose of the trip, for example:
  - Shopping, Sightseeing, Eating, Wandering, Work, Business, Convention, Social, Personal
- Mode of travel:
  - Driver, Private vehicle passenger, Public Bus/Rail, Taxi, Walk, Bike, Tour Bus, Shuttle Bus
- If private auto, number in vehicle and who is the driver (self, roommate, other);
- Departure time from that place, or next trip begin time; and
- Number of persons in travel party.

Demographic Data

- Age;
- Sex;
- Occupation; and
- Income.

■ 11.5 Pretesting

A pretest of the developed forms and procedures should be conducted on several sites in various area types and hotel sizes. No matter how straightforward the forms or procedures, the pretest invariably surfaces one or more problems or constraints that were overlooked, from a typing error on the forms to low response rates for one type of hotel or patron. Knowing the potential problems before full-scale field work begins is invaluable, and can avoid insurmountable difficulties or bad data later in the survey process.

In a pretest, generally several hotels are recruited, surveyed, and analyzed. The staff for the pretest should include the survey planners and field staff who are slated to become field supervisors during the full field study. Personally going through the entire set of procedures allows the field supervisors greater understanding of the strengths and weaknesses of the survey design. Depending on the complexity of the survey, the number of sites could be from three to 10. Sufficient visitor returns should be recovered to make estimates of the validity of the data; this requires at least 30 to 50 returns from each pretested hotel.

Each question in a self-completion form is typically analyzed with one of three outcomes: valid, invalid, or blank. A valid response means that the respondent understood the question and gave a logical response within the data range expected. An invalid response means the respondent did not understand the question or gave an illogical response outside of the expected range. For example, an invalid response often arises during an interview when the interviewer does not fully comprehend the basis and use of the question, and becomes confused by an unusual response. A blank response is self-explanatory, although in an interview the surveyors are trained to ask each question, so blanks should not occur, unless as a non-response for some demographic questions (age/sex/income).

Interviews require an edit of each completed form, and a face-to-face debriefing of the interviewer. Any incomplete data are unacceptable unless the respondent terminated the interview or refused to answer. Special codes should be assigned to cover these contingencies. Often the surveyors need to be reminded to get full and complete geographic detail for the origin information. Illogical data often appear during a pretest interview, because it is difficult for the interviewers to complete a form that may seem out-of-sequence. Survey teams should review the flow of questions, the time required to complete each section, and elicit constructive criticism from the interviewers. The more comfortable interviewers are with the forms, the more efficiently and precisely the data will be collected. Changes to the procedures should be documented carefully. If procedures are altered dramatically, the new procedures should be pretested again.

11.6 Training of Fieldworkers

Interviewers can be secured through a temporary agency or through direct advertisement. Typically, a good interviewer is someone who has done telemarketing or other work involving public interaction. To ensure that candidates can understand and follow instructions for coding, a short test can be used to rate prospective interviewers. Supervisors can be drawn from the interviewer ranks or can be provided by the survey team. An unskilled supervisor can typically manage three to five people in the field in addition to conducting interviews. A skilled manager should be able to supervise 10 to 15 people.

The interviewers should be trained for at least a day or two prior to the first survey day. At the training session, the purpose of the survey should be explained, the daily schedules outlined, and the forms and procedures demonstrated. Detailed attention should be given to each of the items on the forms, especially definitional items such as "what is a trip?" Mock interviews can be conducted showing professional interview techniques and tools. Each surveyor should complete four or more mock-interviews with a team leader before fieldwork begins to make sure that the interviewers are comfortable with the forms. This role playing during training is an invaluable tool to surface questions and problems before fieldwork begins.

A detailed description of the information that should be provided to interviewers and supervisors during training can be found in Appendix I, which contains a sample procedures manual.

11.7 Conducting the Survey

Initial Contact and Site Visit

The first step in the full survey procedures is to contact the hotels to be sampled to elicit their participation. The following procedures are recommended:

1. Call each sampled hotel to verify the address and get the manager's name. A brief explanation, if any at all, is all that is needed for this call.

2. Send a recruiting letter to each sampled hotel. Experience has shown that hotels are most likely to participate in the workplace survey if the first contact letter is sent from the Chamber of Commerce or some other well-known tourism organization, or from a major public agency

(e.g., the mayor's office). This first contact letter should have a phone number that the hotel manager can call to verify that the survey is legitimate.

3. Interview/recruit the hotel. The first recruiting call should be made two to three weeks after an individually addressed and personally signed letter has been sent. The manager is the first contact to garner the hotel's participation. When contact is made with him or her, the importance of that hotel's participation in the survey and the survey procedures will be explained. Agreement to participate will be requested. A full explanation of the procedures during the recruitment call helps reduce late drop-outs which waste resources and time. Conduct as much of the hotel information interview as is feasible to allow the site to be properly scheduled. Keep track of the outcome of each call in the employer contact log.

4. Schedule the survey day. Plotting the sampled sites using a GIS, and recruiting and scheduling sites in the same area for the same day saves on oversight and supervisory time. For in-person interviews, this allows surveyors to carpool even though they may work at separate sites. If the sites are close together, one supervisor can manage oversight and relief of three to five sites (depending on the size and complexity). The survey day is tentative until the site visit is complete, and any special qualities of a particular site are understood.

5. Schedule a personal site visit. Set up a time for a personal visit, for field inspection, and to deliver in-room self-completion questionnaires (one or two days to a week or more before survey day). A personal visit to the hotel to drop off questionnaires and conduct the interview makes a large positive difference in completion rates for each hotel. It is recommended that the use of personal visits, at least for the larger hotels, be considered for the survey.

   During the personal visit, conduct field inspection and estimate the number of surveyors required and the locations of survey sites and collection boxes. It is always a good idea to check the site plan with the contact person before completing the survey design. A copy of the site plan with survey/collection positions shown should be left with the hotel manager. The scheduled survey day can be confirmed unless peculiarities of the site require rescheduling.

6. On the designated survey day, set-up the survey station and/or remind the contact person to deliver in-room questionnaires. The site supervisor is responsible for complying with the instructions and placement shown on the site diagram.

The purpose of the personal visit to the site, although resource intensive, is threefold:

- To provide in-room questionnaires to the hotel staff;
- To complete the data needed on the hotel and to answer any remaining questions the manager may have; and
- To review the survey site.

While the first two objectives could be accomplished by telephone and mailout/mailback of questionnaires, experience has shown that a personal visit to each site has a positive impact on completion rates. A site visit is necessary, however, to review the site and develop a strategy.

In-Person Interviews

In-person interviews may be conducted seven days a week between the hours of 6:00 a.m. and noon, which is check-out time at most hotels. A 24-hour travel recall approach for each person in each occupied hotel room is commonly used.

Because the survey fieldworkers for in-person interviews will arrive earlier than the hotel day manager would normally arrive, the night manager should also be contacted, either by the survey supervisor or, preferably by the day manager or other contact person. This is imperative to keep the survey schedule since a night manager may not allow the survey to start in the morning, thereby requiring rescheduling of the entire day.

The survey station is located in a visible place in the lobby, usually near the front desk. Verbal interviews are conducted with guests who are checking out, waiting in the lobby area, or passing through the lobby. All persons in a room will usually need to be interviewed, just as the household survey commonly accounts for each person in the household separately.

For some recent survey efforts, in addition to the standard clipboard and pencils, or lap-top computer if CAPI is used, each interviewer is equipped with a large, foam-board map of the area and a stand-up "Survey Today" sign posted at the front desk. The map will be used by the interviewer to help the respondents locate trip ends and to code the intersecting streets on the travel diary. For a simple self-geocoding survey, the map may have zones already marked out, and the interview can automatically code the zone number as the destination of the visitor's trip. An example procedures manual for a hotel visitor survey is shown in Appendix J.

Sufficient hotels to accommodate the size of the field staff are scheduled for each survey day. For instance, if the available field crew is two interviewers and one part-time supervisor, each hotel might have to be scheduled for two days to collect sufficient surveys. In this scenario, 35 sampled hotels would take 10 weeks to survey working seven days a week. However, with a field crew of 30 interviewers and three full-time experienced supervisors, four interviewers could be placed at the large hotels and one or two at the small hotels. With eight to 10 crews, the same 35 hotels might only take three to four days to complete.

Although completing fieldwork in a few days sounds enticing, experience has proven that very large field crews can be unwieldy. Errors which are made in the data collection or procedures may not be caught in time to correct or to reschedule the sampled hotel. Crews of 12 to 15 surveyors, with two to three field supervisors, and one overall survey manager work well and allow sufficient personal attention and good quality control.

■ 11.8 Processing the Survey Results

The processing of the data after collection can be as time consuming, expensive, and prone to error as the field collection. Processing includes:

- Editing;
- Coding and data entry;
- Geocoding origins and destinations;
- Computer edits and corrections; and
- Data expansion.

The editing and coding phase for self-completion or PAPI surveys requires a supervisor or trained editor to scan each returned interview form and related survey document to ensure that the information is complete and legible. The forms are generally produced to be self-coding, with a numeric code circled to represent the answer except in the case of trip origin and destination addresses. The editor checks that each data item has been coded, or if vital information is missing, discards the interview as incomplete. The number of interviews collected at a single hotel are reconciled with the available rooms; for instance, one would not accept 200 interviews from a hotel with 25 rooms. The occupancy rate is checked for reasonableness and completeness; if the data are missing or appear to be incorrect, the hotel is called for verification. Once the forms are edited, the complete forms are sorted and placed with the hotel information sheet (which includes hotel name and address, manager's name and phone, number of rooms, occupancy, area-type, and size code) for geocoding and/or data entry.

If the interviewers have collected street addresses and intersection information from the visitors and a GIS is available, automated address matching can be used. Special care needs to be given to the design and collection of address information since visitors are often unaware of where they have been, especially on tours and at special events.

Analysis can be greatly enhanced with additional data to assist in processing the survey, such as a record of special events and special transportation provided during the survey period. Such events can include conventions, shuttle buses run by hotels (including routes, schedules, who runs them , who can use them, cost), hotel tours (eligibility, schedule, cost, itinerary), sports events and any related special transportation, etc. These data can be used to help geocode and analyze the collected visitor information.

The expansion of the hotel survey data to the universe of hotel visitors is based on the total number of hotel rooms available in the study area. As discussed earlier, this information can be obtained from trade associations or similar hotel business groups. The estimation of the expansion factors is a two-step procedure. First, the surveys obtained at each hotel are expanded to the number of occupied rooms at that hotel for that preceding night. Second, the occupied room count for sampled hotels is expanded to total occupied rooms available in all eligible hotels. The basic unit of measurement is the occupied hotel room.

Factoring is the process that weights each completed interview so that the sum of the weights for all completed interviews is equal to the sum of the hotel rooms occupied in the study area. The factoring process consists of identifying an "overall factor" to be applied to the survey results for each hotel.

The completed interviews are first expanded from the number of respondents in each sampled hotel to the number of occupied rooms in that sampled hotel. This first factor is called the *response factor*. The response factor for a stratum is the ratio of occupied units to completed units in the stratum. One could calculate a response factor for each sampled hotel. However, any sampled hotels for which there were zero completed interviews would need to be aggregated with hotels which did have completed interviews. Either method will yield an answer equal to the total occupied rooms in the stratum. A response factor is appended to each completed interview record.

Because not every hotel room is occupied on a typical day and not every hotel is sampled, the surveys are expanded to represent the total number of occupied rooms for all hotels in each area in each size class. This second factor is called the *hotel factor*. The hotel factor accounts for travel by visitors in hotels which were not sampled. This factor is also by stratum, and is equal to the ratio of estimated occupied rooms in all hotels in the stratum to the number of occupied hotel rooms in the sampled hotels in the stratum. If the sampled hotels have the same average occupancy factor as the average occupancy rate for the stratum, then the hotel factor can be simplified to be the ratio of total available rooms in all hotels in the stratum to the available rooms in the sampled hotels.

The occupancy rates for total hotel and sampled hotels should be for the same time period, i.e., if the stratum occupancy rate is an annual average, then the annual average for the sampled hotels should be used rather than the observed occupancy rates during the survey. Occupancy rate information is sometimes considered to be proprietary information and not released for competitive reasons, so that assumptions must be made regarding the rate, and if it is not possible to make a reasonable estimate, then basing the hotel factor on available rooms rather than occupied rooms (the same as assuming an occupancy rate of 100 percent) may be necessary. Sometimes, the occupancy rate information is inflated for publicity purposes and therefore the occupancy rate should be judged for reasonableness and reassurance obtained that all hotels are similarly treated.

The hotel factor is a constant for each stratum and does not change for either sample hotels within a stratum or survey day. The hotel factor is appended to each completed interview record.

The *overall factor* is the product of the response factor and the hotel factor. Once all the factor data is obtained, each sample can have its overall factor calculated in one step using the following calculation:

$$OF_{hab} = \frac{OR_h}{SR_h} * \frac{TA_{ab} * TAO_{ab}}{SA_{ab} * SAO_{ab}}$$

where:

a	=	Hotel size category
b	=	Hotel area-type category
h	=	Sampled hotel
OF_{hab}	=	Overall factor applied to a sample
OR_h	=	Occupied rooms in sampled hotel for night preceding survey
SR_h	=	Number of rooms sampled in sampled hotel
TA_{ab}	=	Total number of hotel rooms available within a stratum
TAO_{ab}	=	Average occupancy rate for all hotels within a stratum
SA_{ab}	=	Number of available hotel rooms in sampled hotels within a stratum
SAO_{ab}	=	Average occupancy rate for sampled hotels within a stratum

For example, assume that a hotel visitor survey is being conducted. In the study area, there are 10,000 hotel rooms available for rent. The hotels are categorized into size and area-type groups and within the medium hotel category in the central business district (CBD) there are 1,000 total rooms available. They have achieved a 80 percent average occupancy rate during the past year resulting in an average of 800 occupied hotel rooms per night for all hotels in that category. The survey design requires that two hotels be surveyed in this category. These two hotels have 400 rooms available and had an occupancy rate of 75 percent during the past year. On the first day of the hotel visitor survey, valid samples are obtained from guests checking out from a total of 20 rooms at one of these hotels being sampled. This hotel had 160 rooms occupied during the night preceding the morning check-out survey. The two hotels that were sampled in that category had a total of 300 rooms occupied on that night.

Therefore,

OR_h = 160

SR_h = 20

TA_{ab} = 1,000

TAO_{ab} = 80 percent

SA_{ab} = 400

SAO_{ab} = 75 percent

and,

$$OF_{hab} = \frac{160}{20} * \frac{1{,}000 * 80\%}{400 * 75\%}$$

$$OF_{hab} = 8 * \frac{800}{300} = 8 * 2.67$$

$$OF_{hab} = \underline{21.36}$$

In this example the response factor is eight and the hotel factor is 2.67. The overall factor is 21.36 for those 20 samples. The samples for the same hotel and same survey day would have the same overall factors, but the factors would differ among hotels and survey days (with rare exceptions).

Once the data have been expanded, the final tabulations will depend on the designed use of the data. To develop a visitor profile, the purpose of the trip into the study area, the number of nights stayed, whether the respondent rented an automobile, the number of persons in the visitor party, the age, sex, and income of the respondent are all valuable information.

For the development of a distribution/mode split model, the person trip rate per occupied room is a basic data item. The trip rates per occupied room should be examined by area type and hotel size to discern significant differences. The trip rates should be developed by mode, purpose of the trip, income of the respondent, time of day, and land use at destination at a minimum.

12.0 Parking Surveys

The collection of parking data has traditionally been conducted to address parking supply/demand, utilization, and turnover issues as part of the transportation planning process. However, as travel demand models have become increasingly sophisticated, parking surveys are also being used to provide additional travel behavior data for input into the modeling process. For example, parking generation surveys can improve the travel model calibration process by identifying and matching the demand and supply of vehicle trips generated to and from parking facilities located within specific traffic analysis zones (TAZs). Parking pricing surveys can also provide a more sophisticated understanding of the price elasticities of parking costs which greatly affect mode choice and consequently, travel behavior.

Parking surveys conducted to improve the travel modeling process are similar to workplace and establishment surveys (see Chapter 10.0), in that trip-makers are usually surveyed at the attraction end of their trip. The purpose of collecting these data relates to the number, type, and geographical distribution of the trips attracted to a specific facility within the framework of the travel model. Workplace and establishment surveys are more common, and, in many cases, may prove to be more effective in gathering travel behavior data than parking surveys. An important consideration related to the implementation of parking surveys is that, by definition, the data may be biased since only information about the automobile travel mode is collected.

Survey teams should consider using the parking survey instead of the workplace and establishment survey for input into the travel modeling process:

- To obtain data about specific parking facility (lots and garages) locations;
- To obtain accurate parking facility cost data;
- To obtain trip origin and destination data on automobile users who may park in a central location while traveling to their actual destinations by other modes such as walking and public transportation (e.g., shoppers and workers in a Central Business District);
- To obtain auto, transit, and walk access information for trip makers traveling from parking facilities to their actual destinations;

- To obtain information on the short-term and long-term parking facility mix;

- To obtain detailed information for specific subareas within the travel modeling system; and

- To obtain data on trip making to and from park-and-ride facilities if new infrastructure improvements are being considered.

The following types of parking facilities should be targeted for surveying in order to collect travel behavior information for input into the travel modeling process:

1. Parking garages or lots available to the general public. If a facility serves only one employer or one building, a workplace/establishment survey will likely result in a higher response rate at lower survey implementation costs. Also, if a particular parking facility is only open to specific parkers such as parkers with monthly passes, parking surveys will probably not be an effective means of gathering unbiased travel behavior data.

2. Parking garages or lots available to the general public that cater to non-work users such as shoppers and tourists. These types of activities are less predictable than work travel, and therefore parking surveys may provide additional input and detail about overall travel behavior.

■ 12.1 Assembly of Background Data

The survey team should first develop an accurate database on the parking inventory of the particular area of study. Similar to the workplace and establishment surveys, key information to gather includes the number of available spaces by parking facility; specific locations of the parking facilities (considering both the existing roadway system and travel model transportation network system); specific driveway locations; parking facility access, egress, and proximity to the existing transit and highway systems; parking facility characteristics such as capacity, square footage, type (surface or garage); various pricing rates and mechanisms; short-term and long-term parking mix; and if available, average parking facility usage and turnover rates.

Typical sources used to develop the parking inventory include:

- Direct interviews with privately owned parking facility management companies;

- Detailed roadway maps (such as Sanborn Maps) and travel model transportation network maps/plots;

- Public Works Departments/Departments of Transportation parking inventories; and

- Assessors Department inventories.

Information collected from the sources mentioned above may not be comprehensive and may be difficult to collect. For example, privately owned parking management companies may not be amenable to sharing information about their parking facility characteristics. Therefore, additional information can also be collected by conducting field visits of the parking facilities in order to gather comprehensive parking inventory data. Field visits typically take the form of windshield surveys designed to identify rate structures, facility types, driveway locations, access and egress to transportation systems, usage, and other key parking facility characteristics.

■ 12.2 Designing and Organizing Parking Surveys

Parking survey design methods include:

- Interviewing automobile parkers arriving and/or leaving a parking facility;

- Providing mail-back questionnaires on the windshields of automobiles parked in the facility; or

- Recording license plates of parked cars, obtaining respondent addresses from DMV files and mailing them a survey.

Mail-back surveys are typically less labor intensive and costly than the interview survey and tend to be more simple to administer. However, mail-back surveys typically obtain lower response rates and require a large distribution of survey forms to achieve the required survey sample. The license plate approach is very similar to the license plate methods described in Chapter 7.0, and therefore is not detailed in this chapter.

With interview surveys, it will be necessary to determine the appropriate sampling procedure (see Chapter 5.0 and the sampling section of this chapter) and interview schedule. For example, should interviews be conducted for arriving or departing motorists from the parking facility. The advantage of conducting interviews upon departure is that the motorist can report the actual duration and price incurred for the particular surveyed trip.

With mail-back surveys, it will be necessary to determine a mechanism to ensure that all parkers receive a survey form. At parking garages or attended parking lots, survey forms can be handed out as parkers enter the facility. At unattended lots or on-street parking spaces, surveyor schedules must be established to determine how often it will be required to distribute survey forms on newly parked cars. At locations that serve mostly commuter parking, a morning distribution of survey forms is typically distributed. However, at parking facilities that cater to a wide range of parkers (such as shoppers, tourists, office workers) and include high parking turn-over rates, frequent survey form distribution may be required.

■ 12.3 Sampling

If the interview approach is used to conduct the survey at unattended lots and/or on-street parking spaces, it will be necessary to identify a sample of specific parking spaces to conduct interviews. Each motorist parking in the identified sample of parking spaces will then be approached by the surveyor for potential interviewing. This method will produce a random sampling similar to interviewing each member of a household using randomly selected telephone numbers in the household travel interview survey.

In order to determine the number of interviewers required to conduct a parking survey, the proportion of short-term versus long-term parkers must be determined. The information obtained in the parking inventory, will provide key data regarding the parking mix to develop the sampling plan for the survey. At garages and attended parking lots, interviews can be carried out at facility driveway entrance and/or exit locations.

If the mail-back survey is used, the parking inventory database will also provide key data regarding the usage, mix, turnover, and number of automobiles using the parking facility being surveyed. This information will be used to identify the survey form printing requirements to ensure that each vehicle parked in the facility will be surveyed. Since the response rate (number of usable survey forms versus the number of survey forms distributed) for mail-back surveys are typically low, survey forms should be handed out to each motorist (or placed on each automobile) to increase the likelihood of obtaining fully completed surveys. The inventory will provide information necessary to determine how frequently fieldworkers will need to go to unmanned and metered parking locations.

12.4 Drafting and Constructing Survey Instruments and Materials

Depending on the survey approach taken, the survey instrument should be constructed to be usable in the field and to elicit the appropriate motorist responses to obtain required data for input into the travel demand modeling process. This includes drafting the appropriate questions to meet the needs of the travel model. The interview and mail-back surveys are typically constructed differently. For example, interview survey questionnaires are designed to allow quick and easy interviewer tallying of motorists responses by using personal interview scripts and CATI programs. On the other hand, the mail-back survey questionnaires because they are self-administered, must be clear and easy for the respondents to fill out.

The construction of the questionnaire typically follows similar procedures as used for other types of surveys including the vehicle intercept and external station surveys (see Chapter 7.0) and workplace and establishment surveys (see Chapter 10.0). Guidelines for constructing mail-back or self-administered questionnaires described in previous chapters should be followed for the parking survey.

If the parking survey is going to rely on distributing self-administered forms on parked vehicles' windshields, the forms need to be designed to stand up to the elements to some extent (surveys of this type should not be conducted in very bad weather). In addition, the forms should be made to be as visible as possible so that motorists see them before they get in their vehicles.

Questions that typically appear on parking survey questionnaires include:

- Purpose of the trip;
- Ultimate (actual) as well as parking facility origin and destination information;
- Location of the residence of the parker (when trip is non-home-based);
- Arrival and departure time to/from the parking facility;
- Perception of the difficulty of finding parking;
- Frequency (average weekly and monthly frequency) of parking at survey location;
- Payment information (form of payment, short-term and long-term costs, etc.);

- Auto occupancy;
- Demographic information about the parker (including income);
- Walking distance/time from parking facility to actual destination; and
- Location and land use of actual destination.

12.5 Pretesting

As with any survey, pretesting should be carried out prior to implementing and administering the survey. For both interviews and mail-back surveys, it is important for the survey team to test the entire process to ensure each component of the survey is feasible and obtains the appropriate level of information required for analysis and travel modeling purposes.

In some cases, mail-back survey pretesting can be administered on a small scale to persons within your company/agency to identify inconsistencies and other issues associated with the format and wording of the questionnaire. See previous chapters of this manual for more detailed procedures and requirements for pretesting.

12.6 Training and Interviewing Fieldworkers

Similar methods for survey training described in other chapters of this manual should be used to train and brief the parking survey fieldwork staff. For example, the training methods described for the vehicle intercept and external station survey and in particular the **Roadside Interview Survey** can be used for the interview parking survey described in this chapter. In addition, the training methods for the **Roadside Handout Survey** described in Chapter 7.0 are very similar to parking mail-back survey also described in this chapter.

In most cases, survey training is conducted prior to the pretest and implementation of the overall survey with all participating surveyors and interviewers. This session is typically conducted several days before the scheduled pretest and overall survey dates. Similar to other surveys described in this manual, surveyors are briefed on the purpose and procedures on how to conduct the survey. Items generally covered by survey team include:

- Project Briefing describing the background and purpose of the survey and a description of survey assignments for all surveyors;

- Survey demonstrations on the procedures of the survey administration describing surveyor/interviewer responsibilities for distributing questionnaires and/or interviewing motorists, survey schedules, etc.; and

- Survey procedures checklist provided to the surveyors and/or interviewers during the initial briefing session including authorization letters and background material.

As part of this process, it is important for the survey team to coordinate with the fieldworkers to ensure that they have been distributed all of the necessary survey materials required to successfully carry out the survey. In the case of the parking survey, the survey materials and instructions for the mail-back and interview surveys differ because of the method for conducting the survey. Similar to specifications described in Chapter 7.0 for the vehicle intercept and external station survey, these materials include:

- Survey forms (interview format and mail-back format as appropriate);

- Record keeping forms;

- Clipboard (for interviewers);

- Writing instruments (preferably pencils); and

- An authorization letter describing the intent of the survey and the request for survey participation.

In the case of the mail-back survey, the survey team must provide additional instructions to the surveyors placing questionnaires on parked automobiles. Fieldworkers should be provided with instructions describing procedures related to the possibility of parkers approaching them or the possibility of parkers remaining in their vehicle during the distribution of the survey questionnaires. Fieldworkers need to know how often they should distribute the survey questionnaires and what area they are expected to cover in the distribution. If the survey questionnaires have serial numbers, fieldworkers will be able to track the parking facility locations and times of survey distribution. If fieldworkers are distributing questionnaires in a staffed garage or parking lot, they must notify the garage attendant before starting to distribute the questionnaires. The survey administrator should discuss details of survey form distribution including:

- If a questionnaire is on a windshield already, there is no need to leave additional questionnaires during subsequent distributions;

- Place the survey questionnaire on the driver's side of the windshield;

- For the on-street survey, make sure to put survey questionnaires on car windshields on both sides of the street;

- Be careful not to damage the windshield wiper or any other part of the car when distributing the survey questionnaire; and

- Survey questionnaires should be placed so that the official logo of the project and sponsoring agency is readily visible to the parker.

Similar interviewing techniques identified for the **Roadside Interview Survey** described in Chapter 7.0 should be used by interviewers to conduct the parking interview survey. The following instructions should be followed if the parking interview survey is conducted:

- If applicable, setup the survey station near parking facility entrance and exit driveways/booths in order to warn motorists of the survey;

- Describe the survey to solicit driver participation;

- If motorists refuse to participate, politely thank them for their time and wait for (or move on to) the next motorist;

- Record all collected information neatly and accurately on the questionnaires; and

- Organize the collected questionnaires by parking facility location and time period.

Variations of interviewing procedures can be used depending on the survey method used and parking facility to be surveyed. For example, the survey station setup will not be an appropriate step for the interviewer if motorists using on-street parking spaces are surveyed. Also, the survey station setup at a staffed parking garage may include a simple notice warning motorists of the survey schedule at the entrance/exit booth.

■ 12.7 Coding

Parking survey coding is conducted using similar procedures used for other surveys described in this manual. In the case of the parking survey, similar techniques are used to code the mail-back and interview surveys. The survey questionnaires are typically designed to be self-coding (except for the origin-destination information), where each survey response can be coded to correspond to its answer check box number. Data coding can either be completed by hand by the surveyors conducting the interview survey and motorists completing the self-administered mail-back survey, or by CAPI for surveyors conducting the interview survey.

The survey data are typically punched into a numerical ASCII database for a specified width and length as determined by the number of questions/responses and sample size of the survey. Individual survey questionnaire responses are typically given an identification number to track the responses for each parker surveyed. Survey origins and destinations must be geocoded to identify the geographic locations of the parkers surveyed. Chapter 14.0 provides a detailed discussion of survey geocoding techniques.

■ 12.8 Cleaning and Editing

Similar data cleaning and editing techniques used for other surveys described in this manual are also conducted for the parking survey. As stated in previous chapters, completed questionnaires should be edited as soon after collection as possible to ensure that the proper surveyor techniques have been used and the appropriate information has been obtained. Range checks should be conducted to identify any data inconsistencies that may occur in the coding process and to verify the accuracy of the data.

13.0 Emerging Use of New Types of Survey Data

■ 13.1 Stated-Response Surveys

Introduction

Definition

The survey techniques and procedures described in other sections of this manual are oriented towards surveys designed to collect data describing actual travel behavior. This type of data is often referred to as Revealed-Preference (RP) data since decision makers reveal their preferences through the choices they actually make in the marketplace. Another type of data that is being used in transportation planning with increasing frequency is based on Stated Responses (SR). This type of data is based on statements made by decision makers on how they would respond in a hypothetical situation.

Lee Gosselin[1] has described a number of techniques that can be included under the general term Stated Response. He has developed a taxonomy of four classes of SR approaches based on whether constraints and/or behavioral outcomes are either predefined or elicited in the survey instruments. These four classes of techniques are summarized in Table 13.1 and described briefly below:

- **Stated-Preference (SP)** - Techniques included in this class focus on choices or tradeoffs among predetermined alternatives in the face of given sets of constraints. A formal experimental design is used to define alternatives in terms of specific combinations of attributes (i.e., travel time, travel cost, etc.) and attribute levels to insure that the influence of each attribute on choice can be inferred. As shown in Table 13.1, both behavioral outcomes and constraints are mostly given.

[1]Gosselin, Lee, M.E.H., The Scope and Potential of Interactive Stated-Response Data Collection Methods, Resource paper, Conference on Household Travel Surveys, Irvine, CA, March 1995.

Table 13.1 Taxonomy of Stated-Response Survey Approaches

	Constraints	
Behavioral Outcomes	**Mostly Given**	**Mostly Elicited**
Mostly Given	Stated-Preference "Given the levels of attributes in these alternatives, which would you prefer?"	Stated-Tolerance "Under what circumstances could you imagine yourself doing...?"
Mostly Elicited	Stated-Adaptation "What would you do differently if you were faced with the following specific constraints?"	Stated-Prospect "Under what circumstances would you be likely to change your behavior and how you go about it?"

Source: Lee Gosselin, M.E.H. "The Scope and Potential of Interactive Stated-Response Data Collection Methods," Resource paper, Conference on Household Travel Surveys, Irvine, CA, March 1995.

The basic type of information sought are choice, rating or ranking data in response to questions such as:

- "Given the levels of attributes in these alternatives, which one would you choose?"
- "Given the levels of attributes in these alternatives, please rank these alternatives in order of preference."
- "Given the levels of attributes in these alternatives, how would you rate each alternative?"

Of the four classes of SR techniques, SP surveys are the most important source of data for developing choice models to represent traveler decisions when faced with new travel alternatives and transportation policy actions.

- **Stated-Tolerance (ST)** - Techniques included in this class do not ask respondents to respond to alternative behavioral outcomes represented by specific attributes and attribute levels. Instead, respondents are asked to identify the conditions under which they would take a particular action or accept a particular behavioral outcome. The basic type of information sought are responses to questions such as: "Under what circumstances could you imagine yourself doing the following?" This class of techniques have not received much attention in transportation planning.

- **Stated-Adaptation (SA)** - Techniques included in this class ask respondents to indicate in a relatively open-ended manner how they would respond when faced with a particular set of constraints. The basic type of information sought are responses to questions such as: "What would you do differently if you were faced with the following specific constraints?"

- **Stated-Prospect (Spro)** - With these techniques, neither the list of possible behavioral outcomes nor a detailed set of constraints is predetermined. Instead, respondents are typically presented with some sort of general scenario (e.g., energy shortage) as a way of initiating the process of eliciting behavioral outcomes and constraints. Measurement methods for these techniques involve the use of simulation gaming techniques. The basic type of information sought are responses to questions such as: "Under what circumstances would you be likely to change your travel behavior and how would you go about it?"

To date, most of the application experience in transportation has been with stated-preference techniques. As a result, the remainder of this section will focus on this class of techniques. A number of references are available for more information regarding the other three classes of SR techniques described above.[2, 3, 4, 5]

Applications

Historically, travel forecasting has been based on actual behavior (i.e., revealed preferences).

Stated-preference techniques have been used extensively in the private sector since the mid-1970s to support product design, pricing, targeting, and marketing decisions for new products and services. In addition, SP techniques have been applied as a means of simulating product demand in order to avoid costly market testing.

Initial applications of SP in the area of transportation date back to the early 1980s[6]. However, SP techniques have only recently begun to be accepted among transportation planning professionals in the United States. This could be due to the historical reliance on revealed-preference data (i.e., data based on observed behavior) for travel forecasting and concerns about the reliability of stated-preferences. In particular, there are concerns that what people say they will do under a specific set of circumstances may be different from what they would do if actually faced with these circumstances.

However, there can also be problems associated with the use of RP data. These include the following:[7]

- In some cases explanatory variables may be highly correlated (e.g., travel time and travel cost), making it difficult (and in some cases impossible) to estimate the effects of these variables;

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[2] Bonsall, P., *Microsimulation of Organized Car-Sharing, The Model and its Calibration,* Transportation Research Board, 59th Annual Meeting, Washington, D.C., January 1980.

[3] Jones, P.M., *HATS: A Technique for Investigating Household Decisions,* Environment and Planning, A 11(1), 1979.

[4] Kurani, K., Turrentine, T. and Sperling, D., *Demand for Electric Vehicles in Hybrid Households: Exploratory Analysis,* Transportation Policy, Fall 1994.

[5] Raux, C., Andan, O., and Godinot, C., "The Simulation of Behavior in a Non-Experienced Future: The Case of Urban Road-Pricing," Preprints, 7th *International Conference on Travel Behavior,* Valle Nevado, Chile, June 1994.

[6] Kocur, G., Adler, T., Hyman, W., and Audet, B., *Guide to Forecasting Travel Demand with Direct Utility Assessment,* U.S. Department of Transportation, Washington, D.C., 1982.

[7] Pearmain, D., Swanson, J. Kroes, E., and M. Bradley, *Stated-Preference Techniques: A Guide to Practice,* Steer Davies Gleave and Hague Consulting Group, 1991.

- Observed behavior may be caused primarily by variables that are not of direct interest, while the variables that are of interest may be "swamped" by these other factors; and

- In situations involving new products, services or policies, there is no observed behavior.

The use of stated-preference techniques overcomes many of these problems.

Transportation applications: things that cannot be represented using RP:

- New services: high-speed rail, toll road facilities, Intelligent Transportation Systems products and services, etc.; and

- Changes in attributes of existing services (fare changes, congestion pricing, etc.).

Design of Stated-Preference Exercises

The design of stated-preference exercises involves the following:

- Developing an experimental design, including the selection of attributes and attribute levels;

- Designing the instrument;

- Defining the context for the exercise; and

- Designing the sampling plan.

Experimental Design

Stated-preference techniques typically make use of an experimental design to determine which combinations of attribute levels should be presented to respondents. The objective of the experimental design is to insure that the attributes presented to respondents are varied independently from one another so that the effect of each attribute on preferences can be identified. Such a design is said to be "orthogonal."

In developing an experimental design, the first step is to specify the attributes and attribute levels to be included in the analysis. As an example, the experimental design used to develop toll road diversion models is presented in Table 13.2.[8] As shown, this experimental design included three attributes:

- Travel time difference on the toll road versus another route;
- Total toll charge; and
- Likelihood of delays on the toll road versus another route.

In general, a minimum of three attributes is usually needed to provide a realistic context for the stated-preference exercise. In general, the attributes associated with a particular stated-preference exercise should represent those factors that are important in the choice process. Experience suggests that the number of attributes presented to a respondent should be limited to six or seven.[9] Presenting respondents with more attributes makes the exercise increasingly difficult for respondents to deal with and may in some instances limit the usefulness of the data. (It should be noted that while it may be necessary to limit the number of attributes presented to any one respondent, the overall design can include additional attributes. The technique for doing this is discussed in a later section.)

Three levels were defined for each of the attributes described in the example presented in Table 13.2. While it is possible to use two attribute levels, a minimum of three levels is required to detect non-linear relationships between attributes and preferences. Therefore when non-linear relationships are thought to exist, at least three levels should be used.

A key design issue in setting values for attribute levels is that these values appear realistic to the respondent. If possible, attribute values should be tailored to be consistent with the alternatives that they would actually be faced with. For example, in the experimental design for the toll road pricing study, travel time differences and toll levels were tailored to the distance that the respondent would actually travel on the proposed facility, which in turn was based on the respondent's home and employment locations.

A "full-factorial" experimental design for this example would include every possible combination of attribute levels. The number of combinations is the result of the number of levels raised to the power of the number of attributes. In this case, three attributes raised to the power of three gives 27 possible combinations. These are presented in Table 13.2.

Each of these 27 combinations of attribute levels represents a toll road alternative that respondents would be asked to evaluate. Experience has

[8] Cambridge Systematics, *E-470 Toll Diversion Model Estimation*, report prepared for Morrison Knudsen and Vollmer Associates, November 1991.

[9] Op. cit., Pearmain, et al., 1991.

Table 13.2 Example Experimental Design: Full Factorial

Alternative	Travel Time Difference	Likelihood of Delays	Toll Cost
	Attributes		
1	10 minutes less	less likely	40 cents
2	10 minutes less	less likely	60 cents
3	10 minutes less	less likely	80 cents
4	10 minutes less	just as likely	40 cents
5	10 minutes less	just as likely	60 cents
6	10 minutes less	just as likely	80 cents
7	10 minutes less	more likely	40 cents
8	10 minutes less	more likely	60 cents
9	10 minutes less	more likely	80 cents
10	same	less likely	40 cents
11	same	less likely	60 cents
12	same	less likely	80 cents
13	same	just as likely	40 cents
14	same	just as likely	60 cents
15	same	just as likely	80 cents
16	same	more likely	40 cents
17	same	more likely	60 cents
18	same	more likely	80 cents
19	10 minutes more	less likely	40 cents
20	10 minutes more	less likely	60 cents
21	10 minutes more	less likely	80 cents
22	10 minutes more	just as likely	40 cents
23	10 minutes more	just as likely	60 cents
24	10 minutes more	just as likely	80 cents
25	10 minutes more	more likely	40 cents
26	10 minutes more	more likely	60 cents
27	10 minutes more	more likely	80 cents

shown, however, that respondents can quickly become fatigued when faced with a large number of alternatives to evaluate. This in turn can lead to significant response errors. Some researchers have suggested that a range of between 9 and 16 options is acceptable, depending on the complexity of the exercise[10]. Therefore, while the stated-preference design for the toll road example is not very complicated, it was nonetheless desirable to reduce the number of alternatives to be presented.

There are several ways to reduce the number of alternatives. These include the following:

- Use "fractional-factorial" designs;
- Remove options that will "dominate" or be "dominated" by all other options in the choice set;
- Separate the alternatives into "blocks," so that the full choice set is completed by groups of respondents, each responding to a different sub-set of options; and
- Carry out a series of experiments with each individual, offering different attributes, but with at least one attribute common to all.

Fractional-Factorial Design - As stated earlier, the experimental design presented in Table 13.3 represents a "full-factorial" design. This type of design includes all possible combinations of attribute levels, making it possible to independently estimate the effects of each attribute on response. The most common way of reducing the number of combinations or alternatives that need to be presented is through the use of a "fractional-factorial" design. These designs use only a portion (i.e., a fraction) of all possible combinations. This approach assumes that some or all of any interactions between attributes, in the way they influence response, are negligible. A fractional-factorial design for the toll road example is presented in Table 13.3. As shown, the number of alternatives is reduced from 27 to 9.

While this approach can significantly reduce the number of alternatives needed for a stated-preference exercise, it does so by ignoring some or all interaction effects. If interactions among attributes are, in fact, significant, their effects will be loaded onto the individual main effects, while it will bias the estimate of the relative importance of individual attributes on response. The degree of bias will depend on the significance of the interaction effects. If this bias occurs, the main effects are said to be "confounded" with interaction effects.

Table 13.3 Example Experimental Design: Fractional-Factorial

	Attributes		
Alternative	**Travel Time Difference**	**Likelihood of Delays**	**Toll Cost**
1	10 minutes less	less likely	40 cents
2	10 minutes less	just as likely	80 cents
3	10 minutes less	more likely	60 cents
4	same	less likely	60 cents
5	same	just as likely	40 cents
6	same	more likely	80 cents
7	10 minutes more	less likely	80 cents
8	10 minutes more	just as likely	60 cents
9	10 minutes more	more likely	40 cents

There are stages by which a full factorial design can be reduced which allow the investigation of some, but not all, interactions effects. There are a number of catalogues available to assist in the design of fractional-factorial designs such as these.[10] In addition, micro-computer-based systems are also available.

Removing Dominant/Dominated Options - This approach applies primarily to stated-preference exercises presented as choice experiments. With this approach, those alternatives that dominate or are dominated in each attribute by every other alternative included in the choice set can be excluded. For example, referring back to the experimental design presented in Table 13.2, 12 of the 27 alternatives could be eliminated because the toll road alternative is less desirable than the non-tolled route. For example, in alternative 25, in addition to the toll, both the travel time and likelihood of delays on the toll road are greater than on the non-tolled route. Further, even those alternatives for which travel time and likelihood of delays are the same, the presence of the toll would make the toll road option less attractive. The only potential drawback with this approach is that any respondents choosing alternatives at random or illogically will not be easily identified based on an analysis of their responses.

Block Design - This third approach involves dividing the total number of alternatives included in an experimental design into sub-sets (or blocks). The sample of respondents is divided into groups, with each group receiving a different block. The success of this approach depends on the similarity of preferences between the different groups of respondents.

Common Attributes - With this approach the attributes to be evaluated are divided among two or more experimental designs. At least one common attribute must appear in each design to allow comparison of relative preferences over all the attributes included.

Instrument Design

Unless the stated-preference exercise is very simple, some sort of visual presentation of the alternatives and attribute levels will be necessary in order to allow respondents to understand and comprehend what is being presented to them. This is particularly true for choice and rating exercise, in which the respondent must compare two or more alternatives. This would limit the usefulness of telephone interviews, unless the respondent has received survey materials in advance.

The format and layout of the instrument used for the exercise will depend to some extent on the type of response sought (i.e., choice, ranking or rating). For choice exercises, respondents will be comparing two or more

[10]Op. cit. Kocur, et al., 1982.

alternatives at the same time. The alternatives comprising the choice set should appear together on a card, sheet of paper or computer screen. For ranking exercises, having each alternative on a separate card is very useful, since this approach allows the respondent to spread them out and physically arrange them in their order of preference. With rating data, it is usually only necessary to consider one alternative at a time independently from other alternatives. Therefore, a wide range of layouts are possible for these responses.

It is always useful and in some cases essential (e.g., when respondents are expected to complete the exercises on their own) to provide materials describing the alternatives, attributes, and attribute levels included in the exercise. This could include drawings or pictures of new travel modes (e.g., high-speed trains) or sample schedules and route maps for new transit services.

Context Definition

A key objective in the design of stated-preference exercises is to establish as much realism as possible. The following points noted by Jones[11] are particularly relevant to building realism into the context of the exercise, the options that are presented and the responses that are permitted:

- Focus on very specific rather than general behavior – i.e., ask respondents how they would respond to a particular product or service under a specific set of conditions rather than in general;

- Use a realistic choice context that respondents have actually experienced or one that they feel they could be placed into;

- Use existing or realistic levels of attributes within the experimental design so that the alternatives are built around these levels;

- Limit the range over which attribute levels are varied to those values that respondents perceive to be possible;

- Wherever possible, incorporate checks on the answers given;

- Allow for the effect of day-to-day variability on choices;

- Make sure that all variables relevant to the choice process are included in the analysis;

- Where possible, simplify the presentation of choice exercises (e.g., by highlighting the attribute levels that are different between alternatives);

[11]Jones, P., *An Overview of Stated-Preference Techniques*, PTRC short course, 1989.

- Make sure that constraints on choice are taken into account (e.g., fixed arrival times at work); and

- Allow respondents to opt for a response outside the set of the experimental alternatives (e.g., in all alternatives in a mode choice exercise are too expensive, the respondent may choose not to make the trip, so "neither" should be included as a possible response).

Sample Design

The same sampling issues associated with revealed-preference data that were discussed in Chapter 5.0 also apply to stated-preference data. The difference with stated-preference surveys is that each respondent typically provides responses to more than one choice exercise. For example, if 50 respondents each complete 5 choice exercises, this would result in 250 data records. It is important to note that even with 250 responses, the sample size from the standpoint of assessing statistical precision is still 50. The fact that there are five data records for each respondent (i.e., five "repeated measures") provides more information about each respondent, but not necessarily more about the population as a whole. Only an adequately sized random sample can do this.

Administration of Stated-Preference Exercises

Key issues in designing a method for administering stated-preference exercises include:

- The degree to which the attribute levels can be tailored to reflect the respondent's situation; and

- The amount of interaction that is possible between the interviewer and the respondent.

There are three primary means for administering stated-preference exercises:

- Self-administered;

- Telephone/mail/telephone; and

- In-person interviews.

Self-administered surveys offer little opportunity for interviewer interaction. While a toll-free 'help' telephone number can be provided, it is not likely that many respondents would go to the trouble of calling. Self-administered survey instruments must be designed very carefully and subjected to rigorous pre-testing. Written material is required to communicate to the respondent the context in which the exercises are to be completed and to define the attributes and attribute levels used in the exercise. If the distribution of the survey instrument can be controlled (by mailing to certain ZIP codes, handing out at toll facilities, etc.), it may be possible to tailor the attribute levels to the respondent's situation. The primary advantage of this method is that it is lower in cost relative to other methods for administering stated-preference exercises.

With telephone/mail/telephone surveys, an initial recruiting call is made to obtain the cooperation of the respondent. This initial recruiting call also provides an opportunity to obtain information that can be used to tailor the exercise to the respondent's situation. The stated-preference exercises are then mailed to respondents. The exercises are then administered as part of a follow-up telephone interview. This provides an opportunity for the interviewer to explain the exercise and answer any questions the respondent may have. This method is more expensive than self-administered, but less than in-person interviews, especially if a broad geographic representation is desired.

In-person interviews provide the greatest degree of interaction between the interviewer and the respondent. It is also one of the more expensive methods for administering stated-preference exercises. In recent years microcomputers have been used to administer choice exercises as part of an in-person interview. Computer-assisted personal interviewing (CAPI) provides an excellent opportunity for tailoring choice experiments based on responses given to preliminary questions. There are several software packages available for designing and administering stated-preference exercises.

Validity of Stated-Preference Results

A concern often voiced about the use of stated-preference data is that people do not necessarily do what they say they will do. Therefore a key issue associated with stated-preference data is validity. Pearmain, et al.[12] have reviewed a number of studies in which the validity of predictions of choice behavior based on stated-preference techniques was investigated. Based on this review, they concluded that the results of most of these studies seemed encouraging, suggesting that stated-preference techniques can predict choice behavior for the sample being studied with a reasonable

[12] Op. cit. Pearmain, et al., 1991.

degree of accuracy. However, they noted that most of the reported studies of validity had the following shortcomings:

- The research was not done in a systematic way;
- The research was carried out as a by-product of a practically-oriented study;
- Some of the studies were based on incorrectly applied prediction methods; and
- Typically the reported research only concerned the reproduction of existing behavior of the sample being studied; few studies deal with the generalization of predictions to entire populations, and very few look at the ability to predict behavioral changes in response to changed circumstances.

They concluded that additional systematic validity research is needed before definitive findings and general guidelines can be given.

Combining Stated – and Revealed-Preference Data

The results of choice-oriented stated-preference techniques is analogous to revealed-preference choice data collected as part of travel surveys. This gives rise to the possibility of combining these two types of data for model development and forecasting. One approach would be simply to pool these two types of data. It has been shown, however, that this naive pooling of stated-preference and revealed-preference choice data can lead to seriously biased models. The key problem, noted by Bates,[13] Bradley and Kroes[14] and others is that these two types of data are subject to different types of errors, making it unlikely that they share a common distribution of unobservables.

A number of approaches have been developed to combine stated-preference data and revealed-preference data for model estimation in a way that accounts for differences in error components. A sequential estimation procedure, described in Ben-Akiva and Morikawa,[15] can be carried out using readily available software. A more statistically efficient simultane-

[13]Bates, J., Econometric Issues in Stated-Preference Analysis, *Journal of Transport Economics and Policy*, XXII(1) 59-69, 1988.

[14]Bradley, M., and E. Kroes, Forecasting Issues in Stated-Preference Research, in E. Ampt, A. Richardson and A. Meyburg (eds.) *Selected Readings in Transport Survey Methodology*, Eucalyptus Press, Melbourne, 1992.

[15]Ben-Akiva, M. and Morikawa, T., Estimation of Switching Models from Revealed-Preferences and Stated Intentions, *Transportation Research* 24A(6), 485-495, 1990.

ous approach has been developed which requires specialized software.[16] This simultaneous approach has been adapted to use a form of nested logit estimation possible with existing software packages.[17]

■ 13.2 Longitudinal Surveys

Nearly all household travel surveys in the U.S. have been one-time "snapshots" of travel behavior in a region. These cross-sectional surveys, even in areas where several surveys have been conducted, have been performed independently, with separate random samples. Therefore, the travel demand models developed for U.S. urban areas capture cross-sectional variation; i.e., variation among individual respondents, but do not capture longitudinal variation, or changes to individual behavior over time. In other words, the changes in travel behavior that might occur when a household obtains a new automobile are modeled by comparing the behavior of households with the original number of vehicles to households with one more vehicle.

Longitudinal analysis is necessary for consideration of several factors affecting travel behavior, including:

- Time lags between an occurrence which changes behavior and the change itself;
- Gaining information about travel conditions;
- Habitual behavior; and
- Experimentation and learning.

To obtain the information necessary for such analyses, a longitudinal, or panel, survey can be conducted. A panel survey consists of several "waves," or repeated surveys performed over time on the same sample. For a household survey, this means that the same set of households is asked to complete a travel survey periodically, say every year or two.

While panel surveys are common in market research outside the transportation field, they are rare within the field. In theory, panel surveys could be developed for many of the survey types described in this manual. However, the difficulties with being able to continually contact respon-

[16] Op. cit. Ben-Akiva, M. and Morikawa, T. 1990.

[17] Bradley, M. and Daly, A., *Estimation of Logit Choice Models Using Mixed Stated-Preference and Revealed-Preference Information,* 6th Annual International Conference on Travel Behavior, Quebec, 1991.

dents over several years has, for practical reasons, limited the use of panels to household travel surveys (discussed in Chapter 6.0). This section deals with longitudinal household surveys.

Because each wave of a panel survey is a cross-sectional survey which is very similar to a one-time household travel survey, panel survey designers should be familiar with the design of and issues concerning household surveys as described in Chapter 6.0. The remainder of this section deals with those aspects of household surveys that are unique to panel surveys. This section should be used only as a supplement to Chapter 6.0.

The only household panel survey that has been conducted for a U.S. urban area is the Puget Sound Transportation Panel (PSTP) in the Seattle area. Because of the uniqueness of this survey effort, it is cited extensively in this section and is described briefly at the end.

Survey Design

The design of the individual cross-sectional travel survey for each wave of a panel survey follows the guidelines provided in Section 6.3. The main additional issues for panel surveys are the number of waves and the time between waves. Ideally, there would be no set number of waves, and the panel would continue indefinitely so that continuing information could be provided. As a practical matter, it will be impossible to guarantee that a panel can continue indefinitely as public agency budgets are not known years in advance.

Because there are few examples of panel surveys, there is no accepted "best" period between survey waves. There are, however, some obvious tradeoffs between longer and shorter intervals. Having longer periods of several years between waves can reduce costs and can provide sufficient "lag" time for various transportation system and other changes to have an effect on travel behavior. Also, the burden on respondents is lower if waves are less frequent. On the other hand, attrition is likely to be higher if the period between waves is long. Not only will respondents lose interest, but more of them will move out of the region or become otherwise ineligible to continue on the panel. The Puget Sound Transportation Panel used waves that were one or two years apart.

Sampling

The development of the initial sample (i.e., Wave 1) for a household panel survey is virtually identical to the development of a sample for a one-time cross-sectional household travel survey, as described in Section 6.5. The only real difference is that respondents are recruited for the continuing survey (all waves) than for a single survey period. There are, however, additional issues concerning the continuation of the panel in subsequent waves, including the following:

- New households must be recruited in subsequent waves to replace households who drop out.
- Households may relocate. If they move out of the study region, they must be replaced; if they move within the region, they should be tracked.
- Households are not static entities; they may merge (e.g., marriage), split-up (e.g., adult children leaving), or add or lose members (births and deaths).
- Households may move into the study region between waves, requiring a mechanism for allowing them to enter the panel to maintain a good representation of the population.

The simplest method for adding new households to the panel is to draw a new random sample of the required number of households, using the same method used to draw the original sample. There are two major problems with this method:

- If dropouts are correlated with certain household or travel behavior characteristics, the new sample will be biased; and
- Changing characteristics of the overall population will not be taken into account.

One way of dealing with the first problem is to classify the households according to important characteristics affecting or related to travel behavior, such as:

- Area type (CBD, suburb, etc.);
- Household size and income;
- Number of autos; and
- Typical travel modes (drive alone, carpool, transit, etc.).

Assuming that the original sample is believed to be representative of the overall population, the new sample should be drawn so that the characteristics of replacement households match those of the dropouts. This can be extended to deal with the second problem as well, assuming information on how the population has changed since the last wave can be obtained.

Another way of dealing with these issues is to assign weights to the households. As discussed in Section 6.12, weights are commonly used in survey data expansion. Depending on the distribution of characteristics of the households, a new set of weights is computed for each wave.

An alternative method for adding new sample households is to base the sample on dwelling units rather than households. In this method, the geographic address continues as the sample element. If households change in composition, they are retained (although any members who move out do not remain in the panel). If a household moves, then the household that replaces them in the dwelling unit is recruited. The main advantages are simplicity, slightly lower costs, and the ability to maintain the sample representation according to dwelling unit-based characteristics (area type, accessibility, income, household size, etc.). It has several disadvantages, however, including the following:

- No information is provided on the cause or effect of the residential move, which could be associated with changes in household composition or income.

- A new household in a dwelling unit is more likely to decline participation in the survey than a continuing household.

Data Items

All data items associated with a cross-sectional household survey should be collected for a household panel survey. The panel survey, however, provides an opportunity to collect additional information on household characteristics that change over time. For example, a household that purchases a new car can report information about the type of vehicle, the type of vehicle it replaced (if any), purchase cost, and perhaps even the reasons for the purchase. Similar questions could be asked about vehicles which are disposed of by the household. Collecting such information would allow the development of a decision-oriented auto ownership model that considers how changing household characteristics affect the number and type of cars a household chooses to own.

Attrition

Probably the most critical issue that is unique to panel surveys is sample attrition. Attrition is defined as households dropping out of the panel after responding to at least one wave of the survey. A household is considered to have dropped out if:

- The household cannot be located for the next wave;

- The household declines to participate in the next wave; or

- The household provides incomplete or unusable responses to the next wave.[18]

Attrition is a serious problem because even if a lost household is replaced, there is no time series information on either the original or replacement household between the previous and subsequent waves, which is the primary motivation for longitudinal surveys. In addition, there is no guarantee that attrition will be random; households with certain characteristics may be more likely to drop out than others.

It is essential that attrition be minimized in panel surveys. This should be done by:

- Maintaining contact with households between waves;
- Tracing households that may move between waves;
- Following up with non-respondents who have agreed to participate; and
- Providing incentives to survey participation, where appropriate.

There are several objectives in maintaining contact with the survey households. It is important to make respondents, who are committing a substantial amount of time and effort, feel that they are appreciated, and that their information is important to transportation planning in their area. This can be done by sending holiday cards, letters of appreciation, and reports on the information collected during the survey. Continuing contact with survey households also provides "early warning" of households who are moving and makes it easier to trace them so that they can continue to participate. In addition, regular communication, which can include providing information about the survey, can maintain interest, especially if there are long periods between waves.

It is obvious that there are benefits to taking time to trace participating households who move between waves. The main advantage, of course, is to allow these households to continue to participate in the panel. Keeping these households is even more critical when one considers that residential location decisions are critical to transportation choices and that there are few if any other sources for data on households who move. Besides maintaining regular contact to provide advance notice of impending or completed moves, another technique to help trace households is to request

[18]Ryuichi Kitamura and Piet H.L. Bovy, *Analysis of Attrition Biases and Trip Reporting Errors for Panel Data*, in Longitudinal Data Methods, edited by David Hensher Pergamon Press, 1987, pp. 287-302.

the name and phone number of someone outside the household who would always know where the panel member was.[19]

Hensher[20] points out that the term "tracing" includes not only locating a household but also obtaining item responses. Since it is critical to maintain households in the sample, it is more critical in panel surveys than in cross-sectional surveys to follow up with respondents who provide incomplete or unusable responses, especially if the respondent has participated in previous waves.

The issue of incentives for household surveys is discussed in detail in Section 6.3. It is raised again here because of the experience of the Puget Sound Transportation Panel.[21] In this survey, the first wave used three different types of incentives in Wave 1: $1.00 pre-survey per *person*, $10.00 post-survey per *household*, and no financial incentive. For subsequent waves, a $2.00 bill was provided for each *person*, paid prior to survey completion. In Wave 1, less than half of the households who received no incentive completed the survey, but over 60 percent of those receiving incentives did. However, the attrition rate for Wave 2 was actually lower for the households who received no incentive in Wave 1 (16 percent) than for those who did (20 percent). The point to be made is that response *rate*, as opposed to the *number* of respondents, is more critical for a panel survey because of the attrition problem, and that any measures that could improve the response rate should be carefully considered.

Despite the efforts to minimize attrition, it is inevitable that there will be some attrition in any panel survey. Households will move out of the area or break up, and some will simply stop participating. The critical issue in dealing with attrition is to ensure that replacement households are chosen in a manner that does not bias the sample, as described above in the "Sampling" section.

Puget Sound Transportation Panel

The Puget Sound Transportation Panel (PSTP), begun in 1989, is the only longitudinal household travel survey in the United States.[22] Each wave

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[19]G.J. Duncan, F.T. Juster, and J.N. Morgan, *The Role of Panel Studies in Research on Economic Behavior, Transportation Research A*, Volume 21, Number 4/5, 1987, pp. 249-263.

[20]David A. Hensher, *Issues in the Pre-Analysis of Survey Data*, in Longitudinal Data Methods, edited by David Hensher Pergamon Press, 1987, pp. 265-285.

[21]Elaine Murakami and Cyrus Ulberg, *Current Status of the Puget Sound Transportation Panel*, presented at the First U.S. Conference on Panels for Transportation Planning, Lake Arrowhead, California, October 1992.

[22]Ibid.

consists of a cross-sectional survey in which respondents are asked to fill out a two-day travel diary containing information on all trips. The surveys were conducted using a telephone contact/mailout/mailback method. The estimated cost of the first four waves is $627,000.

The sample for the survey is stratified by county of residence and by usual travel mode of household members (drive alone, carpool, transit). The initial sample was recruited using random digit dialing, with additional choice-based sampling performed from onboard solicitation of bus riders.[23] In total, transit households comprise about 20 percent of the sample and 10 percent of carpool households. The incentive program, which currently pays each member of a participating household $2.00, is described in the previous section.

Waves in the PSTP have been conducted in the autumns of 1989, 1990, 1992, 1993 and 1994. The original sample size was 1,713 households. For each wave, households who dropped out were replaced; there have been 1,600 to 2,000 households in each wave. Of the households who participated in the original survey (Wave 1), 54 percent completed the survey in Wave 4.[24]

The PSTP takes specific steps to minimize attrition. Regular contact (about twice per year, excluding mailing of the diaries) is maintained with participating households, including notices of diary mailings, summaries of survey results, and holiday cards. In addition, surveys of perceptions, needs, and attitudes have also been conducted three times through 1993.

Summary

The one time snapshot survey of travel is well suited to the task of measuring existing travel consumption in a region. However, when it comes to using the data to anticipate future travel demand or travel demand under changed conditions of infrastructure and/or policies, there is a need for dynamic models of travel behavior calibrated to actual measurements of change in the travel behavior of households. Cross-sectional analysis of change or even change measured by independent household surveys at two points in time lacks the ability to pinpoint change in travel behavior at the household level.

The panel survey, by measuring the change of travel behavior at the individual household level, provides a potentially superior basis on which to

[23]Konstadinos G. Goulias and Jun Ma, *Analysis of Longitudinal Data from the Puget Sound Transportation Panel,* draft report prepared for the Federal Highway Administration, June 30, 1995.

[24]Stephen S. Fitzroy, *Puget Sound Transportation Panel: Four Waves,* presentation to the Travel Model Improvement Program Conference, Dallas, August 1994.

calibrate travel models. The survey can be used in a before and after mode to determine travel response to specific change in the transportation system, policies, traffic control measures, and socioeconomic trends. Panels can be used to monitor travel consumption and travel behavior longitudinally.

Controlling for attrition, bias, non response, and representativeness is critical to the success of the panel approach. In undertaking a panel survey, survey designers should thoroughly review the literature of the topic and enlist the advice and support of practitioners with panel expertise and experience.

14.0 Geocoding of Survey Data

Common socioeconomic indicators (e.g., household income levels, automobile ownership rates), employment requirements (e.g., work shift times), or life-style characteristics (e.g., children in daycare) all contribute to our insight into how and why people travel. In much of the analysis of survey data, such as the number of trips per household in each income range, a trip is a single event and is counted as one unit. However, the fundamental factor which underlies the use of transportation systems is geography. Origin-destination patterns define how many people are traveling in individual corridors, and how many people are in the market to use individual highway facilities or transit services, and how many people converge on downtowns or suburban activity centers. Therefore, travel survey data must be linked geographically.

One of the reasons transportation information is so expensive is because data gathered from surveys on trip origins and destinations must be related to specific geographic locations. This process is commonly referred to as geocoding. Geocoding is the process of identifying the geographic location of a trip end and coding a number, such as traffic analysis zone (TAZ), or Census definition, like a Tract or Block, or X-Y coordinate, to represent that location. Geocoding is often a tedious and time-consuming manual process, but the recent advent of geographic information systems (GIS) has led to greater efficiency and accuracy in the geocoding process.

Geographic Information Systems (GIS) are changing the way survey data are collected, analyzed, and displayed. They are designed to capture, store, retrieve, analyze, and display data files referenced to detailed geographic locations, e.g., latitude and longitude, state plane coordinates, census tracts or blocks, or locally developed geographic schemes such as TAZs. GIS organizes and provides access to geographically coded and referenced data, allowing the user to overlay and analyze it using a common frame of reference (either address or block specific), and display it in an easily understood format.

■ 14.1 Purpose of Geocoding

The travel surveys described in this manual are just some of the examples of data collection efforts which are routinely undertaken in transportation modeling studies to deepen our understanding of the overall demand for travel. Descriptions of locations reported by survey respondents have to be identified in some organized way so that they can be analyzed. Analysis and processing of data collected from these survey efforts inevitably involve geocoding.

Geocoding trip data supports analysis by allowing information collected in the survey (or from the Census) to be graphically displayed and mapped. For instance, the mapping of trip interchanges between zones provides a summary picture of travel in the region by showing the density of movement in particular corridors. A map of the volume of trips over the roadway system overlaid on the top of the capacity of the links making up the system can quickly show the locations where travel is constrained by inadequate transportation infrastructure.

Origin and destination data can also be error checked through the geocoding process. For example, information about the zone, such as the number of households or employees by type in the zone, is gathered to verify the trip ends to that area. If after the data are geocoded, the analyst identifies a significant amount of shopping trips destined to an industrial or empty zone, then error checks on these trip ends can be performed.

Manual Geocoding

Transportation information can be geocoded manually. This effort entails teams of geocoders locating address information obtained from surveys on area roadway/street maps in order to identify the actual geographic area (traffic analysis zone, census tract or block) associated with surveyed trip ends. This information is then keypunched into the data file and linked with the appropriate survey record. Appendix J shows a recent manual geocoding instruction book provided to survey staff workers on the Pima Association of Governments Household Travel Survey.

Historically, manually geocoding travel information has been an expensive and unreliable process. While the information provides great insight into transportation research, it can also dominate planning project resources and budgets. The problems associated with this approach include:

- At best, geographic representation is approximate;
- The process is tedious, time-consuming, of questionable accuracy and reliability;
- It is difficult to geocode manually to points; usually manual geocoding has been done to areas such as zones or census tracts. The problems with geocoding to areas are discussed in Section 14.2.

Geocoding with GIS

Many GIS applications include a geocoding capability that automates this process, allowing a street address, place name, or intersection to be geographically referenced to latitude and longitude, census tract, or traffic analysis zone. Computer-aided geocoding within GIS, such as TIGER/Line Files and Commercial Files described in Section 14.3, offer numerous advantages over manual techniques including:

- First and foremost, GIS, with a good database, can offer *precise* results. Locations can be geocoded to exact X-Y coordinates (expressed according to any desired coordinate system or projection, whether it be State Plane Coordinates, Latitude-Longitude, Universal Transverse Mercator, etc.).

- Native GIS capabilities to perform *point-in-polygon* analysis, i.e., geographic data can be routinely summarized according to any zone system, multiple zone systems, or TIGER File geographic representations. The integrity of the data is also maintained even if zone systems change over time. Data from surveys can be readily analyzed with respect to other socioeconomic data expressed according to other zone systems (e.g., census block groups).

- Automated geocoding with GIS offers significant improvements in geocoding accuracy. While errors can undoubtedly occur through ambiguous address information associated with individual survey records or through errors associated with the address database itself, results will be consistent and will not be subject to judgment errors, fatigue, low skill levels, or other potential problems associated with manual geocoding.

- Automated geocoding is comparatively fast and efficient, and consequently far more economical than manual geocoding. Batch runs can geocode large portions of entire survey databases without user intervention. Rejects, that is those records which can not be resolved by automated geocoding methods, can either be batched out for correction or be inspected interactively. Misspelled words, vague address references, or other problems which can be corrected or interpreted by operators, can also be modified interactively.

- Since many GISs are programmable, high skill levels are not required for geocoders (which has traditionally been low anyway). Geocoders need to be trained in the operation of the program, not in the geography of the region. With application programs, geocoders do not necessarily have to know how to operate the GIS itself.

GIS graphical displays can also be used to compensate for the missing, inaccurate, and incorrect address matches that are likely to occur once the initial rounds of geocoding have been conducted. For example, "Heads-Up Digitizing" can be used to visually locate trip destination paths identified from collected surveys on a digitized road map. This technique identifies the approximate locations of geographic destinations for missing address information. This same technique can be used to identify the likely travel paths of origin and destination zone pairs having identical roadway names in more than one City/Town being surveyed.[1]

14.2 Geographic Unit

Historically, the unit of geography used for analyzing travel data has been zone systems because regions are divided into geographic units (such as census tracts), and travel patterns can be described in terms of origins in one zone connected to destinations in another zone. Census blocks and census tracts both have been used as a geographic zone system in which travel data can be expressed. More often than not, planners define their own zone system (e.g., traffic analysis zones) to describe travel patterns.

Traffic Analysis Zones

Zones are geographic sections dividing the planning area into relatively similar areas of land-use and land activity. Most often, survey data are geocoded to zones that represent the origins and destinations of travel activity within the region. Since typical travel model systems are not powerful enough to represent every household, place of employment, shopping center, and other activity as a separate origin and destination, these land uses are aggregated into zonal representations.

There are serious limitations to geocoding to areas, such as zones, rather than points. These include:

- Surveys geocoded to one zone system can not easily be translated to a different zone system without repeating the entire process;

- Information collected at one point in time may become obsolete because of subsequent zone system revisions; and

- Surveys geocoded to one zone system can not be easily summarized and analyzed with respect to other geographic and data sources.

[1] Sarusa, Wayne A., and Meyer, Michael D., *New Technologies for Household Surveys*, Resource Paper for Household Travel Surveys: New Concepts and Research Needs Conference, Irvine, CA (March 1995).

Census Unit

Zone systems should (and typically do) follow available census data boundaries, either tracts, block groups, or blocks, so that data collected in the decennial census can be used for analysis purposes with minimal manipulation. To implement an efficient data collection and maintenance method, equivalency tables are typically developed to correlate census tracts and census blocks to traffic analysis zones. This table will enable immediate cross reference and database aggregation to traffic analysis zones and various planning areas or other study areas contiguous with Census geography.

The problems previously cited with geocoding to areas rather than points apply to geocoding to census units.

X-Y Coordinates

Much of the current bias in transportation models, such as trip generation and path assignment, are due to the crudeness of zone specification (as well as network definition). Using an X-Y coordinate can generate a precise location for each trip end. The X-Y standard allows the greatest flexibility in terms of redefining geography, such as adjusting zone sizes or recoding to specifications of other zone systems.

The use of X-Y coordinate coding does have a drawback. X-Y coordinates must be designated through a GIS and not manually coded. Therefore, addresses which cannot be automatically matched to a digitized file (which often happens in rural areas) cannot be manually approximated to a particular zone. Although the future of geographic coding will be using the X-Y standard, the decision to use these coordinates must be made on a area by area (travel model by travel model) basis. The travel data may become less representative, for example, if a disproportionate number of trip ends that cannot be coded are from a specific area type, such as a rural area.

Many transportation professionals believe that as *global positioning system* (GPS) equipment becomes cheaper and more accurate, a universal location system based on latitude and longitude will be developed and potentially be used to define geographic systems within travel models. GPS is a federal system of satellites which allow the user to pinpoint any location using triangulation. Equipment for civilian use may be subject to "selective availability," which means that the accuracy is deliberately reduced for national security reasons, but this accuracy level can likely be improved with additional equipment called differential GPS which removes most of the selective availability errors.

■ 14.3 Sources of Base Maps and Address Databases

The availability and cost of the various base map data sources is a primary criterion in determining the suitability for use as the master database for geographic coding and analysis. Another important selection criterion is the accuracy and ability to periodically update the database. Using these two criteria, the following data sources should be evaluated.

TIGER/Line Files

TIGER is a Census Bureau acronym for the digital map database which contains the following digital data for every county in the United States as well as Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Northern Mariana Islands:

- All census map features such as roads, railroads, and rivers;
- Associated collection geography such as census tracts and blocks;
- Political areas such as cities and townships;
- Feature names and classification codes;
- FIPS (Federal Information Processing Standard) codes; and
- Within metropolitan areas originally covered by the 1980 GBF/DIME files, address ranges and zip codes for streets.

The TIGER files replaced the 1980 Census GBF/DIME files. A TIGER/Line is prepared for each county, and the Census Bureau provides files for a State, and all files for the whole nation. The average file sizes are 400 megabytes for a state, and six megabytes for a county. These files are available on CD-ROM in ASCII format.

Typically, significant effort is required to extract street centerline and address information from TIGER files in a format suitable for address-matching. In addition, users should be aware that TIGER files have a reputation for inaccuracies because:

- TIGER files were digitized from 1:100,000 scale maps including actual street locations, and consequently, X-Y coordinates for addresses, which can be inaccurate by as much as 500-feet. This potential error is usually relatively unimportant provided that other GIS layers (e.g., the zone system) conforms to the same TIGER base map.
- TIGER files can also be out-of-date. For example, new subdivisions, roadways, transit systems, and other attributes may not be represented in the database.

In many regions, local governments such as MPOs, counties, cities, and emergency dispatch (E911) agencies, are making commitments to maintain accurate and updated address databases using TIGER files as a base. The newest version of TIGER/Line 1994 includes additional address range and nine-digit zip code information.

Commercial Files

Commercial files are produced and offered by a number of organizations; a source for locating such files is the *American Demographics* magazine. The commercial files usually are based on TIGER files, which are corrected and augmented in ways to match specific markets such as road maps or voting districts. The files specifically augmented and corrected for address matching can be used to save time in geocoding by increasing the coverage of the address ranges provided by TIGER. It is important to check to ensure that these files are as up to date as advertised and to realize that even up to date commercial files may have errors.

So, while a commitment to creating and maintaining regional address databases certainly improves geocoding accuracy and precision, it is by no means required. Address databases can be acquired and installed as part of transportation planning and travel demand modeling projects.

Users should note that successful geocoding through address matching requires, at a minimum, an underlying address system. This element is sometimes forgotten. Typically, most metropolitan areas cover some communities which are rural in character, so references to *Rural Route 1* may not be geocoded efficiently with a GIS. Also, most metropolitan areas encompass significant numbers of respondents who report *post office box numbers* as their official mailing address. These too, cannot be geocoded. Telephone interview surveys can help to ameliorate these problems with careful instructions to field personnel to probe for actual street addresses. However, location data drawn from other sources, such as from self-administered surveys or enrollment files, will present these kinds of problems.

Geocoding inaccuracies due to missing post office box numbers and rural addresses may create a biased dataset. This is an important issue considering the nature of this missing information. For example, inaccuracies would be insignificant if such instances were uniformly distributed throughout a region. However, they typically are not because these issues are much more prevalent in some parts of the region (the rural parts) than in others. Methods can be devised to account for these types of problems, although with less accuracy. For example, survey records can be geocoded according to zip code and possibly allocated to traffic analysis zones based on some type of per capita apportionment, "round-robin," or other random technique. The suitability of these methods depends entirely on how the data are to be used.

■ 14.4 Address Matching and Geocoding

Although trip-end data questions are often designed to ask for the structured address response (street address and number, city, state, and zip code) experience has shown that a minority of respondents present their answers in this format. Respondents often do not know the addresses of their destinations and can typically describe the locations in a general way. For example, some respondents can better identify the closest intersection for a particular destination. The hit rate (address match to geographic representation) achieved during geocoding can vary widely. In some cases, a hit rate of less than 50 percent is obtained. Also, the type of survey, whether it involves an interview where quality control instructions can be followed or a self-administered survey questionnaire with less quality control, has an impact on the usability of address information that can be expected from respondents.

The survey team can identify measures to ensure higher success (hit) rates using interview surveys, including:

- Interviewers can be instructed to probe respondents for full addresses, rejecting post-office box numbers or other insufficient responses.

- "On-line geocoding" can also be used if the interview is being conducted with CATI. As interviewers enter address or place data, the CATI/GIS system seeks to locate the place on a geographical database. Interviewers can be instructed to probe respondents until a match is obtained for the address, intersection, or establishment. The technique requires an excellent geographic database and highly-skilled interviewers. Otherwise, the added interview time and respondent burden brought about by continuous probing reduces the effectiveness of the method. It has been successfully used in a recent household travel survey conducted in the Baltimore Metropolitan Area, using the enhanced 911 emergency system address database.

- Sophisticated geocoding applications using GIS can be used to integrate on-line business directories (available from commercial sources). When these databases are available, interviewers should press respondents for the actual name of the business establishment as businesses are referred to in the telephone book. Also, the nearest intersection can be determined to help resolve business names which operate from multiple locations in the region.

In addition, other geocoding techniques can be employed through GIS, including:

- **Coding to Zones** – In rural areas where address systems do not exist, the most effective approach may involve coding directly to an established zone system (e.g., city boundaries or zip codes). The X-Y coordinate associated with the identified location would be taken from its associated traffic analysis zone.

- **Place and Landmark Names** – GIS applications to support geocoding can offer users the capability to associate X-Y coordinates with general place names or landmarks (e.g., university campuses). Dictionaries describing the locations of these landmarks can be prepared in advance, or, in more sophisticated applications, can be built into the geocoding process as the effort progresses.

- **On-Screen Pointing** – GIS applications can be developed to allow users to use the screen cursor to point to geographic locations on on-screen graphics systems representing a particular region.

To a greater or lesser extent, some of these techniques may result in only the identification of approximate geographic locations and may involve interpretation of the respondent's answer. Under these circumstances, it is important to record the geocoding method actually used as part of the survey effort, so that later analysis can be conducted to distinguish between X-Y coordinates which are known with some accuracy and precision from those which were approximated or interpreted.

No GIS offers native capabilities to incorporate these kinds of functions into a geocoding project. However, since many systems are programmable, geocoding applications that can be run within a GIS can be developed to provide this type of functionality.

Using GIS for geocoding, the survey team can determine geographic points by searching an address database. The address database is typically a digital map of street centerlines for a region which includes each street segment coded with the beginning and ending street numbers, on both the right and left sides of the street. A search of the database can locate the appropriate street segment by the specific address provided by the respondent. Interpolation of the address from the end points of the block can be used to define a unique coordinate for the location.

This procedure dates back several decades with the emergence of GBF/DIME geographic files supported by the Census Bureau. The Census Bureau also offered address-matching software to allow planning agencies to geocode survey databases. These methods have now been eclipsed by geocoding capabilities offered by GIS, which operate in a personal computer or workstation environment, and are, therefore, more widely available to users.

A wide variety of GIS software is available in the marketplace, ranging in price from $600 for versions which operate on personal computers to $20,000 for large and powerful systems that operate on engineering workstations. Various versions of these programs are available from vendors that can be operated on multiple and different operating systems (PC-DOS, OS/2, Windows, and UNIX). The features of these programs vary, and the buyer should explore their suitability for the types of address-matching and geocoding capabilities that are desired. Some of the relevant features that users may desire include:

1. **Capability to Geocode from Address Databases** – GIS packages typically provide some capability to geocode locations based on addresses. For example, street centerline databases (such as those which might be acquired from Census TIGER files) are coded with the beginning and ending address for each street segment, on each side of the street. Locations for addresses appearing in a survey database, then, are typically assigned an X-Y coordinate location along the street segment through interpolation.

2. **Capability to Geocode Intersections** – Survey respondents are frequently requested to identify the nearest intersection. GIS packages should have a capability to parse intersection addresses if users are dealing with surveys of this type.

3. **Capability to Geocode from Parcel Files** – One of the first goals for regions embarking on GIS development programs often involves the creation of a parcel database (developed to support Assessor's Information). Along with other data, a typical parcel database contains address information. Geocoding survey information based on rapid searches of a parcel database offers even greater precision than address-matching based on street centerline databases because X-Y coordinate locations are not interpolated, but are precise to the zone of the parcel.

4. **Programmability** – A capability for users to write applications to geocode or to improve upon the geocoding process can be a desirable feature for the GIS. These applications will permit agencies to write more sophisticated geocoding techniques and to conduct geocoding using less skilled technical staff (staff need only learn how to operate the application, not the GIS itself). For example, household surveys involve many repetitive locations (family members typically travel together, and, therefore, the same destinations recur frequently in the file), so applications can be written to speed the geocoding process by checking if locations have been previously geocoded. More sophisticated applications can be developed to integrate the telephone directory (for business names) on-line with the geographic database to augment geocoding capabilities.

5. **Reject Processing** – Most of the effort expended on geocoding and address-matching involves reject processing. Rejects are survey records for which the GIS cannot fully resolve the respondent location. Reasons for address rejection may include spelling errors, incomplete or ambiguous address specifications, and non-existent addresses. These records must be inspected manually. In addition, individual addresses may not be resolved because of multiple hits. For example, two streets may intersect at more than one location, so the GIS cannot identify the appropriate address match. It is also common for the geocoding process to accept a less than perfect match, i.e., to assume that a close match is acceptable. Extreme caution must be exercised if such a process is used. Users should examine how gracefully GIS handles the various types of rejects, and the degree of user-interaction provided (or required).

6. **Geocoding Offsets** – Ultimately, travel surveys often require location information to be assembled into various zone systems (e.g., census tracts, traffic analysis zones). This can be easily and automatically performed by a GIS through point-in-polygon analysis. Many of these zone system boundaries, however, follow major streets. This may cause problems in the GIS related to assigning zones to points which fall exactly on the boundary. More sophisticated GISs provide a capability to offset X-Y locations so that they will fall into the correct zone.

7. **Address Parsing** – Addresses described on survey records must first be interpreted by the GIS software. The number, street name, street type, city, and zip code information must be identified and then matched against the database. This interpretation of the survey record is known as parsing. The sophistication of GIS systems to parse address information is an important feature and should consider the following questions regarding GIS capabilities:

   - Do address components have to be already divided into separate fields by the user so that they can be easily parsed, or can the GIS do this itself?

   - Do all address components have to exist or can the GIS address-match based on incomplete information (e.g., survey respondents rarely know whether their destination was MAIN ST or MAIN BLVD)? Can the GIS accommodate vague or ambiguous addresses?

   - Does the presence of other address information, such as apartment numbers, confuse the address-matching algorithm?

How well equipped is the address-matching function to accommodate the unique addressing schemes used in the area? For example, the following potential problem areas need to be considered:

- The same street name in two different communities;

- The same street name with different suffixes (Crescent Avenue versus Crescent Place);

- Directional prefixes (East Wyoming versus West Wyoming);
- Different ways of referring to the same street (Martin Luther King Jr. Blvd., M.L. King Blvd., King Blvd., etc.) and;
- The use of Spanish-style street naming, where the street type precedes, rather than follows, the street name (e.g. Camino del Fuego).

14.5 Summary of Recommended Geocoding Procedures

While geocoding procedures will vary depending on the type and characteristics of the specific survey, the following guidelines are recommended.

1. **Geocode to X-Y coordinates.** As discussed in Sections 14.1 and 14.2, there are serious drawbacks to geocoding to areas, such as modeling zones or census tracts, rather than points. Point data can always be later aggregated to areas if necessary. Since point geocoding requires a data file to be used for address matching, this leads directly to the next guideline.

2. **Begin by using an automated matching procedure.** If an interviewing system such as CATI is used, this may be done on-line as the survey proceeds. As mentioned in Section 14.3, all areas in the U.S. have at least one source for address matching, the TIGER file. Many areas may have alternate sources, either public or commercial, that my provide greater accuracy. In any case, a significant percentage of the addresses can be matched at relatively low cost. It should be stressed, however, that there are always errors in automated geocoding and that there is always a substantial number of addresses that cannot be matched automatically.

3. **Check a sample of the results from the automated matching procedure.** Because of the probability of errors, the results from the automated matching procedure must be checked. If a large number of errors is found, the automated procedure must be revised, replaced, or possibly abandoned.

4. **Perform manual geocoding of addresses not matched or matched incorrectly by the automated procedure.**

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