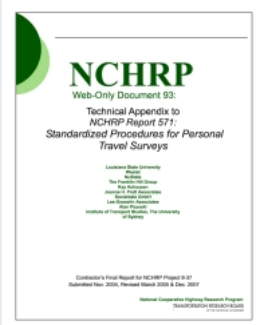

Technical Appendix to NCHRP Report 571: Standardized Procedures for Personal Travel Surveys

DETAILS

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Contents

CHAPTER 1

1. INTRODUCTION

This document represents the technical appendix to the main report of NCHRP project 8-37, published as *NCHRP Report 571: Standardization of Personal Travel Surveys.* It contains chapters that elaborate on and provide background to the main report. Chapter 2 of the Technical Appendix is a summary of the literature reviewed for this project and provides useful background on the state of the practice in household and personal travel surveys, definition and application of standards to surveys in the social and marketing sciences, and other related issues. Chapter 3 provides a brief review of the process that was used to determine what issues would be covered in this research, and how these were then classified. Chapters 4 through 10 provide the detailed background for the standardized procedures that are proposed in the main report. Chapter 11 provides the references that are used in this Technical Appendix.

Each of chapters 4 through 10 are organized to provide a brief definition of the topic, background, or introduction at the outset, followed by a discussion of the research and reviews that were undertaken. Recommendations for adoption of standardized procedures, or for guidelines are not provided in these chapters, because they are to be found in the main report. A cross reference to the main report is provided, however, at the end of each section.

CHAPTER 2

2. Literature Review Results

2.1 REVIEW OF THE STATE OF PRACTICE

2.1.1 Introduction

There has been a tendency for metropolitan areas to concentrate their survey efforts around each turn of a decade, respecting the wishes of the U.S. Census Bureau to stay out of the field in the Spring of the year in which the Decennial Census is undertaken. As a result, the most recent major push to complete household travel surveys took place in the early 1990s, and is well documented in both *NCHRP Synthesis 236* (Stopher and Metcalf, 1996) and the TMIP "Scan of Recent Travel Surveys." (TMIP, 1996). These two documents reviewed surveys through 1994-5. Relatively few surveys have been conducted since then, until the year 2000, during which a number of major surveys were initiated. In this review, it has largely not been possible to include surveys initiated since 2000, except insofar as details may be available from the Requests for Proposals that have been issued. In addition, such surveys do not provide information on outcomes, which are a large part of what is important in this review. Therefore, we have opted not to include any surveys currently in the field, or those that have recently finished fieldwork, but from which final outcomes are not yet known or documented.

This review examines a number of aspects of each survey and outlines how each was achieved. The aspects covered are:

- Design of Survey Instruments;
- Design of Data-Collection Procedures;
- Sample Design;
- Pilot Surveys and Pretests;
- Survey Implementation;
- Data Coding including Geocoding; and
- Data Analysis and Expansion.

Detailed descriptions are not provided, but an attempt is made to identify what appear to be the customary methods, procedures, and measures used in the surveys. Section 1 concludes with a discussion of the impact of technological and social changes on travel surveys.

2.1.2 Review of Recent Surveys

Some Recent Surveys

A few recent surveys were gathered together as part of this project. Of these, six were not included in other recent reviews of surveys. A brief description of the surveys is provided below.

The 1997-98 New York and North Jersey Regional Travel Household Interview Survey (RT-HIS). The NY/NJ Regional Travel Household Interview Survey (RTHIS) was conducted to provide data to construct a state-of-the-art transportation planning model for the New York/ New

Jersey/Connecticut metropolitan region. Data were collected from 28 counties, and the study was conducted by the New York Metropolitan Transportation Council (NYMTC) and New Jersey Transportation Planning Authority (NJTPA) over a period of 16 months extending from February 1997 to May 1998. It used telephone recruitment and a telephone retrieval (CATI) procedure. The survey materials were mailed to the recruited households.

The survey sampling plan was intended to provide sufficient information for mode choice model development and a snapshot of county level travel information for weekday travel. The sample design and selection procedures used a stratification process based on different levels of mode utilization and residential density. The sampling rate varied between 0.04% (minimum) and 0.68% (maximum) among the strata.

Travel diaries were used to record the travel information of participating households who were assigned specific travel days to record their travel over a period of 24 hours. The actual number of households in the 28-county area of the survey was 7,180,538 (sampling frame). In total, 14,441 (including 323 weekend sample) households were recruited to participate in the survey. Of these, 11,264 households completed the travel diaries (10,971 were weekday samples, and 293 were weekend samples). Travel information was retrieved from all household members regardless of age.

The 1996 Bay Area Travel Survey. The 1996 Bay Area Travel Survey was conducted to provide data for the continuing development and improvement of the Metropolitan Transportation Commission's (MTC) Regional Travel Demand Forecasting Model, as well as to provide a better understanding of travel behavior in the San Francisco Bay Area. The Metropolitan Transportation Commission's jurisdiction includes the nine-county area of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solana, and Sonoma counties. The survey was conducted by the Metropolitan Transportation Commission (MTC) of Oakland, CA.

The Bay Area survey was conducted in two phases: January through May of 1996, and again between September and December, 1996. A 48-hour activity diary was used to record all activities and travel conducted during an assigned 48-hour period. Household recruitment was conducted by telephone followed by mailing out of the survey materials. Retrieval of the data was conducted by telephone (CATI).

The proposed sample size for the Bay Area Travel Study was 3,750 households consisting of 1,750 randomly sampled households and 2,000 households that use the Bay Bridge corridor. The sample size was designed to attain a margin of error of 1.3 percent overall at a 90% confidence level. In addition, all strata were to achieve less than a 10% margin of error at the same confidence level. According to preliminary 1996 projections by the Association of Bay Area Governments, the total number of households in the nine-county area was 2,339,160. In total, 5,857 households were recruited to participate in the study. Of these, 3,678 households completed travel diaries. Information was retrieved from all household members regardless of age.

The 1996-97 Corpus Christi Study Area Travel Survey. The Corpus Christi Survey was conducted to collect and update data related to travel characteristics in the Corpus Christi metropolitan area. The survey population included residents of Nueces and San Patricio counties. The survey was a part of an on-going effort of that period by the Texas Department of Transportation (TxDOT) to collect and analyze travel behavior across the state. The data was to be used by TxDOT and local agencies to identify transportation needs in urban areas and to update transportation and air quality models in the region.

The survey collected travel and activity information from respondents over a specified 24-hour period. The sample was designed to attain an accuracy of ±12% at the 90 percent confidence level, resulting in an estimated sample size of 1,550 households. However, in order to cater for unforeseen circumstances, the final sample target was set at 1,705 households. According to the 1990 Census, the Nueces and San Patricio counties had 349,894 residents in 118,333 households. In total, 2,182 households were recruited to participate in the study. Of these, 1,712 households completed travel diaries. Information was collected from all household members aged 5 years and older.

The survey was conducted between April 1996 and April 1997. The survey used the telephone to recruit participants. After recruitment, a respondent package was mailed to each recruited household. Retrieval of travel information was accomplished by CATI.

The 1995 Origin Destination Survey for Northwestern Indiana. In the fall of 1995, the Northwestern Indiana Regional Planning Commission (NIRPC) conducted an Origin-Destination Survey, the first such survey conducted for Northwest Indiana in over twenty years. The survey was conducted to address the ever-increasing challenge of providing more efficient transportation facilities to accommodate escalating travel in the region.

The survey was a self-administered, mail-out, mail-back travel survey. Households were randomly recruited from a list of mailing addresses. The specific objective of the survey was to identify all trips made by members of the participating households on a single survey day. The survey was conducted during September, October and November of 1995, between Labor Day and Thanksgiving.

The geographic scope of the survey was the three counties of Lake, Porter, and LaPorte in northwestern Indiana. The three counties were subdivided into 292 traffic analysis zones (TAZs). Approximately 25,000 households were randomly selected in the three-county area with the objective of obtaining 2,500 usable, completed surveys. This represented a targeted one percent sample, because it was estimated that there were approximately 257,000 households in the sampling frame. Because the households were not evenly distributed throughout the three county areas, sampling was stratified by urban, suburban and rural parts of the region.

The Origin Destination Survey used a one-day trip diary to collect the travel information of the participating households. The survey collected travel information from all households members 14 years of age and older.

The 1996 Broward Travel Characteristics Survey. The Florida Department of Transportation initiated the Broward Travel Characteristics Study (BTCS) in February 1996 to identify the localized trip making characteristics of Broward County and improve the travel forecasting accuracy of the Florida Standard Urban Transportation Model System (FSUTMS) for the area.

A survey package was developed that requested information on household characteristics and income (Household Verification Survey), the daily trip making events (Travel Logs), and the propensity for using transit (the Direct Utility Assessment Survey). The survey utilized a series of telephone and mail-out questionnaire surveys to establish the socio-economic and travel characteristics of Broward County. A systematic random sample pool of 6,851 households was drawn from the Property Appraiser records of Broward County. More than 13,000 telephone calls were made to screen and recruit households to participate in the survey. From the initial sample of 6,654 recruited households, 42 percent of the households (2,803) participated in the Household Characteristics Survey, and 93 percent of those households (2,625) agreed to participate in a subsequent travel log survey.

All households were requested to complete the Household Verification Survey, which included most of the questions asked in the Screener Survey with additional information on the Travel Maker's Profile Code and household income. The major goal of the Direct Utility Assessment (DUA) survey was to identify the survey participant's propensity to use travel modes other than "drive alone" and to develop coefficients for use in transit modeling. For the Travel Log Survey, a series of questionnaires were used to identify the travel characteristics of the study area. The major travel characteristics sought in the study included; household trip generation, trip purpose, trip length, travel time, and modal split.

Mail out survey packages were sent to 2,625 households that agreed to participate in the mail out portion of the study. Approximately 33 percent of these households returned travel logs and 22 percent of these returned DUA surveys. This resulted in a total of 867 households that returned the travel log packages, and 194 households that returned the DUA survey. The survey used a one-day travel diary to collect travel information from participating households. Households were advised to complete the travel diaries for a selected day. The survey collected travel information from all household members six years of age and older. The survey used mail-out, mail-back for the Travel Log Survey, while the Household Verification Survey data were collected by CATI.

The Travel Log survey period for the Broward Survey was scheduled for the fourth and fifth weeks of March 1996. The Department required the travel log portion of the survey to be completed prior to the end of the "peak season" thereby requiring the survey logs to be completed by the end of March 1996. March 19-21 and March 26-28 were selected as the travel log dates for the survey.

The 1991 California Statewide Travel Survey. The California Department of Transportation maintains a state-wide travel database, which is used to estimate, model, and forecast travel throughout the State. The information is used to help in transportation planning, project development, air quality analysis, and a variety of other program areas. The database contains socio-economic and travel data for California as a whole, all rural counties combined, and each of the following 15 urban regions:

- AMBAG (Monterey and Santa Cruz Counties);
- MTC (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties);
- SACOG (Sacramento, Sutter, Yolo, Yuba, and Western portion of El Dorado and Placer Counties);
- SCAG (Los Angeles, Orange, Riverside, San Bernardino, and Ventura Counties); and
- The counties of Butte, Fresno, Kern, Merced, San Diego, San Joaquin, San Louis Obispo, Santa Barbara, Shasta, Stanislaus, and Tulare.

The survey data includes socio-economic household data such as persons per household, vehicle availability, employment status, household income etc. For travel, the survey collected information from all household members as well as out-of-state overnight guests who were five years of age and older. The travel data contains information such as characteristics of all trips by all modes, the location of trip origins and destinations including the time of each trip, trip purpose, and vehicle occupancy.

The survey used telephone recruitment, a mail-out questionnaire and telephone retrieval. Sampling was performed using random digit dialing (RDD) with samples stratified by region for the weekday travel, and a single statewide sample for weekend travel. Regional sample sizes were determined in advance to meet minimum regional statistical reliability requirements. Thus, the statewide total sample was built as an aggregation of basic regional needs. The use of regionally-based sample size determination resulted in non proportional sampling across regions for weekday travel.

The survey resulted in approximately 13,501 households being interviewed for weekday travel and 900 households being interviewed for weekend travel. Interviews were conducted from one of several centralized telephone facilities, with 75 percent of the sample using CATI. Interviews were conducted in English, Spanish, Vietnamese, and Korean, as well as Cantonese and Mandarin. Interviews for the weekday sample were conducted between May 15 and June 28, 1991, while interviewing for the weekend sample occurred between September 9 and October 29, 1991.

The Greenville Urban Area MPO Household Travel Survey. The Greenville Urban Area MPO Household Travel Survey was conducted to address the transportation planning needs for obtaining accurate information on travel characteristics of households in the MPO area and for use in developing and calibrating transportation travel demand models. The Greenville MPO planning area is located in Pitt County, North Carolina. For transportation planning purposes, the Greenville MPO is subdivided into 229 Transportation Analysis Zones (TAZs). These TAZs, which comprise the entire MPO Planning Area, contain a total of 75,000 persons and 33,000 dwelling units.

The survey used telephone recruitment with a mail-out, mail-back questionnaire. The target sample size for this survey was 1,000 households with a targeted response rate of 50 percent. A total of 1,596 households completed the telephone survey and agreed to complete the travel diaries. Of these, 1,058 households actually returned usable travel diaries. Participating households were assigned a travel day (Sunday-Saturday) to record all trips conducted in a 24-hour period by members of the household aged 5 years and over. The survey was conducted over a period of eight weeks (September-November, 1998).

The 2000 Southeast Florida Regional Travel Characteristics Survey. The 2000 Southeast Florida Regional Travel Characteristics Survey was conducted to provide information for

developing planning tools for the surface transportation facilities for the three-county region of Broward, Palm Beach and Miami-Dade counties. The survey was designed to allow state and local government planners to understand when, where, how, and why people travel. It was also designed to provide information that will allow local planners to estimate where growth will occur, estimate congestion, and estimate how the development of roads, buses, and trains might improve travel in the region.

Recruitment was by telephone, followed by a mail-out demographic survey form and a one-day travel diary. Retrieval was by CATI. Travel diaries were distributed to all household residents. Data collection began in December, 1998 and was completed in September 1999. The required sample size was estimated as 5,060 households. This sample required a specified number of households by each of 18 geographic areas (districts) of the three counties under study, and for a set of demographic characteristics. Travel logs were collected for 5,100 households involving all travel conducted by all members of the household on one day. Approximately 10,000 bus riders were surveyed. Visitors were surveyed at 79 hotels. Trucking information was gathered from 848 commercial establishments that use trucks. Workers were surveyed at seven major employment areas in the three counties.

The 1993 Wasatch Home Interview Travel Survey. The 1993 Wasatch Home Interview Travel Survey was a survey conducted on a sample of 3,000 households. The survey was coordinated and managed by the Wasatch Front Regional Council (WFRC). The goal of the survey was to collect information about the demographics and travel characteristics of households within the jurisdiction of the WFRC and another local agency, the Mountainland Association of Governments (MAG). The WFRC covers Salt Lake City and Ogden, Utah, while MAG covers Provo and Orem, Utah.

The survey used a one-day activity diary in which respondents were asked to record each activity they conducted during the 24-hour period. The assigned survey days were weekdays (Monday-Friday) only. The diary days were assigned between March 22 and May 14, 1991. Data were collected from all persons aged five or older in the sampled households. The survey was a telephone recruitment, mail-out, mail-back survey. The household sample was selected using RDD. It was estimated that approximately 7,500 completed households would have to be recruited to yield 3,000 completed households (Salt Lake City 1200, Ogden 900, and Provo/ Orem 900 households) with an estimated 40 percent response rate. The actual number of households recruited was more than 7,512 and the total number of completed households was 3,082 (WFRC 2,181, and MAG 901).

Ohio Kentucky and Indiana Household Activity and Travel Survey 1995. The OKI Household Activity and Travel Survey was conducted to provide the service area of the OKI Governments with a new data base of travel patterns and behavior to assist in updating the region's transportation models. Data were collected from seven counties. These included the Ohio counties of Butler, Warren, Clermont and Hamilton (including the City of Cincinnati); the Indiana county of Dearborn; and the Kentucky counties of Boone, Campbell, and Kenton.

The study was conducted by URS Consultants with Market Opinion Research over a period of six months, in the latter half of 1995. It used telephone recruitment and retrieval (CATI) procedure. Survey materials, including cover letters, were mailed to recruited households. A 24-hour activity diary was used to record all activities and travel conducted during an assigned day.

The proposed sample size for the OKI Household Activity and Travel Survey was 3000 households. The sample size was designed to attain a margin of error of 1.8% overall at a 95% confidence level. Initially, 5000 households were recruited, allowing for a response rate of 60%. Information was retrieved from all household members regardless of age.

Treasure Coast Survey 1996. The Florida Department of Transportation initiated the Treasure Coast Travel Characteristics Study in January 1995 to identify the localized trip making characteristics of the Treasure Coast region and improve the travel forecasting accuracy of the Florida Standard Urban Transportation Model System (FSUTMS) for the area. Data were collected from the counties of Martin, St Lucie, and Indian Counties. The study was conducted by Walter H. Keller, Inc. consultants and sub-consultants Regional Research Associates, Inc. and Marda L. Zimring. Inc. It used telephone recruitment and retrieval (CATI) as well as mail back retrieval. Survey materials were mailed to recruited households.

A survey package was developed that requested information on household characteristics and income (Household Verification Survey), the daily trip making events (Travel Logs), and the propensity for using transit (the Direct Utility Assessment Survey). The survey utilized a series of telephone and mail-out questionnaire surveys to establish the socio-economic and travel characteristics of the Treasure Coast Region. A systematic random sample pool of 5,000 households was drawn from the Property Appraiser records of the Treasure Coast regions. From the initial sample of 1,531 recruited households, 46.4 percent of the households (702) participated in the travel log survey. This survey was identical to the Broward County Survey, with the Household Verification Survey, and the Direct Utility Assessment survey.

Mail out survey packages were sent to 1,531 households that agreed to participate in the mail out portion of the study. Approximately 46 percent of households returned travel logs and 38 percent of these returned the DUA surveys. The survey used one-day, two-day and three-day travel diaries to collect travel information from participating households. Households were advised to complete the travel diaries for a selected day(s). The survey collected travel information from all household members six years of age and older. The survey used mail-out, mail-back for the Travel Log Survey, while the Household Verification Survey data were collected by CATI, as in Broward County. The Travel Log survey period for the Treasure Coast Survey was scheduled for the fourth and fifth weeks of March 1995.

RESEARCH TRIANGLE SURVEY (1994). This survey data set was used in this research, but documentation was not provided to us, beyond what was needed to understand and make use of the data for analysis. Data from this source are reported in the following sections of the report, but no documentation is available to summarize the execution of the surveys.

Examination and Comparison of the Acquired Surveys

The surveys above were examined and compared in an effort to identify common trends in current travel survey practice. Due to the limited sample of surveys considered in this comparison, the results are not taken as entirely representative of current practice. However, this review together with the findings of the survey scans conducted in *NCHRP Synthesis 236* and the Travel Model Improvement Program (TMIP) Scan of Recent Surveys, provide a reasonable review of the state-of-the-art in travel survey practice.

Most of the surveys used a one-day travel diary, although the 1996 Bay Area Survey used a 2-day activity diary, while the Wasatch Survey, the Corpus Christi Survey, and the OKI Survey used 1-day activity diaries. None of these surveys used a time-use diary. Most of the surveys collected similar socio-demographic data, with the usual variables being gender, age, relationship of household members, driver status, and employment status. However, the methods for collecting age, and the categories of relationships and employment status vary from survey to survey. On employment status, for example, Table 1 shows some of the categories used.

Table 1: Examples of Working Status from Recent Surveys

Survey	*Work Status Categories*
Research Triangle	Retired, homemaker, unemployed but looking, unemployed not looking, student, employed, multiple jobs
Wasatch	Employed full time, employed part time, multiple jobs, retired, unemployed
Broward	Retired, homemaker, working, unemployed
Bay Area	Employed, unemployed, homemaker, retired, other
OKI	Working outside the home, working within the home

Trip purpose is another variable that was collected with varying categories from survey to survey. Activity surveys do not explicitly collect data on trip purpose, although it is derived from the activities

reported. To provide an idea of the variations that were used in these surveys, Table 2 provides an overview of some of the categories.

Nine of the twelve surveys collected information on work status, but two did not. Two of the eleven surveys collected data on occupation and one collected data on industry. The remainder did not attempt to collect any industry or occupation data. In the two cases where occupation was collected, the categories were not the same in the two surveys.

Table 2: Examples of Trip Purpose Categories Used in Some of the Surveys

Survey	*Research Triangle*	*Southeast Florida*	*Treasure Coast*	*Indiana*	*Greenville*	*Broward*	*California*
Work		X	X			X	X
Work commute or work errand					X		
Work at regular jobsite	X						
Primary work location				X			
Work at other location	X						
Work-related site				X		X	X
Work at home	X						
Business		X	X				
Drop off/pick up someone	X	X	X	X			X
Visit friends/relatives	X						
Eat meals	X	X	X	X		X	
Social/recreational/entertainment	X	X	X	X			X[1]
Recreational					X	X	X
Shop	X	X	X	X		X	X
Doctor/dentist/other professional	X			X[2]		X[2]	
Other family/personal business	X	X[3]	X[3]	X[3]			
Household					X		
Religious/civic	X						
School		X	X	X		X	X
School at regular place	X						
School at other place	X						
Daycare/babysitter		X	X				
Sleep	X						
Other activities at home	X						
Other activities not at home	X						
Home		X	X			X	X
Change travel mode		X	X				X
Other				X		X	X

[1] Social/entertainment (recreation was defined as a separate purpose)
[2] Medical or dental
[3] All except Research Triangle used the phrase "Personal Business"

As can be seen from Table 2, only the Southeast Florida and Treasure Coast surveys used identical categories, and this because both were conducted by the same firm for the same client. Otherwise, there is no agreement on trip purpose categories. For the four surveys that used activity diaries, there is similarly no agreement on activity categories.

DESIGN OF DATA COLLECTION PROCEDURES. Two of the surveys – Greenville and Wasatch – used mail-out with mail-back for the household travel survey. The remainder used mail out with telephone retrieval. All of the surveys used telephone recruitment to recruit households for the survey, followed by mail out of the survey materials. Four of the twelve surveys used a reminder call on the eve of the assigned travel diary day. Of those surveys specifying the number of attempts that should be made

to retrieve data from a recruited household, one specified three attempts, while two others specified six attempts.

Six of the twelve surveys specified that data were to be collected from all household members, regardless of age. Five specified five years old and above for data collection and one specified six years old and above. Most of the reports did not specify rules with respect to proxy reporting. The Research Triangle survey was an exception to this, specifying proxy reporting for adults, for minors, and for an adult who had completed a written diary. The definition of a complete household was also not provided in the documentation of most of the surveys. For Research Triangle, it was defined as a household with completed records for all household members. Nine of the surveys did not use an incentive. The Bay Area survey provided a calculator as an incentive for a subsample of the recruited households. The Research Triangle Survey provided $1 per household and a pen for each member of the household.

Sample sizes and response rates, where reported, are shown in Table 3. Not all surveys reported response rates. In most cases, it appears that the response rate was that of recruited households, not the overall response rate including response to the recruitment. In the cases of the Bay Area, Corpus Christi, and Research Triangle, the response rates are overall response rates. In the other cases, it is not known, although the reports suggest they are completion rates, not response rates. No other aspects of Data Collection Procedures were defined in the reports on the surveys.

Sample Design. Three surveys used simple random samples. The remainder used stratified samples, with stratification being conducted by geographic area, vehicle ownership, and household size.

Table 3: Sample Size and Response/Completion Rate for the Twelve Surveys

Survey	*Sample Size*	*Response/Completion Rate*
Bay Area	3,678	63% (completion rate)
Greenville Travel Study	1,058	55% of recruited HH
Wasatch Travel Study	3,082	N/A
Indiana Transportation Study	1,070	N/A
Broward Travel Characteristics Study	702	46% (completion rate)
Treasure Coast Study	N/A	N/A
California Statewide Survey	14,417	N/A
Corpus Christi Study	1,712	72% of recruited HH
Southeast Florida Regional Travel Char. Study	5,168	N/A
RT-HIS Regional Travel Interview Study	11,264	78% (completion rate)
OKI Survey	2,870	57% (completion rate)
Research Triangle Survey	N/A	N/A

PILOT SURVEYS AND PRETESTS. Five of the surveys reported using a pilot test or pretest. No details were provided of changes that resulted from the use of these preliminary surveys. Also, no detail was provided on how much of the survey implementation was subjected to pilot testing.

SURVEY IMPLEMENTATION. Again, few details were provided in the reports on survey implementation. Most of the telephone retrieval surveys used Computer-Assisted Telephone Interviewing (CATI) procedures for data retrieval and also for recruitment. In most cases, the reports indicated that CATI included various logic checks and validity checks as part of the programming. Other implementation details are not provided.

DATA CODING INCLUDING GEOCODING. Six (possibly eight) of the surveys used GIS software to geocode data and provided geocodes to the level of latitude and longitude. One survey geocoded the data to Traffic Analysis Zone (TAZ) level only and did not specify the method, although it appears to be manual. Similarly, one geocoded to both TAZ and latitude and longitude, and appears to have done so using manual procedures or a computer-based address-matching software. No information is provided on the remainder. No other information was provided on the data coding.

DATA ANALYSIS AND EXPANSION. Only one survey indicated methods used for expansion and weighting, which was the Research Triangle survey. This survey used a fairly intricate method of

weighting to correct for various biases in the sampling plan, and corrected for the presence of multiple telephone lines in some households and shared lines in others. Weighting was also applied to correct for nonresponse bias on the basis of household size, household income, number of vehicles owned, and age. The comparison base was the Public Use Microdata Sample (PUMS) data of the Bureau of the Census from 1990. However, five of the surveys reported sample biases that were determined either from the sampling plan or from comparison to supplemental data, predominantly the decennial census. The results of this are shown in Table 4. In all cases, except as noted, the categories of households identified are under-represented in the sample data.

Table 4: Sources of Identified Bias in Five Surveys

Survey	*Biases Identified*
Bay Area	Household size > 4 Households with no workers or more than 2 workers Households with no vehicles Households earning less than $20,000 Households earning between $60,000 and $75,000 Renters
Indiana	Two-person households (over-represented)
Broward	Low income households Households with no vehicles
Corpus Christi	Low income households Two-person households (over-represented)
OKI	Two-person households (over-represented)

2.1.3 NCHRP Synthesis of Highway Practice 236

NCHRP Synthesis 236 (Stopher and Metcalf, 1996) provides a review of 55 household travel surveys conducted in the period from 1989 through 1995. The principal aspects of these surveys are summarized below.

Design of Survey Instruments

For the design of the instrument, most surveys comprise three elements: a household element, a person element, and a travel or activity element. In addition, when using telephone recruitment, followed by mail out of the survey, there are at least two instruments required: a recruitment script, and a survey package. To this may be added a retrieval script, when survey data are collected by telephone retrieval (54 percent of recent surveys) or reminder scripts, when survey data are collected by mail (22 percent). A number of features of recent survey instruments are summarized in Table 5. At the date of this review, no time-use surveys had yet been implemented, although two were underway – one in Portland and one in Dallas-Fort Worth. The retrospective surveys did not use diaries, and presumably collected trip-based data, rather than activity data, although this was not established formally.

Table 5: Design of Survey Instruments

Design Feature	*Proportion Using*
Retrieval Method	
Telephone	54%
Mail	22%
Other/Unspecified	24%
Prospective/Retrospective	
Prospective	95%

Retrospective	5%
Instrument Type	
Trip Diary	76%
Activity Diary	19%
Other/Unspecified	5%
Instrument Format – Trip Diaries	
Sheet	86%
Booklet	14%
Instrument Format – Activity Diaries	
Sheet	10%
Booklet	90%

Design of Data-Collection Procedures

The most important elements of this are timing, incentives, reminders, and response rates. Timing of surveys has traditionally been in the Spring or Fall, with the desire to produce an "average" travel day. Table 6 summarizes data on the season in which the survey was conducted. Weather was the reason that the majority (80 percent) gave for conducting the survey in only the spring or the fall, or both. A second timing issue is the days of the week for the survey. Again, the convention has been to collect data only on weekdays, and this was followed in 87 percent of cases. The remaining 13 percent also included weekend days in the survey.

As of the mid-1990s, the use of incentives was still not widespread in household travel surveys. Of the surveys reviewed, 80 percent used no incentive. Of those using an incentive, half used cash, one-third used some form of lottery or drawing, and the remainder provided a gift, such as a pen. One case used both cash and a pen. The amount of the cash incentives was not reported, but other anecdotal information indicates that incentives of one dollar per person (diary) are the most common. Incentives can be offered as an inducement to respond (sent in advance) or as a reward for responding (sent to those completing the survey). The lottery or drawing is normally restricted to a reward. In those cases where cash was used, half provided the incentive in advance, and half as a reward to those completing the survey.

Table 6: Season in Which Survey Was Conducted

Seasons Included	***Proportion Reporting***
Spring only	40%
Fall only	22%
Fall and Spring	10%
Fall/Spring and Summer	11%
Fall/Spring and Winter	8%
All Four Seasons	1.5%
Not Specified	7.5%

Table 7 shows the breakdown of how many reminders, the type of reminders, planned contacts, and the mix of multiple reminders that were used in the surveys. Where three contacts were planned, this was usually a recruitment contact, one reminder, and the retrieval contact.

Response rate has become one of the most critical areas of household travel surveys, as a result of falling rates over the past several decades. This review found a lack of consistency in how response rates were calculated, making it somewhat difficult to determine comparative statistics on response rates. Response rate also depends on the method of data collection. The Synthesis reported that mail-back surveys achieved response rates between 5 and 24 percent, with a mean of 14 percent. For telephone surveys, recruitment rates were reported as ranging from 12 to 100 percent, with a mean of 49.9 percent and median of 50 percent. Although there appears little reason for it, the retrieval method also shows an

influence on the recruitment rate, with the rate averaging 58.3 percent for mail-back surveys, and 45.7 percent for telephone retrieval of the data.

Table 7: Profile of Reminders in Recent Surveys

Aspect of Reminders	*Proportion Reporting*
Using Reminders	
Yes	80%
No	20%
Form of Reminders	
Telephone Call	93%
Letter	7%
Number of Reminders Used	
One	60%
Two to Three	20%
Four or More	20%
Form of Multiple Reminders	
Telephone only	75%
Telephone and Postcards	10%
Telephone and Letter	8%
Telephone, Letter, and Postcard	8%
Planned Contacts	
One Contact (no reminders)	10%
Two Contacts (no reminders)	20%
Three Contacts	50%
Four or More Contacts	20%

Sample Design

Sample design covers several sub-elements. First, there is the sample size, which is summarized in Table 8. Of the surveys using telephone recruitment (78 percent), 83 percent used random digit dialing to draw the sample, while 17 percent used published telephone directories. Seventy percent of the surveys used a minimum age cut off for collecting data of five years of age, while 15 percent set no limit; 93 percent of the surveys intended to exclude group quarters, although four percent inadvertently included some in the end.

The most common method of selecting the sample was telephone recruitment, followed by mail out of surveys and telephone retrieval of the data. This was the method used in 54 percent of cases. Mail-back of surveys following telephone recruitment and mail out of a package of materials was selected by 22 percent of the cases. Thus three-quarters of the surveys used telephone recruitment and mail out of materials.

Table 8: Some Sample Properties

Sample Property	*Final Sample*	*Recruitment Goal*
Sample Size		
Mean	4,167	12,400
Median	2,460	7,700
Percent <2,000	45%	-
Percent >10,000	15%	-
Sampling Method		
Stratified	56%	
Simple Random Sampling	24%	
Other	30%	

Pilot Surveys and Pretests

As noted in the *NCHRP Synthesis 236*, the terms pilot test and pretest tend to be used interchangeably by the transportation profession, even though the survey research literature distinguishes these two activities. In this section, we use the term pilot test to cover either a true pilot test or pretesting. It was reported that 74 percent of the surveys included in the review used some form of pilot test. Among these, all tested the instrument, 58 percent tested survey management, and less than 50 percent tested other elements of the survey, such as training, sampling, data entry, geocoding, analysis, or incentives.

Table 9 shows some statistics of the pretest and pilot surveys. It should be noted that some pilot tests were performed on agency staff and received a 100 percent response rate, which biases the response rates upwards. Also, not all regions reviewed provided both recruitment and completion figures for the pilot, so that the recruitment and sample data do not relate exactly to one another.

As a result of conducting a pilot test, 85 percent of those testing it changed the survey instrument in some way, and 65 percent of those testing the management changed some element of the survey management. Similarly high figures of change are reported for each of the survey elements, except for data entry and analysis, where changes were reported for only 18 and 11 percent of those testing these elements, respectively.

Table 9: Pretest and Pilot Survey Samples

Attribute		***Statistic***
Sample Size		
	Mean	336
	Median	67
	Percent Under 75 Households	82%
	Percent Under 200 Households	94%
Responses		
	Range	0 to 1,800
Recruitment		
	Mean	121
	Median	40
Response Rates		
	Mean Response Rate	57.5%
	Median Response Rate	61.7%

Survey Implementation

Items included under this topic were not reported in the *NCHRP Synthesis 236*. They have to do with such elements as interviewer training, retention of data on incomplete households, cross-checks of data, days and periods to avoid collecting data, etc. These items were not elicited in the review done for the Synthesis Report.

Data Coding including Geocoding

In recent surveys, 43 percent reported manual coding (usually to a separate document) followed by data entry. The second most popular method of data entry was direct entry through the use of CATI, which was used by 39 percent of the surveys. There were two reported instances (three percent) of the use of mark-sensing. The remaining 15 percent used some combination of manual and direct entry procedures.

Geocoding is generally required to be a separate activity, following coding and data entry of literal addresses. Among reviewed surveys, 30 percent used manual geocoding, consisting of having

coders look up addresses, locate them on a map, and provide the appropriate geocodes. Fifty-five percent reported the use of a combination of computer and manual geocoding, with the manual element usually being for those addresses that the computer could not recognize. Nine percent used computer geocoding alone, and six percent reported some other method of geocoding, such as relying on respondents to provide a zip code.

The single most frequently-used source for geocodes was reported to be the TIGER or GBF/DIME files from the U.S. Bureau of the Census, which were used by 48 percent of recent surveys as either their sole or one of their sources of geocodes. The second most frequently-used source was telephone directories, used by 37 percent. Maps were used by 34 percent, while a community database, such as 911 data bases, was used by 28 percent.

The level of geocoding has been changing from the sole use of Traffic Analysis Zones to using latitude and longitude. However, as of the mid 1990s, the most common geocoding level was still the TAZ, used by 36 percent, followed by 33 percent who used the TAZ together with at least one other level of geocode. Coding to latitude and longitude was performed by 31 percent of surveys, while 17 percent used the census tract, 15 percent the zip code, and eight percent used census blocks or block groups.

As noted earlier, data are most frequently coded into three files – a household file, a person file, and a trip or activity file. Each of these files may contain some data from the higher aggregation file, while the higher aggregation files may contain summaries from the lower level files. Approximately 50 percent of the surveys reviewed followed this type of file structure, or a combination of these into a single file. Ninety percent of the surveys used a household file, 80 percent used a trip file, and 65 percent used a person file. Two other file types were reported – an activity file (16 percent) and a vehicle file (18 percent). As of the mid-1990s, 38 percent of agencies did not make their data available to anyone outside the agency, while 26 percent made the data available to any interested party.

Most agencies provide the findings from the survey through a final report, with 85 percent reporting that these final reports are available from the survey. Both newsletters and public forums were reported as being used by 13 percent of agencies.

Data Analysis and Expansion

The rate of completion of recruited households ranged from 36 to 97 percent, with a mean of 69.5 and a median of 72.5 percent. Completion for mail back was lower at 61 percent, while telephone retrieval had a mean of 72.5 percent. As a percentage of contacted households, these response rates provide a range of 10 to 75 percent, with a mean and median of about 36 percent (these figures being obtained by multiplying the recruitment and completion percentages together). For all telephone contact methods, the average response rate was 33 percent, while for telephone contact with mail back, the mean was 35 percent, and for telephone contact with telephone retrieval, it was 32 percent.

In addition to confusion on how to calculate a response rate, there are also differences in what constitutes a completed household for the purposes of calculating the response rate. Of the agencies that reported response rates, 56 percent required information from all household members for the household to be considered complete. Thirty-three percent allowed some household members to provide incomplete information, provided that data on critical variables was not missing. In one survey (two percent), the household was considered complete if no more than one person was missing from the household, while 19 percent had varying numbers of missing persons permitted, depending on household size.

Another measure of the survey that was not reported in the *NCHRP Synthesis 236* was the rate of non-mobile persons and households. These are households and persons reporting making no trips on the day of the survey. In trip diaries, this is potentially a mechanism of non-response, in that persons may indicate they did not travel on the survey day as a way to avoid completing the diary. It is not an effective non-response mechanism for activity and time-use diaries, if in-home activities are also to be reported. However, for an activity diary that requests only detailed out-of-home activities, it is again a potential nonresponse mechanism.

The second issue here is correction of data. Approximately 20 percent of recent surveys took the position that the data retrieved was noncorrectable. Obvious errors in the data retrieved were used, in these instances, as a criterion for acceptance or rejection of a household from the sample. Because time is essential in gaining information from the respondent for correction of data, 70 percent of recent surveys reviewed at least some aspects of each survey record on a daily basis, so that call backs could be made to resolve errors. Of the remainder, eight percent reviewed the data on a weekly basis, two percent on a monthly basis, and ten percent at the end of the survey. The remaining ten percent did not check the data or were not aware as to how the survey consultant checked the data. Even with the checks, 20 percent made no corrections to the data. Two-thirds made corrections to both missing and invalid data, and 14 percent restricted corrections to invalid data only.

Only seven percent of surveys reported making corrections from inference only, while 62 percent made corrections through a combination of re-contact information and inference. When no re-contact was successful or possible, 38 percent left the data as invalid or missing, while 62 percent made some type of repair or discarded the data entirely. The use of such methods of data repair as hot-deck imputation were not reported. All repairs reported were made by inference and correction of earlier invalid, missing, or otherwise erroneous data.

About 80 percent of recent surveys defined certain questions as being critical, and 81 percent of these then discarded households that were missing any of the critical data. The remainder set such households on one side for analysis only where the missing data item was not used. Households that terminated part way through the retrieval of data were dropped from the data set in 60 percent of the surveys, while 30 percent retained them in a separate file. Six percent of surveys indicated that such data remained in the main survey file.

Issues of validation and weighting were not addressed in the *NCHRP Synthesis 236* report. It seems that the profession has largely ignored the issue of weighting of data, and also rarely concerns itself with expansion of data, particularly because the data are generally intended to be used in unexpanded form for model estimation. One part of validation, the examination of trip rates, was reported in some studies. However, as *NCHRP Synthesis 236* reports, this is a complex issue, because there are many ways to define trip rates, and many inconsistencies in how this is generally done. With all of the variety of definitions that can be used (linked and unlinked, inclusion or exclusion of non-motorized trips, minimum trip-length definitions, trip purposes, person or vehicle trips, etc.), the review reported that average person trips per person per day were generally between 3.5 and 4.2, with household person trip rates averaging between 8.9 and 10.2 in the surveys that were reviewed.

2.1.4 TMIP Scan of Recent Travel Surveys

A document from the Travel Model Improvement Program (TMIP) of the U.S. Department of Transportation, reports on a number of recent travel surveys of various types (TMIP, 1996b). These surveys partially overlap those included in *NCHRP Synthesis 236*, but neither set out to be exhaustive, and each contains some different surveys. In addition, the Scan of Recent Travel Surveys (TMIP, 1996a) includes other than household travel surveys. For the purposes of this project, other than household travel surveys are not included.

A useful point is made in this report about the implementation of household travel surveys:

> "All but two of the large MPOs have carried out household surveys since 1990...About two-thirds of the smaller MPOs surveyed have carried out household surveys since 1990...Overall, the largest MPOs have apparently been the most diligent about conducting surveys, due to available resources and to the greater extent of problems confronting large urban areas. It also appears that new survey efforts and practices generally are first introduced into the largest MPOs and then gradually spread over time into smaller urban areas. In particular, a select few of the larger

> MPOs have been at the forefront of revising and expanding both the nature and scope of household travel surveys." (Scan of Recent Travel Surveys, TMIP, 1996a Page 2-1)

In *NCHRP Synthesis* 236, there were 55 surveys that were included. In the TMIP Scan, there are also 55 surveys. Interestingly, the two sets are not identical, with 32 of them being the same. As a result, the findings from the two documents are not necessarily identical. The scan does not provide as detailed information as the Synthesis, and much of the information is not organized in summary form, but is provided through brief half-page summaries of each of the 55 surveys.

Table 10 attempts to summarize most of the relevant information from these brief descriptions. The surveys are organized, in this case, by three MPO size groups and a category of statewide surveys.

Table 10: Summary of Scan of Recent Surveys

Urban Area Size	*Urban Area*	*Sample Size*	*Sampling Method*	*Recruitment Method*	*Min. Age*	*Bike/Walk Trips*	*Retrieval Method*	*Diaries Returned*	*Type of Diary*	*Pilot Test*	*Coding Method*	*Data Repair*	*Timing*	*Resp Rate*	*Incentives*
Group 1 (>2,000,000 Population)	Atlanta	2,400		phone			Phone	No	Trip (1-day)						None
	Baltimore	2,700		phone	5	Yes	Phone		Trip (1-day)		On-line		Fall	44%	None
	Boston	3,800	Stratified	phone	5	No	Mail	Yes	Activity (1-day)		M/C	Yes	Spring		Lottery Ticket
	Chicago	19,314	Random	Mail	14	No	Mail	Yes	Trip (1-day)			Yes		24%	None
	Cleveland	1,600		phone			Phone								
	Dallas/Ft Worth*	6,000	Stratified	phone	None	Yes	phone/mail	Yes	Activity (1-day)	Yes	Computer	Yes	Sp/F		$2/person
	Detroit	7,400	Stratified	phone	5	No	Phone	No	Activity (1-day)		Computer				None
	Houston	2,443	Stratified	phone	5		Phone	Yes	Activity (1-day)		Computer		F/W/ Sp		None
	Los Angeles	16,086	Stratified	phone	5	No	Phone	No	Activity (1-day)	Yes	Comp/M		F/Sp	45%	None
	Miami	2,650		phone		No	Mail	Yes	Trip (1-day)						$2.00
	Minneapolis-St. Paul	9,746		phone	5	No	Phone	No	Trip (1-day)				Su/F		None
	New York (1995)	2,000		phone		Yes	Mail	Yes	Activity (2-day)						$5.00 per wave
	New York (1996)*	12,000	Stratified	phone	5	Yes	Phone	No	Activity (1-day)	Yes			F/Sp		None
	New York (1989)	20,500		phone		No	Phone	No	Trip (1-day recall)				Spring		None
	Pittsburgh	450	Stratified	phone			Mail	Yes	Trip (1-day)						Yes
	San Diego	2,049		phone		Yes	Phone	No	Trip				Spring		None
	San Francisco (1990)	10,900		phone	5	Yes	Phone	No	Trip (1, 3,or 5 days)						$5 for 3 or 5 day survey
	San Francisco (1996)	3,800		phone/transit	None	Yes	phone/mail	Yes	Time-Use (2-day)				W/Sp		
	Seattle	1,700	Stratified	phone (panel)	None	Yes	Mail	Yes	Activity (2-day)						$2/person
	St. Louis	1,400		phone		No	Phone	Yes	Trip (1-day)				Spring		No
	Tampa	1,800	Stratified	Mail		No	Mail	Yes	Trip (1-day)						Map
	Washington, DC	4,800		phone			Phone	No	Trip (1-day)						
Group 2 (750,000 to 2,000,000 population)	Buffalo	2,700	Stratified	phone	5	No	Mail	Yes	Trip (1-day)	Yes		Yes	Spring		None
	Cincinnati	3,000	Probability	phone	None	No	Phone	No	Activity (1-day)		Computer	Yes	Fall		None
	Denver*	5,000		phone/transit		Yes	Phone		Activity (1-day)				Spring		
	Indianapolis	1,000		phone	5	Yes	Phone		Trip (1-day)						None
	Kansas City	1,221	Stratified	phone			Mail	Yes	Trip (1-day)		Computer		Fall		$1, $2, gifts
	Louisville	2,643			None								Sp/Su		
	Milwaukee	17,000		phone/home		No	phone/home	Yes	Trip (1-day)						None
	Portland, OR	4,451	Stratified	phone	None	Yes	Phone	Yes	Time-Use (2-day)		Computer	Yes	Sp/F		None
	Raleigh-Durham	2,000	Random	phone/transit		Yes	Phone		Time-Use (2-day)	Yes	Computer				None
	Sacramento	4,000		phone		No	Phone	No	Trip (1-day)		Computer		Spring		$1
	Salt Lake City	3,082		phone		Yes	Mail	Yes	Activity (1-day)				Spring		None
	San Antonio	2,643		phone			Phone	Yes	Trip (1-day)				W/Sp	28%	None
	San Juan	1,610		phone	5	Yes	phone/home	No	Trip (2-day)				F/W		Lottery for

Urban Area Size	*Urban Area*	*Sample Size*	*Sampling Method*	*Recruitment Method*	*Min. Age*	*Bike/Walk Trips*	*Retrieval Method*	*Diaries Returned*	*Type of Diary*	*Pilot Test*	*Coding Method*	*Data Repair*	*Timing*	*Resp Rate*	*Incentives*
															prizes
Group 3 (<750,000 population)	Albuquerque	2,000	Stratified	phone		Yes	Mail	Yes	Trip (1-day)		GIS				None
	Amarillo	2,590		phone			Phone	Yes	Trip (1-day)						None
	Boise	1,500	Random	phone	5	Yes	Phone	No	Activity (1-day)	Yes	Computer		Spring		None
	Brownsville, TX	1,411		phone			Phone	Yes	Trip (1-day)						None
	Charleston, WV	1,500													
	Des Moines	1,139	Random	Mail		No	Mail	Yes	Trip (1-day)						$100 drawing
	El Paso	2,510		phone	5	Yes	Phone	Yes	Trip (1-day)				W/Sp/Su		None
	Fort Collins	1,000		Mail	5	Yes	Mail	Yes	Trip (1-day)				Spring		None
	Harrisburg	1,161		Mail			Mail	Yes	Trip (1-day)						None
	Honolulu*	4,000		phone	None	Yes	Phone	No	Activity (1-day)				Winter		pen
	Little Rock	856	Stratified	phone		No	Mail	Yes	Trip (1-day)				Fall		None
	Reno	1,050													
	Sherman-Denison, TX	2,289		phone			Mail	Yes	Trip (1-day)						None
	Tucson	1,913	Stratified	phone	None	Yes	Phone	No	Trip (1-day)		M/C	Yes			None
	Tyler, TX	2,646		phone			Mail	Yes	Trip (1-day)						None
Statewide	California	13,500	Stratified	phone		No	Phone	No	Trip (1-day)		Computer				$1
	Indiana	1,000		phone	5	No	Phone	no	Trip (1- and 14-day)				Fall		None
	New Hampshire	2,000	Stratified	phone	None	Yes	Phone	No	Activity (1-day)		Computer				None
	Oregon	10,000		phone	None	Yes	phone	Yes	Activity (2-day)						None
	Vermont	2,425		Mail		No	mail	Yes	Trip (1-day)						None
		4406.9													

* Indicates survey underway at the time of the scan.

Design of Survey Instruments

From Table 10, the only aspect of survey instrument design reported on is the type of diary. In 33 cases out of the 55 (60 percent), trip diaries are specified as being used and four cases did not provide that information. Of the remainder, 15 (27 percent) used activity diaries, and three (five percent) used time-use diaries. In this case, the percentages using time-use and activity diaries is higher than the surveys reviewed in *NCHRP Synthesis 236*, and the Scan uses more recent surveys than the *NCHRP Synthesis 236* report.

Two other design issues that are reported in the Scan are the minimum age from which data were collected. In 15 surveys, the minimum age was five years old, and in one survey it was 14. In ten surveys, there was no minimum age. The remainder did not report this information. Second was the inclusion of non-motorized trips (specifically walk and bicycle trips). In 21 cases, these trips were included. In 18 cases, they were definitely not included, so that only motorized trip data were collected. The remaining cases are not specified.

Design of Data-Collection Procedures

On timing, 19 of the surveys are indicated as being performed in the Spring, Fall, or both. Seven of the surveys indicated that either Winter or Summer was included with either or both of Spring and Fall, while one survey was done in Winter only. The remaining surveys are not specified as to season. Again, this indicates the strong preference to survey in Fall, Spring, or both. Thirteen surveys reported using an incentive, while 34 indicated no incentive was used. The remainder did not specify. This shows a slightly higher rate than in the *NCHRP Synthesis 236* of the use of incentives (24 percent compared to 20 percent). Only four surveys reported a response rate, which ranged from 24 to 45 percent. This appears to show a lower response rate average than the *NCHRP Synthesis 236*, but this is probably due to the low number of surveys reporting a response rate. No indication is provided of how response rates were calculated.

Sample Design

Of those surveys for which the sampling method is reported (22 or 40 percent), the majority (17) selected stratified sampling. Sample sizes varied from 450 to 19,314, with a mean of 4,407. The median is just over 2,500. These figures are almost identical to the results reported in the *NCHRP Synthesis 236*. As in the *Synthesis*, the most common method used to recruit households was the telephone, which was used in 46 cases, either alone or with augmentation such as transit intercepts or on-board surveys. In five cases, solicitation was by mail, and the remainder did not specify.

Pilot Surveys and Pretests

This information was rarely reported in the Scan. Only six surveys indicated that a pilot test or pretest was performed, and usually this was because major changes occurred as a result of the pilot test. No details of the samples for pilot testing were provided.

Survey Implementation

No aspects of implementation were reported in the Scan.

Data Coding including Geocoding

This is an area that was not consistently reported in the Scan. It appears that several surveys completed direct data entry from CATI, and a few specified that geocoding was done by a combination of computer and manual entry.

Data Analysis and Expansion

As with several of the previous topic areas, the Scan includes little information on this subject beyond the mention in a few cases of the fact that data repair activities were undertaken. In seven of the surveys, explicit mention is made of the fact that data repair activities were undertaken, mainly through re-contacting households to resolve anomalies in the data. In all other cases, no mention was made of data repair. No other aspects of data analysis and expansion were covered by the Scan.

2.1.5 Other Reviews

There have been several other reviews performed recently. Included among these is the "Survey of Travel Surveys II" by Purvis (1990), which covers a number of surveys conducted in the late 1980s. This is not further summarized here, because it is largely superseded by the *NCHRP Synthesis 236* and the TMIP Scan. It also provides only very brief summary information on each of the surveys included, with the primary information being the sample size, timing, cost, and contact method.

In 1994, Benjamin put together a report to FHWA entitled *Current Trends in Travel Demand Data Gathering* (Benjamin, 1994). This report reviews four surveys that are also included in the *NCHRP Synthesis 236* and the TMIP Scan and also reviews briefly the NPTS of 1990 and some Urban Regional Studies. Benjamin outlines a possible description of the State of the Art of Household Travel Surveys, based on his reviews of the surveys of the early 1990s. However, contrary to what one might expect, this description does not make recommendations of what should be included in the design of a survey, but outlines some of the recent practices.

In 1994, Axhausen prepared a working paper at the University of London Centre for Transport Studies on *Travel Diaries: An Annotated Catalogue.* This was updated to a second edition in 1995 (Axhausen, 1995). This review is very useful in that it covers many different countries. In fact, of 21 surveys with travel/activity diaries reviewed, only six are from the U.S. One of the useful things in this review is the set of recommendations of the data items that should be included in future surveys, classified into those describing the household, the persons, the vehicles, transit ticketing, movements, and activities. These are reproduced here in Table 11 through Table 16. This review concentrates on the content of the survey diaries, and does not deal with other aspects of the design and implementation of the household travel survey.

Table 11: Suggested Items for a Comprehensive Travel Survey: Household (Axhausen, 1995)

Ref.	*Item*	*Description*
H1	Location	Home address
H2	Size of residence	Some measure of the size of accommodation, such as number of rooms, square feet of usable space and of garden, plot size, etc.

H3	Type of building	Detached, semi-detached, terraced, flat; private, subsidized by privately owned, public sector controlled, public sector operated
H4	Tenure	
H5	Duration of residence	
H6	Duration of ownership	
H7	Age of mortgage	
H8	Number of members	
H9	Number of visitors	
H10	Relationships	Matrix of relationships between all members of the household, plus an indication of the persons visited by visitors
H11	Parking spaces	Number, kind, location, and cost of the parking spaces owned or rented by household members
H12	Communications	Inventory of the media available (number and type) to the household (daily newspapers, telephones, pagers, television, teletext, ...)
H13	Income	Indication of disposable income of the household as a whole
H14	Visits	Number of visits to the residence, especially for the delivery of goods or service provision (preferably with an indication of the access modes)

Table 12: Suggested Items for a Comprehensive Travel Survey: Person (Axhausen 1995)

Ref.	***Item***	***Description***
P1	Sex	
P2	Year of birth	
P3	Marital status	
P4	Education level	
P5	Profession	
P6	Ethnicity	Indication of ethnicity using the national Census standard
P7	Language	Self-assessed level of proficiency in the relevant languages of the survey area
P8	Commitments	Indication of the firm commitments of the respondent current during the survey period; at a minimum work status (working, searching for work, not working) and participation in education. Ideally indications of further firm commitments
P9	Paid jobs	Number and type of paid positions
P10	Hours worked	Number of hours contracted for and average over the last month in each
P11	Working hours	Contractual time table(s) for the survey day
P12	Flexibility	Level and type of flexibility of the working hours (Flextime, shift work, etc.)
P13	Mode to work	Most common mode to work location(s) during the last week/month...
P14	Travel times	Expected travel times for the modes used during the last week/month...
P15	PT accessibility	The *n* (=3, 4, 5) most frequently used public transport services. For each service: initial stop/station, distance from home (in min. or m.), service number, usual destination
P16	Car pooling	Indication of participation in a car pool and the cost sharing arrangements
P17	Parking	For employer/school-provided parking: type, location and cost; otherwise most common type, location and cost over the last week/month...
P18	Education	Type of current course
P19	Driving License	Types and length of ownership of the different licenses held
P20	Cycling	Indication of ability to cycle
P21	Vehicles and tickets	Cross-reference to all household vehicles owned and used
P22	Income	Indication of the disposable income and its sources (wages, retirement pensions, disability pensions, parental allowance, transfer payments, i.e., grants, welfare, housing benefit, etc.)
P23	Handicap	Types of mobility handicap, both temporary and permanent
P24	No mobility	Indicator of why no out-of-home activities were performed on a survey day
P25	Start location	Location at the beginning of the first survey day (e.g., at 3:00 a.m.)

Table 13: Suggested Items for a Comprehensive Travel Diary: Vehicle (Axhausen, 1995)

Ref.	***Item***	***Applicable***	***Description***
V1	Make	ODU	
V2	Model	ODU	
V3	Body	ODU	Type of body (saloon, estate, etc.; touring bike, mountain bike, etc.)
V4	Seats	ODU	Number of regular seats
V5	Year of Production	O	

V6	Year of Acquisition	O	
V7	Replacement Status	O	Indication if vehicle replaced an earlier one or was an additional purchase
V8	Fuel	O	Type of fuel used
V9	Motor	O	Indication of motor size: cc, number of cylinders, power
V10	Weight	O	
V11	Converter	O	Presence of catalytic converter
V12	Current kilometrage	O	Odometer reading at the start of the survey period
V13	Kilometrage	O	Odometer reading at the end of the survey period
V14	VKT	O	VKT during the last year
V15	Check up	O	Date of last inspection of the motor
V16	Information sources	O	Types of information sources attached to the vehicle (radio, RDS-TMC, telephone, route guidance systems, etc.
V17	Owner	ODU	Reference to household member or outside institution
V18	Responsible	O	Reference to legally responsible household member
V19	Users	O	List of users among the household members and their level of use
V20	Fixed costs	O	Distribution of fixed costs between different persons and institutions involved; may be broken down by further categories
V21	Variable costs	ODU	Distribution of variable costs between different persons and institutions involved; may be broken down by further categories
V22	Home location	O	Indication of where the vehicle was located during the last week/month
V23	Parking	O	Which, if any, of the household parking spaces is allocated to this vehicle for overnight parking

O Vehicles owned by household members
D Vehicles driven, but not owned by household members (associated with person form)
U Vehicles used, but not owned by household members (associated with person form)

Table 14: Suggested Items for a Comprehensive Travel Diary: Season Tickets and Similar (Axhausen, 1995)

Ref.	*Item*	*Applicable*	*Description*
S1	Type	OU	Type of ticket
S2	Area	O	Area covered by the ticket
S3	Validity	O	Period of validity of the ticket
S4	Date of acquisition	O	Month
S5	Replacement status	O	Indication if the ticket replaced an earlier one or was an additional purchase
S6	Owner	OU	Reference to household member or outside institution
S7	Users	O	List of users among household members and their level of use
S8	Fixed costs	O	Distribution of fixed costs between different persons and institutions involved
S9	Loan	O	Availability and amount of season ticket loan
S10	Variable costs	OU	Distribution of variable costs between different persons and institutions involved

O Tickets owned by household members
U Tickets used, but not owned by household members (associated with person form)

Table 15: Suggested Items for a Comprehensive Travel Diary: Movement (Axhausen, 1995)

Ref.	*Item*	*Applicable*	*Description*
M1	Start time	ST	End of last activity
M2	End time	ST	Start of next activity – end time of movement
M3	Start wait	S	Duration of wait before start of movement
M4	Waiting time	T	Amount of waiting and transfer times during the trip
M5	End location	ST	
M6	Mode	S	
M7	Mode sequence	T	
M8	Route	ST	Indication of route by major facilities used (bridges, tunnels, motorways, public transport lines, etc.)
M9	Stops	T	Public transport stops
M10	Costs	ST	Total amount spent on tolls or fares and share covered by respondent

M11	Parking	ST	Type, legality, and location/distance to destination; total cost and share of respondent; cross-reference to employer parking or parking space at home
M12	Company	ST	Size of company and breakdown by household and non-household members
M13	Situational handicap	ST	Type of situational handicap
M14	Parallel activity	ST	Type of parallel activity engaged in during travel (reading, working, phoning, etc.)
M15	Availability	TJ	Cross reference to all household vehicles/season tickets available for the duration of the trip/journey including ensuing activity
M16	Information sources	ST	Type of information sources available during the movement
M17	Information used	ST	Type of information sources used during the movement and usage cost

S Applicable at stage level
T Applicable at trip level
J Applicable at journey level

Table 16: Suggested Items for a Comprehensive Travel Diary: Activities (Axhausen, 1995)

Ref.	***Item***	***Description***
A1	Purpose	
A2	Land use	Type of environment
A3	Time window	Earliest and latest possible start time
A4	Start time	Arrival time at the activity location
A5	End time	End of activity
A6	Wait time	Time spent waiting before the start of the activity
A7	Importance	Importance relative to the other activities of the day
A8	Success	Degree to which expectations for the activity were fulfilled
A9	Commitment	Level of commitment to other persons participating in or depending on the activity
A10	Substitutability	Ability to replace activity with a different one
A11	Flexibility	Ability to forgo the activity at the time of arriving at the destination
A12	Planning interval	Time since the traveler planned to engage in the activity
A13	Execution horizon	Time before the activity has to be executed
A14	Frequency	Number of activities of this type per week/month…
A15	Regularity	Presence of a fixed rhythm for the activity
A16	Expenses	Amount of money spent during the activity by the respondent
A17	Company	Size of party divided by household and non-household members
A18	Situational handicap	Type of situational handicap encountered during the activity
A19	Information sources	Information sources available during the activity
A20	Information used	Information sources used during the activity and their costs

In 1996, the Institute of Urban and Regional Development at the University of California at Berkeley published a Working Paper on "Land Use and Travel Survey Data: A Survey of the Metropolitan Planning Organizations of the 35 Largest U.S. Metropolitan Areas" (Porter *et al.,* 1996). Again, this document overlaps significantly with the *NCHRP Synthesis 236* and the TMIP Scan, and, again, the details provided are brief, generally noting the timing of the survey, sample size, method of contact, and the survey instrument in some cases. From the summary of results, it is noted that 32 of the 35 metropolitan areas conducted at least one household travel survey since 1985, and 28 conducted one since 1990. For most household surveys, it was noted that the sample size is between 1,500 and 3,000 households. Nothing else that is new or relevant was included in this report.

In a paper by Ampt *et al.* (1998), some characteristics of current best practice are outlined that seem to be relevant to this study. These are:

- "Collection of stage-based trip data – ensuring that analyses can relate specific modes to specific locations/times of day/trip lengths, etc.;
- Inclusion of all modes of travel, including non-motorized trips;
- Measurement of highly disaggregate levels of trip purposes;

- Coverage of the broadest possible time period: e.g., 24 hours of the day, seven days of the week, and even possibly all seasons of the year (365 days);
- Collection of data from *all* members of the household;
- High quality data that is robust enough to be used even at a disaggregate level; and
- An integrated data collection system incorporating household interviews as well as origin-destination data from other sources such as screenlines and cordon surveys."

These points suggest some of the important elements that should also be included in any effort to standardize household travel surveys. They also raise the issue of whether or not part of the standardization should address other necessary surveys that may be required to support the household or personal travel survey, and that should be included as a matter of necessity. This paper also introduces the idea, not discussed in any of the sources so far reviewed, of a continuous survey process. Specifically, the authors recommend a survey that should be collected "...each day of the week *throughout the year* and over several years." (Ampt *et al.,* 1998, italics in the original). Some of the issues relating to this type of design were addressed elsewhere in this project, to the extent that such a continuous, year-round design is considered further.

The paper also describes a different way of sampling that permits the sample to be drawn from a small number of traffic analysis zones, but with sufficient richness to permit stratification not only on socioeconomic data, but also on such things as spatial differences in terms of distance from the CBD and access to the transit network. At the same time, the authors demonstrate a sampling procedure that permits use of 26 classes, stratified on household size, income, and vehicles. The paper also outlines some aspects of instrument design, correction, expansion, and validation of data that may be helpful in the standardization of personal travel surveys, although it must be noted that, for the context for which this paper was written, personal face-to-face interviews were possible and considered as a potential major strategy for data collection. Conclusions based on this methodology must be applied with care in contexts where such interviews are not feasible.

2.1.6 Impact of Technological and Social Changes on Travel Surveys

Overview of Trends in the New Global Economy

The increasing availability of small, powerful and affordable technology and connection via the Internet to the global economy has led to adoption of telework – literally, work "at a distance" – as a means to address environmental problems, help balance work/life responsibilities and gain flexibility and quick response to opportunities in the emerging e-commerce economy.

Telework is a reorganization of the workplace, both in concept and execution. Telecommuting, or telework, falls under the umbrella of flexible work arrangements. Many authors see teleworking as closely parallel to the creation of new organizations variously called virtual, imaginary, extended, and collaborative organizations (Cohen, 1997). This enlarges the concept of telecommuting as a trip reduction strategy to viewing telework as just one component of the response to new business opportunities. In standardizing travel surveys, the critical point to consider is whether new travel patterns will emerge as location becomes relatively unimportant due to increasing reliance on telecommunications.

The initial motivation for telecommuting was to reduce commuting trips and thus, mobility. Instead, "…the home is becoming only one location of an increasingly decentralized, multi-locations working environment" (Gareis, 2000). The corporation as a physical entity will probably continue to be needed, but mobility is becoming an increasingly important part of modern society (Drucker, 1994). In sum, we have a situation in which new technologies and telecommunications are rapidly developing. They include PCs, notebooks, personal digital assistants (PDAs), cell phones, and broadband (3G) with both fixed and wireless access to the Internet. They also include integrated products such as the wireless

phone connected to personal databases and a universe of information. In effect, the tools necessary for work are transferred from the office to the worker. The possibility of working anywhere in time and space is intersecting with societal trends such as more women working, a greater choice of career options and opportunities to realize work/life preferences. Therefore, compared with the population surveyed in the past, the trends indicate:

- Greater variety of travel patterns;
- More home-based work;
- More mobile workforce;
- Blurring of the 40-hour work week into a 24-7 integration of work, family responsibilities and leisure; and
- More mixing of work with non-work travel.

The question is, how can travel surveys be standardized so as to capture these trends?

Standardization Challenges

DEFINITIONAL PROBLEMS. Working at home has an impact on organizational behaviors and on the individual worker (Sparrow and Daniels, 1999). Home-based work may occur on a full-time schedule, or more typically, on a part-time or episodic basis (Pratt, 2002). Tasks are performed not only in the home but also at other locations distant from corporate headquarters such as on a plane or in the car. As those work patterns are accepted as normal practice, the words "telecommuting" or "telework" most likely will disappear.

If forecasts are correct, there will be one billion mobile phone subscribers worldwide by 2005, and "this will be more than all the PCs and automobiles combined" (Golob, 2001). More significantly, the mobile phone combined with the PDA and access to broadband Internet, puts the power of an office in one's hand. It is equivalent to shrinking the grandfather clock onto everyone's wrist – but far more profound.

An approach to monitoring these technological and social changes within the context of travel surveys is first to measure home-based work, which is being done, as described in the next section. The greater challenges are to measure mobile work and the global workforce, which is covered in the next subsection.

Measurement of Work at Home

ASKING THE RIGHT QUESTIONS. In designing travel behavior surveys, the problem is to define "work," "home," and similar words that are commonly used in our language but which have acquired associated meanings (Pratt, 2000a). The difficulty has not been resolved by coining new terms to describe non-traditional ways to work. Such words as "telecommuting," "teleworking," "at-home work," "hoteling," "home-based business," "road warriors" and "mobile workers," lack any agreed-upon definitions yet they are used in common parlance as if they did. These new work styles need to be measured by objective criteria in order to provide meaningful data for understanding any consequent variations in travel behavior.

Standardizing questions in terms of measurable variables, such as the place of work and the time in days and hours spent at each location, leaves researchers the option of applying their own definitions that fit the context of their analyses. Thus, rather than ask "How many days a week do you telecommute?" the more precise question can be asked: "How many days last week did you work at home instead of going to your usual work location?" This approach has the advantage that information gathered over years can be used unambiguously in various contexts. Definitions can be applied at the point of analysis (STILE, 2004). Thus, using the phrase "work at home" as the standard and clearly identifying the time

units measured – in this survey, "days per month" and "during normal business hours" – the numbers of "telecommuters" in 1999 can be reported as follows:

Classic telecommuting as understood by employers, is allowing some employees to work at home one or two days per week. As of 1999, 19.6 million employees and independent contractors, or ten percent of U.S. adults, were working at home during normal business hours for one or more days per month (Pratt, 1999). They worked at home an average of 9 days per month. An additional 10.4 million employees would like to work at home if their employers would let them.

PIGGYBACKING STRATEGY USED TO MEASURE WORK AT HOME. Large samples and lengthy questionnaires are necessary to capture the variety of travel behaviors. Yet cost, respondent burden, and other barriers usually preclude separate surveys devoted to work at home. However, piggybacking work-at-home questions onto on-going surveys, as illustrated below, has provided rich detail that contributes to a deeper understanding of today's travelers. The two-fold methodology obtains new perspectives on travel behavior by: 1) phrasing the questions in objective terms so that the responses can be compared across data sets and 2) adding questions to existing periodic surveys (Pratt, 2001).

FEDERAL SURVEYS. Following that strategy, a series of questions were added to federal surveys including the Nationwide Personal Transportation Survey, the American Housing Survey, Current Population Survey, National Longitudinal Surveys of Labor Market Experience, Survey of Income and Program Participation, and the Characteristics of Business Owners survey. Table 17 lists some of the relevant topics included in some of the surveys.

When those variables are cross-tabulated with work at home, a wealth of information becomes available for supplementing or aiding interpretation of travel data. For example, the 1995 Nationwide Personal Transportation Survey (NPTS) inventories daily personal travel and therefore serves as a baseline for comparing data collected regionally. A number of questions included work at home as a listed response in a choice set. As Figure 1 shows, three questions directly probed the practice and frequency of working at home (Pratt, 1997).

Table 17: Characteristics of Mobile Workers Collected by Federal Surveys (As of 1995) (Pratt 1997)

VARIABLE	*SURVEY*						
	AHS	**CBO**	**Census**	**CPS Supplement**	**CPS Computer Supplement**	**NPTS**	**SIPP**
COMMUTING							
Distance	X					X	
Time	X		X			X	
Mode	X		X			X	
TRIPS							
Local						X	
75+ miles							
Purpose						X	
FAMILY							
Home Address	X		X	X	X	X	X
Income	X	X	X	X	X	X	X
Unit	X		X	X	X	X	X
WORK							
Activities		X	X	X	X		X
Address		X	X			X	
Computer use					X		
Days of week							X
At home	X	X	X	X	X	X	X
Home hrs/days	X				X	X	X
Multiple jobs				X			X
Schedule					X		X
WORKER							
Classification	X	X	X	X	X		X

Education	X	X	X	X	X	X	X
Occupation		X	X	X	X	[1]	X
Industry		X	X	X	X		X

Surveys, in order listed are*: American Housing Survey (AHS), Characteristics of Business Owners (CBO), 1990 Decennial Census, Current Population Survey Supplement(CPS), Current Population Survey Computer Supplement, Nationwide Personal Transportation Survey (NPTS),* and *Survey of Income and Program Participation (SIPP).*

[1]Asked only of persons whose work required driving a licensed motor vehicle as part of the job

SECTION F – EDUCATION AND TRAVEL TO WORK – (HOUSEHOLD MEMBERS 16 YEARS OR OLDER; PROXY PERMITTED)

Q3 Do you have more than one job?
1 YES – The next questions are about your primary job or occupation.

Q4 What is the street address of your workplace?

(IF R WORKS AT OR OUT OF HOME, ENTER "HOME" FOR STREET NUMBER. IF R HAS NO FIXED WORKPLACE, ENTER "NONE" FOR STREET NUMBER.)

Q5 What is the one-way distance from your home to your workplace?
____blocks or miles
NO FIXED WORKPLACE – GO ON TO NEXT SECTION
WORKS AT OR OUT OF HOME GO TO NEXT SECTION

Q8 How do you usually get to work? Please tell me <u>all</u> the kinds of transportation you usually use.
WORKED FROM HOME/TELECOMMUTED (20 possible responses)

Q9 What is the main means of transportation you usually use to get to work—that is, the one used for most of the distance?
WORKED FROM HOME/TELECOMMUTED (20 possible responses)

Q19 On any day last week, did you work from home <u>instead</u> of traveling to your usual workplace?
IF R WORKED AT HOME <u>INSTEAD</u> OF GOING TO THE WORKPLACE. DO NOT INCLUDE WORKING AT HOME IN <u>ADDITION</u> TO WORKING AT THE WORKPLACE.)

Q20 On any day in the past <u>two months</u>, did you work from home <u>instead</u> of traveling to your usual workplace?

(CODE YES ONLY IF R WORKED AT HOME <u>INSTEAD</u> OF GOING TO THE WORKPLACE. DO NOT INCLUDE WORKING AT HOME IN <u>ADDITION</u> TO WORKING AT THE WORKPLACE.)

Figure 1: 1995 Nationwide Personal Transportation Survey (NPTS)

The *phrasing* of the actual work-at-home questions asked is difficult to standardize since the context of each survey differs. For example, the American Housing Survey (AHS) collects data on housing, including household characteristics, income, neighborhood quality, recent movers, work space in the home, and home-based work. National data are collected in alternate years covering, on average, 55,000 of the same housing units each time.

The AHS identifies job classification, which the NPTS does not. Individuals are differentiated by those who work at home 1) on a wage and salary job, 2) as a self-employed person or contract worker or business owner, or 3) instead of traveling to work. However, even within that one survey, some of the results are not directly comparable because the wording and skip patterns of questions that identified spaces within the dwelling used for work differ in the two survey years.

METROPOLITAN AREA SURVEYS. Several regional surveys have included work-at-home as a topic. Again, the phrasing of the questions varies, but objective information is obtained that makes comparisons possible.

1996 DALLAS-FORT WORTH HOUSEHOLD ACTIVITY SURVEY 24-HOUR DIARY. The household survey conducted from January to May in 1996 in the Dallas-Fort Worth region collected extensive activity and travel data on a sample of over 4,000 households. The work-at-home questions were included in the one-day travel diary[1] (Figure 2). Frequency of work at home was asked in regard to both the main and any second job.

1994 ACTIVITY AND TRAVEL SURVEY OREGON AND SW WASHINGTON. Sponsored by Metro of Portland, Oregon, the *1994 Activity and Travel Survey* asked respondents to fill out a 10-day diary on assigned travel days (Figure 3). The household diary did not identify non-travel activities except as implied by destination: "What was your activity?" "When did your activity take place?" Thus, if the activity was working at home, it would be listed as "work" with the home address filled in under "location." (Pratt, 1997, p. 65.)

In addition to the household diary, a CATI questionnaire was used that collected work-at-home and other transportation-related data as shown in Figure 3. In both the CATI questionnaire and the diary, respondent heads of households were asked for information about all members of the household including themselves.[2]

[1] Source: 1996 Dallas/Fort Worth Household Activity Survey
[2] Oregon CATI Questionnaire Version #2

Q16 Where do you usually work for your main job?
There is no address (e.g., traveling salesman, repairman)
In my home

Q18. Did you work at this address on the diary day?
Yes
No Why not?
No. 8 of 12 possible responses = Worked at home today

Q25. Including today, how many days in the past seven days did you work at home for your main job INSTEAD of going to your main job place?

Q27. Do you have a second job?

Q32. Where do you usually work for your second job?
There is no address (e.g., traveling salesman, repairman)
In my home

Q35. Including today, how many days in the past seven days did you work at home for your second job INSTEAD of going to your main job place?

Q21 In the past two months, about how often have you worked from home instead of traveling to your usual workplace?
1. TWO OR MORE DAYS A WEEK (11+ TIMES)
2. ABOUT ONCE A WEEK (5-10 TIMES)
3. ONCE OR TWICE A MONTH (2-4 TIMES)
4. LESS THAN ONCE A MONTH (ONE TIME)

(CODE YES ONLY IF R WORKED AT HOME INSTEAD OF GOING TO THE WORKPLACE. DO NOT INCLUDE WORKING AT HOME IN ADDITION TO WORKING AT THE WORKPLACE.)

Figure 2: 1996 Dallas-Fort Worth Household Activity Survey 24-Hour Diary

THE 1995 OHIO-KENTUCKY-INDIANA (OKI) REGION SURVEY. The OKI survey specified two categories of in-home activities of which one was "Paid Work (in-home)". Nine types of out-of-home activities included "Paid Work." In recording each activity on the assigned day, the respondent had the option of checking IN-HOME, PAID WORK (in home). Thus the survey resulted in a complete record of periods of working at home interspersed with trips and other activities. The note: "All activities in the home not related to paid work should be recorded as…." clarifies that the respondent is not necessarily paid extra for time worked at home.

Q35F In a typical week, how many hours does [NAME OF OTHER PERSON 1]WORK?
Q38A-38F What is the address of (NAME OF OTHER PERSON 1)'s primary job?

Q39A-39F Does (NAME OF OTHER PERSON 1) work at home?

Q4OA-40F Of the [#HRS FROM Q35]hours (NAME OF OTHER PERSON 1) works in a typical week, how many hours are worked at home?

Q45A-45F In the past five work days, bow many days did (NAME OF OTHER PERSON 1) travel to work by:

(READ LIST. MUST SUM TO "5".)

1 _____CAR (DROVE ALONE)
2 _____CARPOOL
3_____PUBLIC TRANSIT (SCHOOL BUS/TRAIN)
4_____OTHER
5_____DID NOT TRAVEL TO WORK DURING PAST *5* DAYS

Figure 3: 1994 Activity and Travel Survey Oregon and SW Washington

THE 1997-8 RESEARCH TRIANGLE HOME INTERVIEW STUDY. The Research Triangle CATI interviews did not differentiate whether or not work at home was "paid." As the respondent filled each time slot by checking "meals," "shop," "work," or by writing in an activity, he or she was asked "Where did PERSON/you do that? (PLACE, STREET, CROSS STREET, CITY AND ZIP) with boxes to check indicating "home," "work," or "other." Thus work was captured as taking place in one of those three places.

Key Variables for Identifying Work at Home

Based on the review of the surveys that included Telework:

- Work at home needs to be differentiated according to when it is performed, that is, during normal business hours (self-defined), after-hours, on week-ends or interspersed with trips;
- Time-use surveys must clarify whether work at home is "income-producing" (versus unpaid housework);
- The job classification variables including employee, self-employed, and contractor status are critical to measure, because there are differences in the travel behavior of employees and the self-employed;
- Work at home is associated with the second job or business, so that multiple job-holding may be important to capture; and
- Because an advanced degree, higher income, use of technology, and the occupations of manager, professional, or sales are strongly associated with home-based work, the items education, income, occupation and technology ownership are useful to include in surveys.

Measurement of the Mobile, Global Workforce

The impacts of mobility on traffic and air quality will be increasingly important to measure as workers respond to new opportunities in the e-business economy. The literature review suggests that if, as

expected, travel patterns vary as behavioral change follows technology innovation, a number of factors must be considered in any attempt to standardize the measurement of mobile workers. They include, for example:

- Identification of where the individual is in time and space.
- Identification of his or her activity at that time.
- Consider identifying multitasking, e.g., driving a car and conducting work on a mobile phone.
- Identification of the work place(s).
- Special caution is needed because of the traditional phrase "home-work" trip. Work no longer takes place in one non-residential location. It may take place at the corporate workplace, in the home – during normal business hours or after-hours and on weekends – during travel, or at a customer's or client's job site.
- Identification of the routine work/travel pattern, e.g., does the person regularly work at home, i.e., "telework," work at home one day a week, work in the employer's office four days but travel to another city once a month, etc.?
- Knowledge of technology and telecommunications used. Although it may not provide primary knowledge of travel, information on the use of wireless, PDAs, the Internet and combinations of all three may supply valuable data for interpreting and forecasting travel behavior. The information is essential for capturing the relation between use of the Internet and trip substitution or complementarity. (For example, does shopping on the Internet increase or decrease trips to the mall; does it increase truck trips to neighborhoods?)
- Travel increase – work, leisure, work/leisure.
- Travel decrease – Trip substitution; Tele-, Internet and video conferencing.

2.2 REVIEW OF RELEVANT STANDARDIZATION PROCEDURES

2.2.1 Introduction

A review of current travel survey practice reveals that standards are not prevalent in the execution or evaluation of travel surveys. As stated by the Chief Statistician of Statistics Canada:

> "In some professions best practice is codified precisely or defined by reference to professional codes and standards. No such precise code exists in the domain of survey methodology. Indeed, survey methodology is a collection of practices, backed by some theory and empirical evaluation, among which practitioners have to make sensible choices in the context of a particular application. These choices must attempt to balance the often competing objectives of quality, relevance, timeliness, cost, and reporting burden." (Statistics Canada, 1998, p. 2)

Thus, the closest to standards existing in the travel survey field are generally accepted good practices. However, there is little doubt that standards in travel survey practice can assist in maintaining quality and facilitate evaluation and comparison of travel survey data.

Before proceeding, it would be helpful to clarify the use of the term "standards" and "standardized procedures" as used in this report. Standards are considered minimum thresholds of the properties of a product that must be attained in order for the product to be acceptable. In the context of travel surveys, and taking a broad view of the properties a travel survey should embrace, the properties considered would typically be the quality of the data, the ethics employed in collecting the data, and the procedures used to evaluate, document, archive, and disseminate the information collected. Standardized

procedures, on the other hand, are stipulated methods of conducting an activity. By fixing a process, ambiguity is reduced, standards are indirectly achieved, and assessment is promoted by clarity of concept and the opportunity to compare values from different sources. Thus, standardized procedures are an indirect application of standards but they also enhance communication and understanding, promote efficiency, and facilitate assessment of the product.

There is evidence in the literature of both the setting of standards and the imposition of standardized procedures in travel surveys. For example, standard time use categories have been recommended by several agencies including the Statistics Division of the United Nations and the Australian Bureau of Statistics (United Nations Secretariat, 2000b; Trewin, 1997). However, the move toward establishing standards in the industry is in its infancy, and suggested standards tend to be general and tentative in nature. As described in the opening paragraph of this section, specific standards and procedures for travel surveys do not exist at the moment, but there is an emergence of documented "good practices" that serve as guidelines in the industry. Similarly, there are suggested standardized procedures such as the Council of American Survey Research Organizations (CASRO) or the American Association of Public Opinion Research (AAOPR) methods of response rate calculation, although there is not universal acceptance of either of these procedures as a standard in travel survey practice.

There have been attempts in the past to define quality in travel surveys, establish norms of ethical conduct, describe good practices, and introduce the concept of certification or accreditation of agencies that conduct travel surveys. These represent the initial effort within the travel survey industry at establishing standards and standardized procedures.

2.2.2 Standards

Defining Quality

In the manufacturing world, where standards are used extensively, it is common to define the quality of a product in terms of criteria such as size tolerances, hardness, resistance to fatigue, and so on. However, in travel surveys, quality is a much more comprehensive concept. Statistics Canada (1998a) suggest that quality in travel survey data should be measured in terms of six properties: relevance, accuracy, timeliness, accessibility, interpretability, and coherence. Relevance is the value of the data to a user. Thus, data may have different relevance depending on the use to which they are put, and the more data items that are relevant, the higher the quality of the data for the specified use. In surveys with adequate sample sizes, accuracy is primarily the lack of bias (Richardson *et al.*, 1995, p. 99). Timeliness is the time value of information where its usefulness and value decreases with age. Accessibility is the ease with which data are obtained from a holding agency, but where ease is considered in its broadest sense and includes the form in which the data are provided, the availability of supporting descriptive information of the data, means of dissemination, and how likely a user is to know who to contact and be able to contact them. Interpretability is the ease with which a user will understand and correctly use data provided by an agency. Definitions, descriptions of procedures used, and a declarative description of the data set and the codes used, enhances the interpretability of data. Coherence is the consistency of terms, codes, concepts, and procedures within and across data sets.

Many of the properties describing the quality of data above must be subjectively assessed. Because relevance is a component of quality, this also means that the quality of data will change from application to application depending on the purpose to which the data are put. Thus, not only must quality assessments be made subjectively but they will also vary from user to user. This makes setting standards for data quality difficult except in terms of the general or generic features of a survey. Furthermore, a careful review of these proposed quality terms reveals that several of them are actually not related to the generic quality of data, but incorporate characteristics of the user or the value of the data at a different

time. These include relevance, timeliness, and accessibility. Each of these help measure the value of data in a particular application, but none of them provide a measure of the quality of data *per se.*

Ethics

Several survey research organizations have established codes of practice and regulations aimed at directing their members to practices that ensure a certain code of conduct or ethical standard. CASRO has produced a document titled the *Code of Standards and Ethics for Survey Research* in which the responsibilities of the survey company as regards the execution of the survey, interaction with the client, and handling of the data are described (CASRO, 1997). In this code of standards, the respondent's interests are described in terms of anonymity in any reported data, ready identification of the company conducting the survey, prohibition of taping or recording of an interview without the respondent's knowledge, and respecting the right of the person being interviewed to refuse to be interviewed or to terminate an interview in progress.

The Marketing Research Association (MRA) also has a Code of Ethics by which its members are expected to abide (MRA, 2000a). In the code, guidelines are provided on how the research firm is to conduct itself with respect to those interviewed, to the client, to subcontractors, and to the public as a whole. Most significant is the manner in which members of the MRA are required to treat those they interview. In a document titled the *Respondent Bill of Rights*, the MRA requires that their members abide by the following principles when interviewing members of the public (MRA, 2000b):

- The privacy of the individual, and the information they provide in the survey, will be protected;
- The name, address, phone number, or any other personal information of the respondent will not be disclosed to third parties without the respondent's permission;
- The interviewer will always be prepared to identify himself or herself, the research company he or she represents, and the nature of the survey being conducted;
- The respondent will not be sold anything or asked for money as part of the survey;
- Persons will be contacted at reasonable times to participate in the survey and they may request to be re-contacted at a later date if more convenient;
- A person's decision to participate, answer specific questions, or terminate the interview will be respected without question;
- A participant will be advised in advance if the interview is to be recorded and they will be informed of the purpose of the recording; and
- The respondent is assured of the highest professional standards in the collection and reporting of the information provided.

In Europe, similar standards have been established by the European Society for Opinion and Marketing Research (ESOMAR). ESOMAR is primarily European in its membership but also has members in approximately 80 other countries around the world. ESOMAR has published rules for its members that describe the rights of respondents, the professional responsibilities of the researcher, and the mutual rights and responsibilities of the researcher and client (ESOMAR, 1999a). The rules are very similar to those stipulated by CASRO and MRA with a few qualifications to adapt them to the multinational environment in which they are applied. ESOMAR has separate guidelines for tape and video recording and client observation of interviews or discussions (ESOMAR 1999b). It also has rules regarding the conduct of market and opinion research using the Internet (ESOMAR, 2000). In the case of tape and video recording of individuals, or their observation from a hidden location, the main issues relate to prior notification and permission, and safeguards on the release of recordings. With regard to surveys conducted via the Internet, the same principles apply as outlined before, but extra care is required to ensure that information transfer is secure, that permission is obtained from parents for children under the

age of 14 to participate, and, if e-mail is used, that respondents who have indicated that they do not want to be re-contacted, be omitted from any further communication.

Good Practices

The general standards and ethics of the previous paragraph describe the general approach that must be adopted by survey research companies when conducting travel surveys. To provide guidance on how to implement those principles, some organizations have accumulated and documented "good practices" that are consistent with those principles. The "good practices" are not standardized procedures, because they are not prescribed and they do not define a specific procedure. However, they do direct practice in a general direction that leads to more uniform procedures than otherwise would be achieved.

Statistics Canada has produced a comprehensive set of "good practices" in travel surveys in their document *Quality Guidelines* (Statistics Canada, 1998a). Guidance is provided on how to conduct each step in a survey and how to structure and operate a survey company, so as to collect quality data. With respect to advice on individual steps in conducting a travel survey, guidance is provided on the most efficient and effective manner of executing the following tasks:

- Objectives;
- Concepts, definitions, and classifications;
- Coverage and frames;
- Sampling;
- Questionnaire design;
- Response and non-response;
- Data collection operations;
- Editing;
- Imputation ;
- Estimation (i.e., estimating population parameters from sample values);
- Seasonal adjustment and trend-cycle estimation;
- Data quality evaluation;
- Disclosure control;
- Data dissemination;
- Data analysis and presentation;
- Documentation; and
- Administrative data use.

With respect to the management environment, it is recommended that a Quality Assurance Framework be established. This involves establishing an institutional structure and assigning responsibilities to specific individuals in the company to maintain quality. This is similar to the rapidly growing Total Quality Management process, employed by many companies, to establish and maintain quality in their operations (Richardson and Pisarski, 1997).

CASRO have produced similar guidelines on "good practice" in their *Survey Research Quality Guidelines* document (CASRO, 1998). They provide guidance on the execution of the following steps in the survey execution process:

- Problem definition;
- Sample design;
- Interview design;
- Data collection;
- Data processing; and
- Survey reporting.

In providing guidance on establishing a problem definition, they describe the necessity of obtaining background information on the need and use of the data to be collected, of establishing objectives with the client, and determining topics to be covered in the survey. The sample design includes definition of the population to be sampled, determining the sample frame, sample size, and weighting, and providing a full description of the procedure to be followed in conducting the survey including call-back and replacement procedures if any. In coding non-responses they suggest that all the following categories be used:

- Respondent not reachable (i.e., busy, etc.);
- Respondents not available after callbacks;
- Total refusals;
- Respondents not interviewable (i.e., language/speech problems, etc.);
- Respondents not qualified; and
- Completed interviews.

In the interview design, general guidelines are provided on designing the questionnaire or interview. In the guidelines for data collection, considerable guidance is offered on interviewer training, supervisor procedures, interviewing protocol, and validation procedures. In data processing, it is noted that data editing must first be applied to remove illegible, incomplete, or inconsistent errors in the data. During this phase, missing data that can be inferred from other complete data (e.g., the gender of a respondent from their name) may also be replaced. Coding must be consistently conducted and detailed coding of missing data must be made. Survey reporting should always include the study title, the name of the client and the research company, the date, and information on the survey such as the target population, location, respondent qualification requirements, and sample size. Information regarding the execution of the project such as the interview dates, sample design, disposition rules, response rate, weighting, and results of validation runs, should be reported.

Certification/Accreditation

One of the needs satisfied by standards is the assurance a user or client has when a product they plan to purchase carries the approval or certification of a recognized standards agency. One of the main functions of standards in the manufacturing industry is the assurance to the consumer that a product carrying the seal of a reputable standards organization, is of reliable quality. Standards of this type are usually handled at the national level by national standards organizations, although international standards agencies such as the International Standards Organization (ISO) also exist. The ISO uses national standards organizations and experts from each individual field to establish standards in those areas in which standards are requested by suppliers or consumers. The ISO requires that suppliers structure and operate their company according to quality management principles. The ISO defines a quality management principle as:

> "... a comprehensive and fundamental rule or belief, for leading and operating an organization, aimed at continually improving performance over the long term by focusing on customers while addressing the needs of all other stakeholders." (ISO, 1997)

The rationale is that by adopting appropriate quality management principles within an organization, the best quality product is produced irrespective of the type or nature of the industry involved. The ISO requires that organizations registered with them abide by the following eight quality management principles (ISO, 1997):

- The organization must be customer-focused. That is, it must understand the customer's needs, meet the customer's requirements, and strive to exceed the customer's expectations.
- The organization must have effective leadership. The leaders must direct the organization's progress and promote unity of purpose among the employees of the organization.
- The organization must involve all its members in its operation. Members must be able to contribute their individual abilities to the benefit of the organization.
- Individual components in the operation of an organization must be managed as a process. Applying a process approach improves efficiency of the operation.
- The organization should manage its operation as a system of interrelated processes.
- The organization should always be looking for ways to improve its operation.
- Decisions in the organization should be based on factual information.
- A mutually beneficial relationship must be maintained between the organization and its suppliers. Relationships are sustained when both parties benefit from the association.

These quality management principles are principles of management that could be expected in any well-managed organization. However, while philosophical and general in nature, guidelines are provided by ISO on how to structure and operate a company so as to maintain and pursue these principles. These are described in the ISO 9000 series of guidelines. These guidelines apply to a wide array of activities and are not only applicable to manufacturing as typically perceived. Richardson and Pisarski (1997) have translated the ISO guidelines into requirements for a travel survey company. They maintain that while it requires considerable commitment from the company to implement and maintain, its benefits in being able to deliver a quality product in a consistent manner are substantial.

One of the factors that may drive travel survey companies to seek ISO certification or accreditation in the future is if agencies commissioning surveys increasingly require ISO certification. Agencies may be attracted to this option because it reduces significantly the responsibility they bear in ensuring good quality data are produced. This may be a particularly attractive option for those agencies that feel uncertain about their own ability to assess quality effectively.

2.2.3 Standardized Procedures

There is little evidence of standardized procedures in travel surveys in the literature. However, there are at least two areas in which the prospects of introducing standardization have been discussed in the literature. These are the standardization of terminology or concepts, and the standardization of measures of assessment used to evaluate the quality of the survey. These areas of standardization are reviewed below.

Terminology

One of the greatest barriers to comparison of data between different data sets is the inconsistency in terminology and survey procedure used in different surveys. While standardization of survey procedure may be undesirable, given the variety of purposes and objectives directing individual data collection efforts, confusion due to inconsistent use of terms is unnecessary. The classic example is the definition of a trip which is likely to vary from survey to survey (Richardson, 1997). Other terms which may not always generate a common perception include expressions such as coverage, validation, deduction, and calibration. Overall, a distinct need appears to exist to establish a glossary of terms that can serve as a standard description of commonly used terms.

Another area where standard terminology would be beneficial is in the phrasing of questions typically included in a travel survey. An example would be the phrasing of the question to determine vehicle ownership of a household. The question could be phrased so as to clearly indicate whether

vehicles not owned by the household, but available for their full-time use, or vehicles owned by the household, but not in operating condition, should be included in the total number of vehicles or not. A particular difficulty is incorporating new behaviors that impact travel such as work at home and Internet shopping. The question of standardizing questions and content of travel surveys needs further study before recommendations can be made.

Classification

An area where there is great potential for standardization is in the establishment of standard classifications. Data are often classified into categories to reduce the variety of cases, to make obtaining the data less offensive to the person being interviewed (as when establishing household income), or to combine the characteristics of several variables into a single category. Data are often categorized to portray household income, occupation, educational level, stage in life cycle, land use, industry, and race. If standard classification systems can be adopted, the opportunity to compare values among different data sets will be enhanced. Because some secondary data sets such as the Decennial Census and National Personal Transportation Survey (NTPS) (or its successor, the National Household Travel Survey) are important sources of information and are likely to be used to supplement a travel survey, it would be advantageous to adopt classification systems that are as similar as possible to those of these data sets.

A standard classification of industry and other economic activities used in the past has been the Standard Industrial Classification (SIC) system. However, the SIC has recently been replaced by the North American Industry Classification System (NAICS). The NAICS provides a detailed classification of industrial, commercial, and public service activities (NTIS, 1997). Due to its wide acceptance and use, it would be advantageous to use the NAICS classification scheme in travel surveys.

ESOMAR has established a standard socio-economic classification system called the European Social Grade (ESOMAR, 1997). The European Social Grade is a function of the "terminal education age of the main income earner" and the occupation of the main income earner for those households which have an actively employed income earner. For those households that do not have an employed person in the household, the occupation of the main income earner is replaced by the "economic status of the household." Terminal education age is defined as the age category in which the main income earner received his or her last professional training or education. Age categories are 13 years or younger, 14, 15-16, 17-20, and 21 years or older. Occupation is described in terms of seven categories ranging from management through professional to unskilled worker. Economic status is determined by the number of the following consumer items owned by the household:

- Color television;
- Video recorder;
- Video camera;
- Two or more cars;
- A still camera;
- A home computer;
- An electric drill;
- An electric deep-fat fryer;
- A radio clock; and
- A second home or holiday home/apartment.

Six economic status scale categories were established from the above information by giving the value of six to those households possessing five or more of the above items, ranging down to a value of one for those households owning none of the above items or who failed to answer the question.

From the five terminal education age categories and seven occupation categories, eight social grade categories were established for households with workers as shown in Table 18. The numbers in the

table range from 1 for the social grade described as "well-educated top managers and professionals" to 8 for the social grade described as "less well educated skilled and unskilled manual workers, small business owners, and farmers/fishermen." A similar classification into eight social grades is established for households without a worker using economic status in place of occupation category.

Table 18: Eight Social Grade Categories

Terminal Education Age of Main Income Worker	***Occupation Category***						
	1	**2**	**3**	**4**	**5**	**6**	**7**
21+	1		2		3		5
17-20	1	2	3		4		
15-16	2	3	4		5		6
14	3	5			6		8
13 or less	5			7	8		

Source: Adapted from ESOMAR (1997)

The European Social Grade was applied in the 12 nations in the European Union in seven separate waves of surveys between 1992 and 1995. The samples were random samples of approximately 1,000 households per nation in each wave. The Social Grade has been used to compare the socio-economic composition of the different countries. It can also be used to observe the change in socio-economic status within a country over time given sufficient passage of time between surveys. The developers of the European Social Grade believe that, while the measure was developed using European data and reflects European conditions, the concept could be used in other areas of the world with the necessary adjustments to economic and social factors in the expression.

Coding

Another part of the travel survey process that will benefit from standardization is coding. Coding is the assignment of labels to data to facilitate identification or analysis. For example, household income intervals are assigned numerical or alphanumeric labels to distinguish individual income categories. Descriptive variables such as driver license status, gender, educational level, and occupation, as well as item non-response categories such as no answer, refused, or not applicable, are usually assigned codes. The benefit of standardizing codes arises when categories with the same intervals use the same codes among different data sets. Similarly, if the types of missing data items were coded into the same number of descriptive categories, comparison and understanding of the terms would be enhanced.

Assessment

The means of assessing the quality or accuracy of travel survey data are currently few and are not applied uniformly among practitioners. Three measures of data quality that are suggested as good candidates as assessment measures in the literature are coverage error, response rate, and sampling error for key variables (Statistics Canada, 1998a, p. 51). The topic of assessment and recommendations as to how it can be measured are discussed in greater depth in Chapters 4 and 5.

CHAPTER 3

3. Identification and Categorization of Potential Procedures and Assessment Measures

3.1 APPROACH

This chapter discusses specifically which aspects of the survey procedure and which measures of assessment of the survey were considered to have potential for standardization. The items were identified using information gathered and synthesized in the preceding chapters of the report, and by considering the steps in the design and execution of a typical travel survey and assessing the potential that each activity in that process presented for standardization. The specific categories of design and execution used in this process were:

- Design of survey instruments;
- Design of data-collection procedures;
- Sample design;
- Pilot surveys or pretests;
- Survey implementation;
- Data coding including geocoding; and
- Data analysis and expansion.

The above structure was also used to categorize the items identified for standardization.

While identifying opportunities for standardization, the research team was mindful of the need to not "over-standardize" so as to stifle future innovation and improvement. In setting forth these opportunities, therefore, care was taken to look for potential pitfalls that would be stifling to the further growth and development of the personal travel survey.

It also became apparent, in examining all of the aspects of personal travel surveys, that some aspects were susceptible to defining and recommending standardized procedures, while others were suitable only for guidance or guidelines. Therefore, the subsequent sections of the report indicate which elements of the survey were recommended for standardized procedures, and which are suitable only for guidelines.

It is also clear that the standardized procedures proposed in this project must be revisited from time to time. As more surveys are executed, social mores change, societal habits and values change, and what is considered good consistent practice today may become far below what is considered good practice in the future.

In the remaining sections of this chapter, the elements are grouped into three categories – those that are ready for immediate implementation as standardized procedures or guidelines, those that required development into standardized procedures or guidelines within this project, and those that were beyond the scope of this project. These aspects are referenced within the table that summarizes all the potential areas of standardization, so that the context of each can be seen.

3.2 EVALUATION OF POTENTIAL AREAS FOR STANDARDIZATION

In this section, the potential areas for standardization are summarized, categorized, and evaluated. The evaluation includes an assessment of the level of effort required to implement the standardized procedure, the potential benefits, the expected costs of implementation, and whether a field test was considered necessary or not. The ranking of importance of each potential area of standardization is also provided. The elements are categorized in terms of whether standardization could be accomplished immediately, whether it required further analysis, or whether it was beyond the scope of this project. The level of effort required to implement the procedures were subjectively assessed as being either low, medium, or high. The benefits of standardization were estimated in terms of the contribution standardization was expected to make to achievement of each of the following goals:

- Improvement in survey *quality*;
- Improvement in survey data *reliability*;
- Improvement in survey data *usefulness*;
- Improvement in *cost effectiveness* or value;
- Improvement in *comparability* among surveys;
- Improvement in ability to *measure survey quality*;
- Improvement in *clarity*; and
- Improvement in *completeness.*

The benefits are listed in Table 19 (on page 79) in the order of significance for each item. Thus, if comparability is listed first, it is because this is seen as the greatest benefit from standardizing this item. If reliability is last, it is because reliability is seen as the least significant of the benefits that would arise from standardizing the item.

The costs were estimated only in broad terms and are categorized as high, medium, low, none, and negative. High costs are those that were expected to lead to increases in the unit costs of a survey on the order of 25 percent or higher. Medium costs were those in the range of 5 to 25 percent, while low costs were those that result in cost increases of less than 5 percent. The category of "none" arises when implementation leads to no increase in cost of a survey, because it involves only a redefinition of a task already undertaken. Negative costs arise in the event that adoption of a standardized procedure or assessment measure is expected to lead to a decrease in unit costs of the survey.

Table 19 (on page 66) provides the summary of the potential procedures and assessment measures for standardization. It is important to note that costs are assessed on the basis of increases to *unit* costs. Some standards may have no effect on unit costs, but may result in overall higher or lower survey costs, while others may affect unit costs but may affect overall costs in the opposite direction. An example of the first of these is the specification of sample sizes, which does not change unit costs, but may increase overall survey costs for those regions that have traditionally used inadequate samples. An example of the second is the number and type of contacts, which is likely to increase unit costs, while decreasing overall costs, as a result of decreases in the amount of sample needed and greater completion of the sample initially selected. To avoid confusion, we have footnoted these types of occurrences.

For those tasks where existing data sets are considered adequate to address the issue, or where a fieldwork test is not appropriate, the fieldwork category is indicated as "No". If a fieldwork test appears to be necessary in addition to working with existing data, the category is indicated as "Yes"; in the event that only a fieldwork test is useful to establish the potential of a standard, then the category is indicated as "Only". If existing data were thought to be adequate for the task, but a fieldwork test could be beneficial, then the category was marked "Maybe". Finally, each item was ranked in importance to help select those that could be completed in the project. Items were marked in importance using categories ranging from Very High to Low and from this the research program was derived based on the time and funding available.

3.2.1 Categories of Classification

The aim of the second task in this project was not only to elaborate on the list of potential procedures and assessment measures for standardization, but also to categorize these into whether a standard was ready for immediate implementation, whether it could be researched sufficiently to adopt as a standard within the time and budget available, or that it was beyond the scope of this project. However, as the categories were considered it became apparent that there were issues and assessment measures where part of it was categorized at one level and part at another level. For example, the issue of survey ethics was assessed as falling partly into the "immediate" category and partly into the "in this project" category. Furthermore, it also became apparent that the meaning of "immediate" was generally not the same as instantaneous, or without additional work. Even those aspects considered to be possible for immediate implementation as standards, e.g., the time of day at which to begin and end the diary period, still would require writing up as a standard, and could involve at least some review by the team and others outside the project.

3.2.2 The Rating Procedure

To undertake the rating of potential procedures and assessment measures for standardization, eight criteria were proposed that are related to the benefits of standardization. These criteria are the same for both procedures and assessment measures, but, because a procedure specifies *how* an activity is to be conducted while an assessment measure measures *how well* a survey has been executed, the manner in which procedures and measures are evaluated on the criteria is different. The evaluation of a procedure involves measuring the benefit of standardization on the eight criteria. An assessment measure is evaluated by its ability to assess the quality of the survey, including the quality of the data obtained and the effectiveness and efficiency of the process employed. The criteria to evaluate the merit of standardizing procedures are:

- The ability of the procedure to promote the quality of the data as represented by the:
  - *Accuracy* of data collected;
  - *Accessibility* to the data;
  - *Interpretability* of the data (i.e., correctly understand the nature of the data); and
  - *Coherence* or *Comparability* of the data (i.e., its consistency in terms of terms, codes, concepts, and procedures).
- The *ease* with which the procedure can be applied (i.e., low level of effort and lack of complexity);
- The *clarity* of the procedure (i.e., nonambiguity or lack of uncertainty regarding the nature of the procedure);
- The *universality* of the procedure (i.e., the applicability of the procedure to the majority of surveys); and
- The *criticality* of the procedure (i.e., the urgency of applying the procedure).

For assessment measures, the criteria reflect how well an assessment measure is able to measure the condition or quality of a survey. The criteria that may be used to evaluate an assessment measure are:

- The ability of the assessment measure to assess survey *accuracy*;
- The ability of the measure to assess the *accessibility* of the data;
- The ability of the measure to assess how well data is documented so that the nature of the data can be correctly *interpreted* by a new user;
- The ability of the measure to assess the *coherence* (i.e., comparability or consistency) of the data;

- The *ease* with which the assessment measure may be applied;
- The *clarity* of the assessment measure;
- The *universality* of the assessment measure; and
- The *criticality* of the assessment measure.

The procedures and assessment measures identified in this study were assessed on the above criteria using a numeric weighting-and-rating process to provide a single index of assessment. First, the criteria were given weights, and then each potential procedure or assessment measure was rated on each of the eight criteria on a scale from zero to three. Because both of these activities are subjective, all members of the team were asked to review the weights and the individual ratings, to determine a consensus on the aspects and assessment measures. The weights assigned were:

- Improve accuracy of the data – 2.0;
- Improve accessibility to the data – 1.0;
- Improve interpretability of the data – 1.0;
- Improve Coherence or Comparability of the data – 2.0;
- Ease of use of the procedure – 1.0;
- Clarity of the procedure – 0.5;
- Commonality or universality of the procedure – 0.5; and
- Criticality of the procedure– 0.5.

As an example of the use of these, the first candidate procedure for standardization in Table 19 is minimum question specification. This received ratings of 1, 0, 1, 2, 2, 2, 3, 2 on the eight criteria. Applying the weights to these ratings and summing them produces an aggregate total of 12.5, or an average rating of 1.47. The maximum rating that could be achieved, if an item were scored as 3 on all eight criteria is an average score of 3.00. However, in application, no aspect received an aggregate score higher than 18.5, or an average of 2.18, so that this average was considered to indicate an item of high importance. In fact, in the final scorings, quartiles of the aggregate score were used to divide the items into four groups. Values in excess of 18.5 were considered to indicate items of very high importance, those between 13.5 and 18.5 high importance, between 12 and 13.5 medium importance, and those below 10.5 low importance. No aspect scored below 5.5.

3.2.3 Summary Table and Evaluation of Potential Areas for Standardization

In subsequent sections of this Technical Appendix, the reference category shown in the leftmost column of the table is used to refer to the item. The initial letter indicates which part of the survey process the item belongs to, while the numeric value was simply assigned in the order in which the items were initially presented and developed in this project. Thus, S-3 indicates that this is the third item in the sample design part of the survey process.

Table 19: Summary of Potential Procedures and Assessment Measures for Standardization

Ref	*Item*	*Category*	*Effort Req.*	*Potential Benefits*	*Expected Costs*	*Fieldwork Required*	*Import-ance*
Design of Survey Instruments							
I-1	**Minimum Question Specification**	In this project	Low	▪ Comparability ▪ Completeness ▪ Usefulness ▪ Reliability	None	No	High

Ref	*Item*	*Category*	*Effort Req.*	*Potential Benefits*	*Expected Costs*	*Fieldwork Required*	*Import-ance*
I-2	**Standardization of Categories**	In this project	Low	▪ Comparability ▪ Usefulness ▪ Reliability ▪ Quality ▪ Clarity	None	No	Very High
I-3	**Collection of In-Home Activities**	In this project	Medium	▪ Comparability ▪ Completeness ▪ Usefulness ▪ Quality	Low	Yes	Low
I-4	**Ordering of Questions**	In this project	Medium	▪ Quality ▪ Reliability	None	Yes	Low
I-5	**Standard Question Wordings**	In this project	Medium	▪ Quality ▪ Clarity ▪ Usefulness ▪ Reliability ▪ Comparability	None	Yes	Very High
I-6	**Instrument Design**	In this project/ Beyond scope	Medium to High	▪ Quality ▪ Clarity ▪ Usefulness ▪ Comparability	Low	Yes in future work	High
I-7	**Multi-Tasking of Activities**	In this project/Beyond scope	Medium to High	▪ Usefulness ▪ Comparability ▪ Completeness ▪ Quality ▪ Reliability	Low	Yes in future work	Low
I-8	**SP Data**	Beyond Scope	High	▪ Comparability ▪ Quality ▪ Clarity ▪ Usefulness ▪ Reliability	Low to Medium	Yes in future work	Low
Design of Data Collection Procedures							
D-1	**Number and Type of Contacts**	In this project/Beyond scope	Medium	▪ Cost Effectiveness ▪ Quality ▪ Reliability	Low to Medium[3]	Yes	Low
D-2	**Who Should be Surveyed**	In this project	Medium	▪ Comparability ▪ Usefulness ▪ Quality	Low	No	Medium
D-3	**Proxy Reporting**	In this project	Medium	▪ Cost Effectiveness ▪ Quality ▪ Completeness ▪ Reliability ▪ Usefulness ▪ Comparability ▪ Measure of Quality	Low to Medium	Yes	High
D-4	**Complete Household Definition**	In this project	Medium	▪ Quality ▪ Cost Effectiveness ▪ Clarity ▪ Completeness ▪ Comparability ▪ Measure of Quality ▪ Usefulness	Medium	No	Very High
D-5	**Classification of Contact Outcomes**	In this project	Low	▪ Comparability ▪ Measure of Quality	None	No	Medium
D-6	**Sample Replacement**	In this project	Medium	▪ Cost Effectiveness ▪ Quality ▪ Measure of Quality	Low	No	High

[3] This is an instance where an increase in unit costs should lead to an overall decrease in survey costs.

Ref	*Item*	*Category*	*Effort Req.*	*Potential Benefits*	*Expected Costs*	*Fieldwork Required*	*Import-ance*
				▪ Comparability ▪ Reliability			
D-7	**Item Nonresponse**	In this project	Medium	▪ Quality ▪ Cost Effectiveness ▪ Comparability ▪ Reliability ▪ Measure of Quality	Low	Yes	Low
D-8	**Unit Nonresponse**	In this project/Beyond scope	Medium	▪ Quality ▪ Comparability ▪ Reliability ▪ Cost Effectiveness	Low	Yes	Low
D-9	**Times of Day for Contacts**	In this project	Medium	▪ Quality ▪ Comparability	None to Low	No	Low
D-10	**Initial Contacts**	In this project	Medium	▪ Quality ▪ Comparability ▪ Cost Effectiveness	None to Low	Maybe	Medium
D-11	**GPS Surveys**	Beyond Scope	Medium to High	▪ Comparability ▪ Quality ▪ Cost Effectiveness	Medium	Yes	Low
D-12	**Internet Surveys**	Beyond Scope	Medium to High	▪ Quality ▪ Comparability ▪ Cost Effectiveness	Medium	Yes	Low
D-13	**Incentives**	In this project/Beyond scope	Low	▪ Quality ▪ Cost Effectiveness ▪ Reliability	Low to Medium	Yes	Low
Sample Design							
S-1	**Sample Size**	In this project	Medium to High	▪ Cost Effectiveness ▪ Comparability ▪ Reliability ▪ Quality ▪ Usefulness	None[4]	No	Medium
S-2	**Sizes and Procedures for Augment Samples**	In this project	Medium	▪ Comparability ▪ Quality ▪ Usefulness	None[5]	No	Medium
S-3	**Collecting Augment Samples**	In this project/Beyond scope	Medium to High	▪ Quality ▪ Completeness ▪ Usefulness ▪ Comparability	None[6]	No	Low
S-4	**Stratification Options**	In this project	Medium to High	▪ Cost Effectiveness ▪ Quality ▪ Reliability ▪ Comparability ▪ Usefulness	None to Low	No	Low
S-5	**Specification of Sampling Error Requirements**	In this project	Medium	▪ Quality ▪ Measure of Quality ▪ Comparability ▪ Reliability ▪ Usefulness	None[7]	No	Medium
S-6	**Default Variances**	In this project	Low to Medium	▪ Quality ▪ Comparability	None	No	Medium

[4] Although unit costs will not change, overall survey costs will increase for those cases where the sample sizes are significantly larger than those used prior to establishing standards.
[5] Where an augment sample has not been collected in the past, this would increase overall survey costs. Where an augment sample needs to be changed in nature, this could lead to either an increase or a decrease in overall survey costs, but is not likely to affect unit costs in most cases.
[6] Will not increase unit costs, but may result in a significant increase in overall survey cost.
[7] Will not impact unit costs, but has the potential to increase (or decrease) overall survey costs.

Ref	*Item*	*Category*	*Effort Req.*	*Potential Benefits*	*Expected Costs*	*Fieldwork Required*	*Import-ance*
				▪ Usefulness ▪ Reliability ▪ Measure of Quality			
Pilot Surveys and Pretests							
P-1	**Focus Groups**	In this project/beyond scope	Medium to High	▪ Usefulness ▪ Quality ▪ Reliability	Low	Maybe	Low
P-2	**Requirements for Pretests or Pilots**	In this project	Medium	▪ Quality ▪ Cost Effectiveness ▪ Usefulness ▪ Reliability	None[8]	Maybe	High
P-3	**Sample Sizes for Pretests and Pilots**	In this project	Low to Medium	▪ Quality ▪ Cost Effectiveness ▪ Usefulness ▪ Reliability	None[7]	No	High
P-4	**Sample Sizes for Comparing Methodologies**	In this project	Low to Medium	▪ Quality ▪ Cost Effectiveness ▪ Usefulness ▪ Reliability	None[7]	No	High
P-5	**Reporting of Pretests and Pilots**	In this project	Low to Medium	▪ Usefulness ▪ Comparability	None[9]	No	Medium
Survey Implementation							
E-1	**Interviewer Training**	In this project/ Beyond scope	Medium to High	▪ Quality ▪ Reliability ▪ Usefulness	None to Low	No	Medium
E-2	**Ethics**	Immediate/In this project	Low to Medium	▪ Quality ▪ Comparability	None	No	Low
E-3	**Mailing Materials**	Immediate/In this project	Low	▪ Cost Effectiveness ▪ Completeness ▪ Comparability	Low	Yes	Low
E-4	**Respondent Questions**	Immediate/In this project	Low	▪ Cost Effectiveness ▪ Quality	Low	Maybe	Low
E-5	**Caller ID**	Immediate	Low	▪ Quality ▪ Cost Effectiveness ▪ Completeness	None	Maybe	High
E-6	**Retention of Data on Incomplete Households**	In this project	Low	▪ Quality ▪ Measure of Quality ▪ Reliability ▪ Usefulness	None	Maybe	Very High
E-7	**Cross-checks in Data Collection and Data Review**	In this project	Low to Medium	▪ Cost Effectiveness ▪ Quality ▪ Reliability ▪ Usefulness ▪ Comparability	None to Low	Maybe	High
E-8	**Days and Periods to Avoid for Data Collection**	In this project	Low to Medium	▪ Comparability ▪ Cost Effectiveness ▪ Usefulness ▪ Quality	None	No	Very High
E-9	**Answering Machines and Repeated Call-Back Requests**	In this project	Low	▪ Cost Effectiveness ▪ Comparability ▪ Reliability	Low	No	High
E-10	**Methods to Reduce Incorrect Reporting**	In this project?[10]	Low to Medium	▪ Quality ▪ Reliability	Low	Maybe	Very High

[8] None of these items will impact unit costs, but each one may add significantly to the time and cost requirements of the overall survey.
[9] This will not impact unit costs, but documentation will add slightly to the overall costs of the survey.

Ref	*Item*	*Category*	*Effort Req.*	*Potential Benefits*	*Expected Costs*	*Fieldwork Required*	*Import-ance*
	of Non-Mobiles			▪ Cost Effectiveness ▪ Usefulness			
E-11	**Reporting Time of Day**	Immediate	Low	▪ Comparability ▪ Reliability ▪ Cost Effectiveness	None	No	Medium
E-12	**Time of Day to Begin and End Reporting**	Immediate	Low	▪ Comparability ▪ Usefulness	None	No	Low
E-13	**Creation of Identification Numbers**	Immediate/In this project	Low	▪ Comparability ▪ Usefulness	None	No	Very High
Data Coding Including Geocoding							
C-1	**Geocoding Standards**	In this project	Medium	▪ Quality ▪ Completeness ▪ Comparability ▪ Usefulness	Low to Medium	No	High
C-2	**Level of Geocoding to be Performed**	In this project	Medium	▪ Quality ▪ Comparability ▪ Usefulness	Low	Maybe	High
C-3	**Geocoding Out-of-Region Addresses**	In this project	Medium	▪ Completeness ▪ Usefulness ▪ Cost Effectiveness	Low	No	Medium
C-4	**Missing Values, Use of Zero, Etc.**	Immediate	Medium	▪ Clarity ▪ Comparability ▪ Usefulness ▪ Cost Effectiveness	None	No	Very High
C-5	**Coding Complex Variables**	Immediate	Medium	▪ Clarity ▪ Comparability ▪ Usefulness	None	No	Very High
Data Analysis and Expansion							
A-1	**Assessing Sample Biases**	Immediate/In this project	Medium	▪ Measure of Quality ▪ Comparability ▪ Reliability	Low	No	Medium
A-2	**Weighting and Expansion of Data**	Immediate	Low	▪ Reliability ▪ Quality ▪ Usefulness	Low	No	Medium
A-3	**Missing Data Imputation**	In this project/Beyond scope	Medium to High	▪ Quality ▪ Comparability ▪ Reliability ▪ Usefulness	Low	No	Low
A-4	**Data Archiving**	In this project/Beyond scope	Medium to High	▪ Comparability ▪ Usefulness ▪ Cost Effectiveness	Low	No	High
A-5	**Glossary of Terms**	In this project	Low	▪ Comparability ▪ Clarity ▪ Usefulness	None	No	Very High
A-6	**Documentation**	In this project	Low	▪ Comparability ▪ Quality ▪ Completeness ▪ Reliability	None to Low	No	Very High
Assessment of Quality							
Q-1	**Computing Response Rates**	In this project	Medium	▪ Measure of Quality ▪ Comparability ▪ Reliability	None to Low	No	Very High
Q-2	**Transportation Measures of Quality**	In this project	Low to Medium	▪ Measure of Quality ▪ Comparability	None to Low	No	High

[10] Not a clear potential for standardization.

Ref	*Item*	*Category*	*Effort Req.*	*Potential Benefits*	*Expected Costs*	*Fieldwork Required*	*Import-ance*
				▪ Reliability			
Q-3	**Coverage Error**	In this project	Low to Medium	▪ Measure of Quality ▪ Reliability ▪ Comparability ▪ Quality	None to Low	No	High
Q-4	**Sampling Error**	In this project	Low	▪ Measure of Quality ▪ Quality ▪ Reliability ▪ Comparability	None	No	High
Q-5	**Proxies**	Immediate	Low	▪ Measure of Quality ▪ Quality ▪ Reliability ▪ Completeness ▪ Comparability	Low to Medium	No	Very High
Q-6	**Validation Statistics**	In this project	Low	▪ Measure of Quality ▪ Quality ▪ Comparability ▪ Reliability	Low	Maybe	Low
Q-7	**Data Cleaning Statistics**	Immediate/In this project	Low	▪ Measure of Quality ▪ Comparability ▪ Usefulness ▪ Completeness	None to Low	Maybe	Medium
Q-8	**Number of Missing Values**	Immediate	Low	▪ Measure of Quality ▪ Comparability ▪ Completeness	Low	No	High
Q-9	**Adherence to Quality Guidelines**	Immediate/In this project	Low	▪ Measure of Quality ▪ Quality ▪ Comparability	None to Low	No	Medium

CHAPTER 4

4. Design of Survey Instruments

In this chapter, those elements relating to the design of survey instruments are discussed, and proposed guidelines and standardized procedures are described. The elements are provided in the same order as shown in the preceding chapter.

4.1 I-1: MINIMUM QUESTION SPECIFICATION

4.1.1 Definition

This item is concerned with establishing the minimum question content of a household travel survey, whether it is time-use, activity or trip based, in order to obtain essential information about travel, activity, demographic and vehicular attributes of the household. It is important to note that the concern here is with specifying a *minimum* set of questions that all surveys should include. Most, if not all, surveys will probably include additional questions beyond these. However, if this minimum set is used consistently all surveys, both the usefulness of each survey will be enhanced, and the comparability among surveys will be improved.

4.1.2 Research on Minimum Questions

Achieving a set of minimum questions or a list of core survey questions, as phrased by Pratt (2003), will enable the development of standard variables and categories and allow for uniformity and, hence, comparability across data sets. Another benefit of this process is that the value of data already collected will increase while the cost of implementing the proposed standardization remains minimal. Analysis of such data may provide insight into travel behavior and therefore this information may be used in transportation planning tools. Table 20 presents a preliminary suggestion for minimum question specifications.

Comparing this table with the seven metropolitan data sets, it was found that none of these data sets totally conformed to the minimum question recommendations. One metropolitan data set had 27 out of 33 items represented and this was the closest to conformity with the list in Table 20. It was observed that items H2, H3, H5, H6, P7, and A1 in Table 20 were represented in all of the data sets. The poorest representation was for the items P6, P8-P11, A10 and V1-V6. Household items were best represented in the data sets followed by activity items and personal items. Vehicular items were very poorly represented. This clearly illustrates the need for a set of minimum questions because this is an important area for which data should be collected; such data may provide insight into the travel behavior of households as well as provide information that can be used to study environmental impacts caused by particular vehicles.

Table 20: Preliminary Suggested Minimum Question Specifications

Category	*Ref.*	*Item*	*Description*
Household	H1	Location	Home address or home position in geographic terms
	H2	Type of Building	Detached, semi-detached, terraced, flat, etc.

	H3	Number of Members	
	H4	Relationships	Matrix of relationships between all members of the household
	H5	Income	Indication of total household income (gross, annual) from all sources
	H6	Number of Vehicles	Summary of number of vehicles from vehicle data
Personal	P1	Gender	
	P2	Year of Birth	(Preferable to requesting age)
	P3	Commitments	Work and/or student status for each person
	P4	Paid Jobs	Number of paid positions and hours worked at each in the past week
	P5	Occupation	Type of work done
	P6	Job Classification	Employee, self-employed, etc.
	P7	Driving License	Whether or not a current drivers license is held
	P8	Non-mobility	Indication of why no out-of-home activity was performed on a survey day including work-at-home days
	P9	Start Location	Location at the beginning of the first survey day
	P10	Education Level	Highest level of education achieved
	P11	Handicap	Types of mobility handicap, both temporary and permanent
	P12	Race[11]	Defined as currently measured in the U.S. Census
	P13	Hispanic Origin[1]	Defined as currently measured in the U.S. Census
Vehicle	V1	Make	
	V2	Model	
	V3	Body Type	E.g., car, van, RV, SUV, etc.
	V4	Year of Production	
	V5	Ownership of Vehicle	Household/person, lease, institution
	V6	Use of Vehicle	Main user of vehicle and possible list of other users
Activity	A1	Start Time[12]	
	A2	Activity or Purpose	
	A3	Location	Where the activity was performed, unless traveling
	A4	Means of Travel	If activity is travel, what mode(s) was used
	A5	Mode Sequence	Unless collected as fully segmented data
	A6	Group Size	Number of persons traveling with respondent as a group
	A7	Group Membership	Number of persons in the group who live in respondent's household
	A8	Costs	Total amount spent on tolls, fares and respondent's share
	A9	Parking	Amount spent to park
	A10	Public Transit Route	Name/number of bus route, train, other transit used on each segment

In addition to the items in Table 20, it may be suggested that questions relating to the following issues should be included:

- The housing tenure of the respondent (own or rent status: a household item); and
- If traveling by private vehicle, whether the respondent was a driver or passenger (activity item).

It may also be useful to determine whether the respondent possesses a cell phone and has access to the internet, and if so, whether this is at home, work or both. However, such a question is currently not considered essential for inclusion in the minimum question set.

In Table 20, a household item identifying racial and cultural background was not suggested from the original sources. However, despite the controversy associated with asking questions about this item, race and ethnic origin should be included in the list. According to Pratt (2003), information on race is required to define the sample population and to conduct interviews; matching interviewers to respondents

[11] All surveys shall use the U.S. Census Bureau definition of Race.

[12] Only start time needs to be ascertained in a time-use or activity survey, because, by definition, the start time of an activity is the end time of the previous activity. Only the last activity should need an end time.

may increase response rates for CATI surveys. The data gathered on this characteristic of the household may provide insight as to why certain journeys and activities are made, e.g., home-based school trips made by the parent or the guardian. This information may also explain why one of the parents or a guardian is not part of the workforce and hence why annual household income is in the lower income bracket.

Cultural differences are important to acknowledge before, during and after the data analysis process especially from an environmental justice perspective. Obtaining an adequate sample of people from different racial and income backgrounds, within the sample drawn for the household travel survey will lead to sufficient representation of minority groups and, hence, avoid sample bias. Decisions emanating from unbiased data should take into account travel patterns and needs of particular minority groups and hence address the environmental justice objective: no person or group of people shall be subjected to a disproportionate share of adverse environmental impacts resulting from a development in urban infrastructure or other policy outcome (EPA, 2004).

Ethnicity, on the other hand, is not necessarily part of the characterization used in environmental justice, and there is no evidence that it has ever been used in a travel demand model, or in any form of forecasting from transportation data. However, after extensive discussions with the panel for this project, it is recommended as a question to be included in the minimum question specification. In various situations relating to environmental justice, it is being used, and its omission, when race is asked, was seen to be potentially problematic.

Household income is a characteristic on which people are reluctant to give information. It was considered for inclusion in the minimum question specification, but was rejected for several reasons. First, the reluctance of people to provide it means that often as much as 20 percent of the sample may have missing income data, so that the variable often cannot be used practically in modeling or related activities. Second, phrasing the income question to gain consistent data is very difficult. In its Quarterly Survey of Income and Expenditure, the U.S. Bureau of the Census uses a battery of about 25 questions to ascertain annual household income. The average household travel survey tries to do this with one question. The result is certain to be inconsistent, In addition, it is a known fact that households will frequently misreport income, either inflating income to impress the interviewer, or deflating it, in order to avoid perceived risks of reporting of survey results to the Internal Revenue Service. Based on all of these issues, it was decided to exclude household income from the *minimum* question specifications.

While examining the seven data sets and establishing the common questions and variables, it was noted that, for one of the data sets, a question asked about the number of licenses in the household, whereas, for the other data sets, the question asked about the number of licensed drivers in the household. Both questions ask about drivers' licenses however one quantifies the number of licenses in the household, while the other quantifies the number of licensed drivers in the household. The difference will arise if a household member holds more than one driver's license. The information that is of real value here is whether or not the household member has a valid driver's license and therefore the latter question should be asked. Question wording and content is important, because the data obtained from incorrectly worded questions will not be the desired information as explained above. This topic is discussed in more detail in section 4.3.

Achieving a set of minimum questions will enable the development of standard variables and categories and allow for uniformity and hence comparability across data sets. Another benefit of this process is that the value of data already collected will increase, while the cost of implementing the standard proposed remains minimal. Analysis of such data may provide insight into travel behavior and therefore this information may be used in transportation planning tools.

Another issue is whether or not personal travel surveys need to collect data on the alternative transport modes, destinations, or other elements that were in the decision set of the respondent, but not chosen. This is an issue that is restricted to surveys that are conducted for the purposes of building models of travel choices. However, it is an issue that has not been addressed adequately elsewhere. It is recommended that these questions not be included in the minimum question specification. In general, current practice is not to ask questions on alternative modes and destinations, and their characteristics,

and there is a potential for serious burden problems in trying to do so. In many instances, the information gathered will be a matter of guesswork on the part of respondents, and it is questionable as to whether this is relevant to any model-building exercise. There may be special cases where such questions are warranted, but they should not be part of the minimum specification.

A second issue is whether or not travel times, distances, and costs should be asked for in the minimum set of questions. It is again recommended that these questions should not be included in the minimum question specification. In the matter of travel times, distances, and costs, it is well known that respondents generally do not report these values accurately. For travel time, it is generally more reliable to ask the time of departure and time of arrival, and derive the travel time for this. While it is true that most people will round clock times to the nearest 5 or 15 minutes, so that the time derived will not be particularly accurate, travel times themselves will usually be rounded to the nearest 15 minutes, so that not much different accuracy is obtained from a question of elapsed time. The data from the 1996 North Central Texas Council of Governments Household Travel Survey illustrates this point quite well, as shown in Figure 4. The peaks show the 5 and 15 minute rounding very clearly. Indeed, from an analysis of the data, we find the distribution of reported minutes for the end of an activity shown in Table 21. Only 13.4 percent of respondents gave a time to the nearest minute, while 45.2 percent gave the time as on the hour or the half hour. Similar results are found in most surveys.

Table 21: Distribution of Reported Activity End Times from 1996 NCTCOG Survey

Reporting of Minutes for End of Activity	***Percent of Valid Reports***
Reported on the hour	29.5%
Reported on 15 minutes	7.2%
Reported on 30 minutes	15.7%
Reported on 45 minutes	7.3%
Reported as 5, 10, 20, 25, 35, 40, 50, or 55	26.9%
Reported not as a multiple of 5 minutes	13.4%

Further, people report times that are usually neither the real times, nor the perceived times. Rather, they are the perceived times filtered through a process of conversion to a time that the individual desires to report, either to make the choices that he or she has made seem more logical and justified, or to reflect what he or she believes the interviewer wants to hear. Travel distances are also not usually known accurately, and people can usually only report out-of-pocket costs, such as fares, tolls, and cash payments for parking, but will usually not report other aspects of cost with any reliability. For example, there are a number of reports that indicate that, when asked how much a car trip costs, around 50 percent of people report that it costs nothing. This was so widely demonstrated in the 1960s and 1970s, that most surveys since then have not asked the question. For this reason, only the out-of-pocket cost elements are recommended for the standard of minimum question specifications.

One additional question that should be included is to ascertain if the person would be willing to be contacted again for other transportation study projects. This question allows qualification of households that could be used for validation activities, as well as for a variety of other purposes, such as membership of a panel. It would also provide a potential pool of respondents for use in focus groups of various types. Recommendations are found in section 2.1.1 of the Final Report.

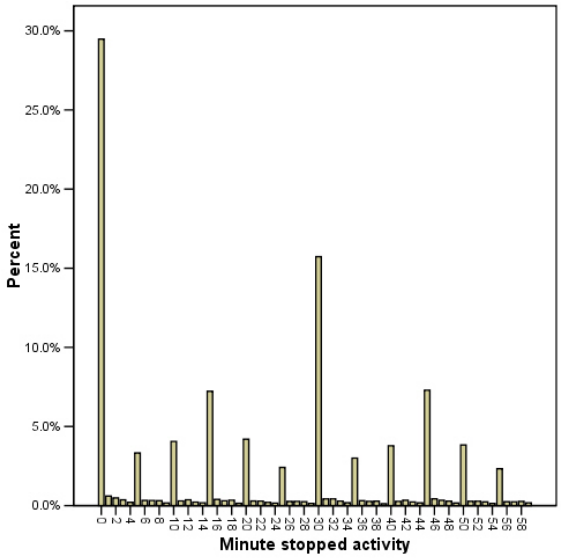


Figure 4: Activity End Times from 1996 NCTCOG Survey

4.2 I-2: STANDARDIZATION OF CATEGORIES

4.2.1 Need for Standardization

There appears to be considerable merit in defining consistent categories for those questions that are included in the minimum specifications, as well as also considering categories for some of the questions that are not specified within the minimum, but which may be included in many surveys. Probably, the most important of these are race (not including ethnicity), employment status, building/dwelling type, relationships among household members, means of travel, mobility disabilities, education levels, and activities.

Lack of standardization in these categories makes it extremely difficult to make comparisons between surveys and also may preclude some elements of transfer of models from one location to another, as a result of inconsistent categorization. Furthermore, many of these variables are also supplemented from the Census, so that consistency with census definitions is also important.

Table 22 shows those questions for which standard categories appear likely to be needed. In many instances, the standard categories should represent a minimum set of categories, with the possibility that more detailed categories could be created as subsets within the minimum set of categories. This may be particularly true for activity or purpose.

Additional questions for which standardized categories might be developed are income and housing tenure. In these cases, we have defined standardized categories that could be used in the event that the question was included. This also ties into the issue of standardized question wordings, where

some of these more difficult questions should probably be the subject of standardized wordings to assist in a comparable design as discussed further in section 4.3.

Table 22: Questions for Which Standard Categories Should Be Set

Category	*Reference*	*Item*
Household		
	H2	Type of Building
	H4	Relationships
Person		
	P6	Job Classification
	P8	Non-mobility
	P10	Education Level
	P11	Handicap
	P12	Race
Vehicle		
	V3	Body Type
	V5	Ownership of Vehicle
	V7	Fuel Type
Activity		
	A2	Activity or Purpose
	A4	Means of Travel

Across the seven data sets examined, variables that described household income, type of dwelling, type of activity, means of travel, and employment status had conflicting and overlapping categories. The problem was not so much the conflicting categories, because this could be corrected by manipulating the data (recoding) in order to get the value codes representing the same category. The real problem is the overlapping of categories e.g., an income category of $30,000, given a value code of 4, whereas the value code of 5 represents $30,000-$40,000. This cannot be corrected if the data for income is only presented as categorical data. The U.S. Bureau of the Census currently defines income in $2,500 steps from $0 through $100,000, and then defines a single group in excess of $100,000. In most personal travel surveys, it is not necessary to define income to this level of disaggregation. However, steps of $10,000 from $0 through $100,000 could be considered to represent a necessary minimum. This would allow comparability among personal transportation surveys, as well as comparability to the Decennial Census and any other surveys that use the same income categories. Income, however, does pose additional problems that result from inflation and economic growth. This means that incomes in, say, the group from $20,000 to $25,000 represent something different in 1995 than they do in 2005. The way in which this might be handled is addressed in the Section 9.5 of this Technical Appendix.

While comparing the seven data sets, the variable that described the building/dwelling type also posed significant problems. It was not known whether the definition of townhouse was the same across the data sets because, in one case, townhouse was grouped with condominium, while in another data set, townhouse was grouped with duplex and triplex type housing. The definition of condominium is not clear as it is not really a housing type but rather a type of ownership. Clearly this demonstrates the need for a universal definition to be adopted.

Recommended standardized categories are provided in section 2.1.2 of the Final Report.

4.3 I-5: STANDARDIZATION OF QUESTION WORDINGS

4.3.1 Item Description

To permit comparisons across surveys conducted in different locations, at different times, it is essential that certain key questions be asked in the same manner. It is also important that the question wording or response definitions in a local survey be consistent with the wording (and definitions) used in a national survey or census, especially for variables that may serve as the basis for sampling, expansion, and checking for bias.

4.3.2 Review of Candidate Wordings

Candidates for standardization of question wording include:

- Variables that are used in sample stratification or expansion, and to check for potential bias:
  - Number of members in household;
  - Number of vehicles;
  - Income;
  - Owner or renter; and
  - Gender.
- Other characteristic questions that may impact travel:
  - Disability.
- Questions that are critical to transportation planning:
  - Number in traveling party;
  - Activity or trip purpose; and
  - Working at home.

Other questions, such as travel costs, were reviewed but were deemed too dependent on local conditions to permit a recommendation for standardization.

Number of Persons in Household:

This is an essential data item that is used to classify households in most household travel survey sampling frames, to check for potential bias in the sample, to allow conversion of household rates to person rates, and, procedurally, to determine how many diaries to be sent to a given address. The average household size from the Census data is frequently used as one of the key variables to expand a survey sample to a region's population. Thus, household size is one of the most critical data items in the entire survey.

Because its charge is to have an accurate count of the entire population, the U.S. Census has a detailed definition of persons to be included and excluded from the household count. This is shown in the first row of Table 23. The remaining rows of Table 23 display the standard question wording for several of the recent larger household travel surveys. Note that travel survey practitioners have found it useful to re-iterate that the count is to include infants and small children, and to exclude college students living away and visitors. Travel surveys should follow the general form of the question wording from the NHTS, but change the word "household" to "at this address", to prompt for inclusion of housemates:

> *"Including yourself, how many people live at this address? Please do* ***not*** *include anyone who usually lives somewhere else or is just visiting, such as a college student*

away at school. (If further clarification is needed--include infants and children, live-in domestic help, housemates, roomers)"

Table 23: "Number of Persons in Household" Question Wording

Survey	*Wording*
2000 U.S. Census	How many persons were living or staying in this house, apartment or mobile home on April 1, 2000. (Include in this number • Foster children, roomers or housemates • People staying here on April 1, 2000 who have no other permanent place to stay • People living here most of the time while working, even if they have another place to live DO NOT INCLUDE: • College students living away while attending college • People in a correctional facility, nursing home or mental hospital on April 1, 2000 • Armed Forces personnel living somewhere else • People who live or stay at another place most of the time)
2001 National Household Travel Survey	Including yourself, how many people live in your household? Please do **not** include anyone who usually lives somewhere else or is just visiting, such as a college student away at school.
Bay Area Travel Survey 2000	So that we know how many diaries to send – including yourself and all children, how many people live at this address?
2000-02 Southern California Travel and Congestion Study	Now I need to get information about the persons in your household. How many people, including yourself, live in your household? (Includes all persons who sleep there at least 3 nights per week.)
1996 Dallas-Ft. Worth Household Travel Survey	How many people live in your household, including infants and live-in domestic help?

Number of Vehicles

Another key variable for classifying (or stratifying in sampling) households or persons in travel surveys is the number of vehicles they have available for travel. Once again, this variable is frequently used as an expansion variable or as a check for sample bias.

As shown in Table 24, there is general consensus on the standard wording of the question, but there are differences in whether two-wheeled vehicles are to be included in the count. The U.S. Census does not specify motorcycles in its definition of vehicles, although most motorcycles do weigh less than one ton so they should be included in the count. Travel survey practitioners have typically crafted the question so that only vehicles that actually run and are available for daily travel are to be included in the count. This is done specifically to exclude the non-working, hobby car parked in the garage or driveway. Note that this phrasing may lead to the average number of vehicles reported under local travel surveys (only vehicles in working order) being somewhat less than the average number reported to the Census (all vehicles).

When asking for the number of vehicles, the question should be worded:

"How many vehicles are owned, leased, or available for ***regular use*** *by the people who currently live at this address? Please be sure to include motorcycles, mopeds and RVs. (As clarification, regular use means are in working order)"*

Table 24: "Number of Vehicles in Household" Question Wording

Survey	*Primary question*	*Motor-cycles specified?*	*Ask about number of bicycles?*
2000 U.S. Census	How many automobiles, vans, and trucks of one-ton capacity or less are kept at home for use by members of your household?	No	No
2001 National Household Travel	How many vehicles are owned, leased, or available for regular use by the people who currently live in	Yes	How many adult-size bicycles does your

Survey	your household? Please be sure to include motorcycles, mopeds and RVs.		household have in working order?
Bay Area Travel Survey 2000	How many vehicles are available to your household? Include owned and leased cars, vans and trucks, and company vehicles available to household members for general transportation.	How many motorcycles or mopeds does your household have in working order?	How many bicycles, in working order, does your household have?
2000-02 Southern California Travel and Congestion Study	Now, how many vehicles are presently available to members of your household? This includes all cars, vans, trucks, RVs, SUVs, motorcycles and mopeds, whether owned or leased or provided by an employer.	Yes	How many bicycles in working condition are available to members of your household for use in their daily travel?
1996 Dallas-Ft. Worth Household Travel Survey	How many cars, pickups, trucks, vans or motorcycles are available for use by you and other members of your household?	Yes	No

A second issue in asking about number of vehicles is whether, and then how, to ask about bicycle availability. It would be useful for travel surveys to include a separate question regarding the availability of bicycles for daily travel:

> *"How many bicycles in working condition are available to members of your household for use in their daily travel?"*

Income

Income, while not being one of the minimum questions, is often included and often used as a check for potential sampling bias and less frequently as a sampling or expansion variable. U.S. Census Long Form (Form D-2) asks respondents to report individual person income in dollars (as an open-ended amount) from each of the following income sources:

- Wages, salary, commissions, bonuses or tips from all jobs
- Self-employment-income from own non-farm business or farm business, including proprietorships and partnerships;
- Interest, dividend, etc;
- Social Security or Railroad Retirement;
- Supplemental Security Income;
- Public assistance or welfare;
- Retirement or survivor or disability pensions;
- Any other sources of income.

However, while asking for income at the person level, the Census reports income at the household level. While the level of income source detail required by the U.S. Census is not usually necessary for travel surveys, a definition of income that is consistent with the Census definition is important. The key issue for travel surveys appears to be whether income is asked about at the person level (as in the Census and the 1996 Dallas-Ft. Worth Travel Survey), or at the entire household level (as in most other recent travel surveys). To the extent that travel models are being developed that apply at the person level, it is likely that more surveys will need to ask for person-level income. However, even for these models, household level income is important. Typical income question wordings are shown in Table 25.

Table 25: "Income" Question Wording

Survey	***Person or Household***	***Primary Question***
2000 U.S. Census	Person	<For each person> Mark the "Yes" box for each income source received during 1999 and enter the total amount received during 1999 to a maximum of $999,999. For income received jointly, report, if possible, the appropriate share for each person; otherwise report the whole amount for only one person.
2001 National Household Travel Survey	Household	<In surveys like these, households are sometimes grouped according to income.> Please stop me when I get to the category that best describes your total household income, before taxes, in the past 12 months. (We want to include income from sources such as wages and salaries, income from a business or a farm, Social Security, pensions, dividends, interest, rent, and any other income received.)
Bay Area Travel Survey 2000	Household	Please stop me when I get to the category that best describes the total 1999 combined income for everyone living in your household:
2000-02 Southern California Travel and Congestion Study	Household	What was your total household income in 1999 from all sources before taxes, for all members of your household?
1996 Dallas-Ft. Worth Household Travel Survey	Person and Household	What was person <One's> total annual income last year before taxes? Please read me the income range that is closest to your household's total annual income last year before taxes: I'd like to confirm that this amount includes all members of your household, even those who are unrelated to you.

Another issue in wording the income inquiry is the time period specified for the income (e.g., prior 12 months, or prior tax year). It is recommended that the question be asked about the prior year, since most U.S. respondents will know their annual income from the prior year's tax period. Household income should be asked in the following manner:

> *"Please stop me when I get to the category that best describes the total combined income for everyone living at this address for last year"*

Owner or Renter Status

Owner or renter status is another variable that is often used as either a check for sample coverage bias, or as a variable to expand sample data to population data, usually Census data. The most common wordings of that question are shown in Table 26. The U.S. Census reports all household units that are not owner occupied as being renter occupied, whether cash rent was paid or not. Thus in order to use the Census as a comparison set, the question should parallel the Census wording.

The question regarding owner or renter status should be worded:

> *"Do you own or rent your home?*
> *1 Own/buying (e.g. paying off a mortgage)*
> *2 Rent/lease or*
> *3 Provided by job or military"*

In the analysis, response option categories 2 and 3 should be combined.

Table 26: "Owner or Renter Status" Question Wording

Survey	*Question Wording*
2000 U.S. Census	Is this house, apartment or mobile home— • Owned by you or someone in this household with a mortgage or loan? • Owned by you or someone in this household free and clear (without a mortgage or loan)? • Rented for cash rent? • Occupied without payment of cash rent?

2001 National Household Travel Survey	Is your home owned or rented? • Owned • Rented • Provided by job or military
Bay Area Travel Survey 2000	Do you own or rent your home? • Own • Rent
2000-02 Southern California Travel and Congestion Study	Do you own or rent this home? • Own/buying • Rent
1996 Dallas-Ft. Worth Household Travel Survey	Do you own or do you rent your home? • Rent/lease • Own/buying (e.g., paying off a mortgage)

Gender

This variable is frequently used to check for sample bias. As may be seen from Table 27, the only issues are whether the question is worded to ask for a person's "sex" or "gender," or asks whether the person is male or female. To avoid any confusion over what is being asked, it is suggested that the question be worded:

"Are you (is this person) male or female?"

Table 27: "Male or Female Status" Question Wording

Survey	*Question Wording*
2000 U.S. Census	What is this person's sex? ☐ Male ☐ Female
2001 National Household Travel Survey	Please tell me your first name, age and sex. ☐ Male ☐ Female
Bay Area Travel Survey 2000	Are you (is this person) male or female? ☐ Male ☐ Female
2000-02 Southern California Travel and Congestion Study	And what is (your/their) gender? ☐ Male ☐ Female
1996 Dallas-Ft. Worth Household Travel Survey	And what is person number (1's, 2's, etc) gender? ☐ Male ☐ Female

Disability

It is useful to ask respondents for the presence of physical or other long-term disabilities that affect mobility. This question is often used as a check for reported immobility on the assigned travel day(s); it is less frequently used as a check for sample coverage bias.

Table 28 presents common wordings of this question in travel surveys, as compared to the U.S. Census wording.

A question asking about disabilities that impact travel should be asked. The wording of the question should parallel that in the U.S. Census, but should focus more specifically on the travel:

"Do you have a disability or condition that has lasted 6 or more months and which makes it difficult to go outside the home alone, for example to shop or visit a doctor's office?"

If the respondent replies "yes" to having a condition that limits travel, the survey should include a follow-up question, to probe either for the specific disability (as in the Bay Area, Southern California, or Dallas surveys) or for the condition's impact on use of travel modes (as in the NHTS).

Table 28: "Disability Status" Question Wording

Survey	*Question Wording*
2000 U.S. Census	Does this person have any of the following conditions: 1. Blindness, deafness or a severe vision or hearing impairment 2. A condition that substantially limits one or more basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying Because of a physical, mental or emotional condition lasting 6 months or more, does this person have any difficulty in doing any of the following activities: • Learning, remembering or concentrating? • Dressing, bathing, or getting around inside the home? • (if person is 16 years old or over) Going outside the home to shop or visit a doctor's office • (if person is 16 years old or over) Working at a job or business?
2001 National Household Travel Survey	{Do you/Does SUBJECT} have a medical condition that makes it difficult to travel outside of the home? If yes, How long {have you/has SUBJECT} had this condition? Because of this condition, {have you/has SUBJECT} • reduced {your/his/her} day-to-day travel? • asked others for rides? • limited driving to daytime • given up driving altogether? • used the bus and subway less frequently? • used special transportation services such as dial-a-ride?
Bay Area Travel Survey 2000	Do you (Does <insert name>) have a disability or condition that has lasted 6 or more months and which makes it difficult to go outside the home alone, for example to shop or visit a doctor's office? If yes, what type of disability is that? • Blind/visual • Transferable wheelchair • Non-transferable wheelchair • Deaf/hearing impaired • Mentally disabled • Cane/walker • Other (Specify:)
2000-02 Southern California Travel and Congestion Study	Do you /does<he/she> have a physical, mental, or other health disability that has lasted 6 or more months and which makes it difficult for<you/him/her>to go outside the home alone, for example to shop or visit a doctor's office? If yes, what type of disability is that? • Difficulty standing, walking or climbing stairs • Visually impaired/blind • Hearing impaired/deaf • Wheelchair • Require cane/walker Other
1996 Dallas-Ft. Worth Household Travel Survey	Do you (does he/she) have any physical limitation that affects the type of transportation you (he/she) can use? • Difficulty standing • Difficulty climbing stairs • Visual/blind • Hearing impaired/deaf • Wheelchair • Cane/Walker • Other

Number in Traveling Party

The number of persons in a traveling party is usually used to determine vehicle occupancy. The 2001 NHTS used this question series to cue up a trip roster so that trips made by multiple members of the same household traveling together did not have to be reported separately.

As can be seen in Table 29, the issues for question wording are:

1. Whether to ask for the number of persons including, or excluding the respondent;
2. Whether to ask number in traveling party for all trips, or only for those trips made by a private vehicle; and
3. Whether to ask a follow-up question regarding how many members of the traveling party were household members.

Table 29: "Number in Traveling Party" Question Wording

Survey	*When Asked*	*Question Wording*
2000 U.S. Census	Asked only if mode of travel to work last week was car, truck or van	How many people, including this person, usually rode to work in the car, van or truck last week?
2001 National Household Travel Survey	Asked of all trips	Was anyone with {you/SUBJECT} on this trip? Were any household members with {you/SUBJECT} on this trip? If Yes, Which household members? Did any non-household members go with {you/SUBJECT} on this trip, such as friends, relatives, or other people {you know/he/she knows}? If Yes, How many non-household members went on this trip with {you/SUBJECT}? **[DO NOT COUNT OTHERS THAT HAPPENED TO BE USING THE SAME BUS, PLANE, TRAIN, ETC.]**
Bay Area Travel Survey 2000	Asked only if used private vehicle	Including yourself (themselves) how many people were in the vehicle?
2000-02 Southern California Travel and Congestion Study	Asked only if travel mode was drove, passenger in car/truck/van or motorcycle/moped	What was the total number of people traveling with <YOU >? NOT INCLUDING THE PERSON YOU'RE ON Of those, how many were household members?
1996 Dallas-Ft. Worth Household Travel Survey	Asked only if used household vehicle	How many other people were in the vehicle with you (him/her), not counting yourself (himself/herself)? How many of these were members of your household (only asked if number in household was greater than one)?

There do not appear to be any data that speak directly to whether including or excluding the respondent in the count of members of a traveling party makes any difference in accuracy.

In the interests of consistency, the following wording would be most useful:

> *"Including yourself, how many people were traveling with you? How many of these were household members?"*

If CATI is used, it is suggested that the follow-up question regarding number of household members only be asked when the household size is greater than one. At a minimum, the number in the traveling party should be asked whenever a private car, van, or truck is the mode of travel. It is a matter of local survey discretion whether to ask this question on all trips, regardless of mode.

Activity or Trip Purpose

To compare data across surveys, it is essential that there be common set of definitions when asking about activities or trip purposes. However, as may be seen from Table 30, there is no standardized wording, or even consistency of practice in terms of what activities are included in what might appear to be a standardized activity category.

Table 30: Activity or Trip Purpose Response Categories

Activity or Trip Purpose	*2001 National Household Travel Survey*	*Bay Area Travel Survey 2000*	*2000-02 Southern California Travel and Congestion Study*	*1996 Dallas-Ft. Worth Household Travel Survey*
Personal Care and Maintenance	(Asked about trip purpose, not activities)	Household chores and personal care (child care, care of others, meal preparation)	Other at-home activities	Other at-home activities
		Sleep		Sleep at home
Meals	Social event	Meals at-home, take-out, restaurant, coffee, snack	Eat meal (restaurant, drive through, take-out)	Eat meal (restaurant, drive-thru, etc)
	Get/eat meal			
	Coffee/ice cream/snacks			
Shopping	Buy goods: Groceries/clothing/ hardware store	Shopping (Away from Home) for gas, groceries, drugs, clothes, shoes, furniture, cars, etc.	Shopping	Shop for groceries, house wares, medicine, etc. Community Services: Includes volunteer work; attendance at meetings arranged by social, political, scouting, religious, etc. organizations; and, attending civic ceremonies and meetings.
		Shopping (At Home) browsing by catalog, TV or Internet		Shop for furniture, clothes, autos, appliances, etc.
	Buy gas			Buy gas
Medical	Medical/dental services	Sick or Ill, Medical appointment	Medical	Visit doctor, dentist, health center, hospital
Education Activities	Go to school as a student	School or school related/College/Day Care/Homework (or other school-related work)	School (attending classes)	Preschool, school, college, university
	Go to religious activity		Other school activities (sports, extra-curricular)	
	Go to library: school related		Childcare, Day care, after school care	Child care, day care, after school care
Personal/ Household Business	Buy services: video rentals/dry cleaner/post office/car service/bank	Personal Services/ Banking/Gov., e.g., barber, beauty shop, dry cleaning, banking, government services	ATM, buy gas, quick stop for coffee, newspaper, etc.	ATM, banking, post office, utilities
	Use professional services: attorney/ accountant			
	Attend funeral/wedding		Banking, Post Office, pay bills	Other personal or household business (laundry, dry cleaning, shoe repair, video rental, barber/beauty shop, lawyer, accountant, broker, etc.
	Use personal services: grooming, haircut/nails			
	Pet care: walk the dog/vet visits			
	Attend meeting: PTA/ home owners assoc./local government			

Activity or Trip Purpose	*2001 National Household Travel Survey*	*Bay Area Travel Survey 2000*	*2000-02 Southern California Travel and Congestion Study*	*1996 Dallas-Ft. Worth Household Travel Survey*
Social/ Recreational		Social Activities, visiting, conversation in or out of home	Visit friends/relatives	Visit friends or relatives (including sleeping over)
		Volunteer/Civic/Religious services or activities (meetings, volunteer work, worship, weddings, etc.)	Occasional volunteer work	Occasional volunteer work
			Community meetings, political/Civic event, public hearing	Community meetings, political or civic event, public hearing, etc.
			Church, temple, religious meeting	Church, temple, religious meeting
	Go to gym/exercise/play sports	Recreation/ Entertainment (hobbies, exercise, TV)	Fitness Activity (Playing sports, gym, bike ride)	Gym/health club
	Rest or relaxation/vacation	Relaxing/Resting (reading, listening to music, thinking)	Recreational (vocational, camping. etc.)	Exercise/recreation (golf, tennis, sports, jogging, walking the dog, biking, etc.)
	Visit friends/relatives		Entertainment (watching sports, movies, dance, bar, etc.)	Entertainment (movies, spectator sports, museum, etc.)
	Go out/hang out: entertainment/theatre/sports event/go to bar			
	Visit public place; historical site/museum/ park/library			
Work or Work Related	Go work	Work or Work Related, in or out of home	Work (including regular scheduled volunteer work)	Work (including regularly scheduled volunteer work)
	Return to work			
	Attend business meeting/trip		Work-Related (sales call, meeting, errand, etc.)	Work-related (sales calls, meetings, errands, etc.)
	Other work related			
Working at Home			Working at home (related to main or second job)	Work at home
Travel		Driving, Riding, Walking, Biking, Flying		Traveling
Transport Someone	Pickup Someone	Pick-Up/Drop Off Passenger	Pick up someone or get picked up	Pick up someone or get picked up
	Take And Wait		Drop off someone or get dropped off	Drop off someone or get dropped off
	Drop Someone Off			
Changed Transportation Mode	Not a separate activity	Changed type of transportation	Change mode of transportation	Wait for/get on vehicle Leave/get off vehicle

Activity or Trip Purpose	*2001 National Household Travel Survey*	*Bay Area Travel Survey 2000*	*2000-02 Southern California Travel and Congestion Study*	*1996 Dallas-Ft. Worth Household Travel Survey*
Accompanying someone	Asked elsewhere to cue trip roster		With another person at their activity out of home	Be with another person at their activity
Other Activities		Non-Work (non-shopping) Internet use (e-mail, browsing, games)		

Some of the critical consistency issues are:

- In asking for work or work-related activities, it is essential to use the same definition of work as used in the census, if the intention is to later on compare number of workers per household from the survey to the population. The question used by the U.S. Census to classify respondents as workers is: "Last week, did this person do any work for either pay or profit?" For travel survey designers, this means that the response options should permit a clear delineation between paid and unpaid work such as regular volunteering and working at home.
- In some surveys, the home address is used to distinguish between those activities that may occur in or out of the home (e.g., meals, work). In others, there are separate response options for activities that could be performed either at or away from home, such as meals, work, shopping (using the Internet).
- There is no agreement as to which activities should be included in the general categories of personal/household business, social activities, and recreational/entertainment.

It should be noted that much of the practice in enumerating activities has to do with which activities the survey designer feels are most likely to be overlooked if they are not listed separately. The often-listed activity of "Buying gas" is an example.

In the absence of any transportation-related taxonomy for classifying activities, it is recommended that the categories defined in Section 8.4 of this Technical Appendix be used as the standardized categories.

For work or work-related activities, volunteer work should be specifically excluded from the definition. When asking for activities, a category "Other at-home activities" should always be included. Activities that could be performed either at or away from home, such as meals, work, shopping (using the Internet) could be asked for separately.

To provide comparability across surveys, it is recommended that the activity or trip purpose categories of personal/household business and social/recreational be defined as follows:

- Personal/Household Business: Includes buying or availing of services such as video rentals, dry cleaners, post office, car service, bank, ATM, personal services such as barber/beauty shop, government services such as post office or utilities, professional services such as lawyer, accountant, stock broker;
- Social and Communication: Includes talking or conversing in-person or by telephone or via the Internet; visiting friends and relatives, participating in community or cultural events; and, visiting entertainment and cultural venues;
- Community Services: Includes volunteer work; attendance at meetings arranged by social, political, scouting, religious, etc. organizations; and, attending civic ceremonies and meetings; and
- Recreation and Leisure: Includes playing sports; exercise; walking for leisure (including walking the dog); reading; watching TV/videos; and surfing the Internet.

Working at Home

As noted earlier in this Technical Appendix, the issue of successfully identifying home-based work has emerged as an issue in many travel surveys. As shown in Table 30, there have been many different approaches used to assess home-based work. Pratt (2000) suggests using a two-fold methodology that includes: 1) phrasing the questions in objective terms so that the responses can be compared across data sets; and, 2) adding questions to existing periodic surveys.

She suggests that the key variables necessary to identify work at home are:

- The hours/times of work:
  - During normal business hours (self-defined);
  - After-hours;
  - On week-ends; and
  - Trips interspersed with work at home.
- Clarification that work at home is meant to be work for pay or profit;
- Including a question(s) about a second job or home-based business, because working at home is strongly associated with these;
- Including among job classification categories separate options for employee, self-employed and contractor status; and
- Asking all respondents about work at home, including those who are retired, homemakers or part-time workers (the skip patterns in CATI should not automatically exclude certain persons).

Pratt also suggests that because an advanced degree, higher income, use of technology and the occupations of manager, professional or sales are strongly associated with home-based work, the items education, income, occupation, and technology ownership are useful to include in surveys.

All of these are indicators that may be derived from post-survey analysis, if the questions about work include clarification that what is meant is work for pay or profit, and questions about multiple jobs are included.

Recommended standardized wordings are provided in section 2.1.3 of the Final Report.

CHAPTER 5

5. Design of Data Collection Procedures

5.1 D-1: NUMBER AND TYPE OF CONTACTS

5.1.1 Definition

This item is about how many times and by what methods households should be contacted to obtain complete household responses. In terms of recruitment, the question arises as to the number of times a household should be contacted to obtain a complete recruitment response, especially if initial contact results in the household requesting to be called back, or simply a non-contact (answering machine, busy, and modem/fax).

In relation to data retrieval, the number of reminders and the methods of conducting these reminders depends on the survey mode employed initially. For example, if recruitment took place through e-mail and data retrieval was through the internet, then mailing out reminder postcards or letters is unlikely to provide as good a result as if the reminders were e-mail reminders. However, this warrants further investigation given that this survey mode is not widely used, especially in relation to travel surveys.

5.1.2 Review of Number and Type of Contacts

Table 31 shows the variability in the number and type of contacts made during the survey process for six recent travel related surveys. The Victorian Activity and Travel Survey, conducted in the state of Victoria, Australia, has used the following schedule:

- Initial contact letter;
- First mailing;
- First reminder;
- Second Reminder;
- Third reminder, entire survey package re-sent;
- A cover letter from the Survey Director stressing the importance of cooperation by respondents; and
- A Fourth reminder (Richardson, 2000).

The wide variability in the survey process, in terms of contact and reminders, emphasizes the need for standards. The following is a summary of recent literature about this topic.

Literature Review

The number and type of contacts, along with the data retrieval method employed, will impact on the final response rate (Axhausen, 1999). Various other design features also influence the response rate. For example, it was found that university sponsorship, pre-notification, personalized letters, salience, and follow-up procedures led to improved response rates (Ettema *et al.,* 1996; Melevin *et al.,* 1998; Cook *et al.,* 2000). Advance letters may increase the response rate by 5 to 13 percent. The time of receipt of the

letter, as well as distinctive postage markings[13], also play a role (Zmud, 2003). However, the advance letter may have a negative impact because the respondent can now prepare to refuse to participate (Zmud, 2003). In addition, the use of a "motivator" who motivates household members to undertake the survey task, and also is available to be contacted at any time by any member of the household, has been shown to be effective in increasing response rates in Europe (Brög, 1983; van Evert, Brög, and Erl, 2005).

Table 31: Type and Number of Contacts During the Recruitment and Retrieval Phase of Various Recent Travel Surveys

Survey	*Advance Letter*	*Telephone Recruitment*	*Next Contact*	*First Reminder*	*Second Reminder*
Emergency Evacuation (ITS – Sydney)	No	Yes	A week later; email contact containing information about principal agents involved in study, web address for internet survey and id number (password)	A week later; email reminder to households that have not responded	A week later; 2nd email reminder to households that have not responded
SE Florida	No	Yes	Mail out of survey package; cover letter, survey materials including 24 hr travel diary	CATI Retrieval	None
OKI	No	Yes	Mail out of survey package; cover letter, survey materials including 24 hr travel diary	CATI Retrieval	None
Broward	Yes	Yes (3 attempts)	Mail out of survey package; cover letter, survey materials including 24 hr travel diary	Follow- up calls after assigned travel day; Mail Back retrieval	None
NYC	Yes and call	Yes (9 attempts)	Mail out of survey package; cover letter, survey materials including 24 hr travel diary	Reminder call	CATI Retrieval after assigned travel day
DFW	No	Yes and intercept recruitment	Mail out of survey package; cover letter, survey materials including 24 hr travel diary	Reminder call	CATI Retrieval after assigned travel day

The number and type of contacts to households depends on the recruitment and retrieval mode(s) employed. For example, if the internet and e-mail are the retrieval methods used, then it may not be useful to employ telephone reminders to respondents. If mixed mode surveys are employed, then it is most likely that follow-up modes will also be mixed, to achieve the greatest levels of contact. However, it is important to acknowledge the findings of Dillman *et al*. (2001) with respect to mixed mode surveys: it was found that the success of the second mode of survey delivery in reducing unit non response was very small. The key is to give the respondents the choice of how to respond; this was a significant finding from the stated choice analysis for non-respondents in section 5.6 of this report.

Non-contacts

Non-contact is becoming more of an issue due to changing household structure and flexible work arrangements as well as technological and physical barriers (Kalfs and van Evert, 2003; Zmud, 2003). From this arise important questions: when is the best time to contact households and how many calls should be attempted before a household is no longer included in the sample? In many multicultural societies such as the United States, the United Kingdom and Australia, time and type of contact with a household can have social implications and this may influence unit non-response and hence, overall response rates. For example, households may engage in certain cultural activities at particular times during the week. If contacted about survey participation during these times, the households may become

[13] The markings and distinct features of the letter may help the respondent to remember what the research is about (Zmud, 2003).

quite annoyed: the disruption to their cultural activity(ies) being perceived as a lack of respect. This has not yet been investigated (Kalfs and van Evert, 2003), and unfortunately, this is beyond the scope of the current project.

Young persons and better educated persons are more difficult to contact. Households with one adult and employed household members required more calls to first contact (Keeter *et al.,* 2000). Also, it was found that highest contact rates for first calls occurred for households with incomes between $25, 000 and $35,000 (29.6 percent) on Monday to Thursday evenings between 6 and 9 pm (Dennis *et al.,* 1999). Both the low income group ($0-$15,000) and the high income group ($75,000 +) had the lowest contact rates for the same time slot. Overall, it was found that the median household income group ($25,000 to $35,000) had the highest household contact rate (Dennis *et al.,* 1999). This is also the case for respondents to travel surveys; hence, non-response bias exists because households with higher or lower income have different trip rates (De Heer and Moritz, 1997; Kam and Morris, 1999; Richardson, 2000).

Reminders

Reminders may involve a reminder postcard, telephone call, email, or re-sending the entire survey package. Generally, as a rule of thumb, if the initial contact generates a response rate of R, then the first reminder will add 0.5R, the second 0.25R, and the third, 0.125R, etc. Thus, three reminders almost double the initial response rate. For example, studies have shown that reminders to a survey can double the response rate that otherwise would have been obtained through a single mailing of a survey (Richardson, 2000; Lahaut *et al.,* 2003). Larger households and households with children were slower to respond to the survey; therefore, reminders increase the likelihood of these households responding, which helps to decrease non-response bias (Kam and Morris, 1999).

In relation to mail out/mail back surveys, reminder calls were not successful in increasing response rates because many households appeared to have thrown out their survey package (Freeland and Furia, 1999). In this case, a second mailing was conducted to households to increase the response rate. Also, it was found that telephone reminder calls were ineffective when limited to only listed telephone numbers. It is more likely that people with higher incomes have "silent" telephone numbers and these people are also highly mobile (Freeland and Furia, 1999). People of higher socio-economic status are more difficult to contact (Kalfs and van Evert, 2003; Zmud, 2003); therefore, a postcard reminder may be more useful. Areas historically difficult to contact will have increasing response rates if a second mailing of the questionnaire is conducted. This was found to be the case when a second mailing was sent out to households that had not yet responded (Whitworth, 1999).

However, too many reminders act like the Law of Diminishing Returns in economics (Cook *et al.,* 2000). In addition, it was found that respondents to later mail outs often under-report trips or do not travel as much (Kam and Morris, 1999; Polak, 2000; Richardson, 2000). The longer households take to respond to the survey, the higher the item non-response rates: decreasing data reliability with increasing response time (Kam and Morris, 1999). There appears to be a trade-off between increasing response rates and data reliability (Kam and Morris, 1999). Therefore, how many reminders should be made to households? This really is a function of the initial response rate, the survey environment, and the time frame of the data collection period.

Call Attempts (Re-Calls[14])

Research by Black and Safir (2000) found that a statistical difference exists on test variables between households that completed a survey and households that could not be contacted. Also, according

[14] Re-calls are not call backs. Call back is a disposition code whereby the household requested to be called back. This call disposition code therefore, indicates that the call has not been resolved and requires more calls to achieve a final call resolution.

to Stec *et al.,* (1999) and Colombo (2000), re-calling households will provide information on response probabilities that may be used in the estimates of non-response bias. However, the maximum number of calls made, varied in the two studies consulted. In travel surveys, there may be, at least, ten call attempts made.

In essence, to reduce the incidence of non-response bias, non-contact and call-back conversions must be conducted. Also, in travel surveys, these call attempts are not distributed evenly in the population. This creates problems in relation to bias reduction. As shown in Section 5.8 of this report, call-back and non-contact conversions showed different mean trip rates for every call attempt. For example, the mean trip rate for households that required two calls to be converted from a non-contact, was 8.005, for households that required three calls to be converted, the mean trip rate was 8.5636. Therefore, selectivity[15], in relation to subsequent call attempts, will not reduce the incidence of non-response bias.

The question now arises as to the number of calls that should be conducted. Findings of research conducted by Harpuder and Stec (1999) indicated that an average of five call attempts was required to obtain a complete interview. This research also suggests that between four and six call attempts is most appropriate. After six call attempts, the reduction in non-response bias resulting from the number of non-contacts is not significant (Harpuder and Stec, 1999).

Call History File Analyses

These results are from the analyses conducted on call history files, files containing the recruitment history for sampled households, for travel surveys that were conducted in two major areas in the United States. The data retrieval mode was either CATI or mail back. The importance of this analysis is threefold:

1. Call history files have not been analyzed in this depth;
2. This type of analysis has not been conducted on two stage surveys. The importance of these results is that they show the effectiveness of non-contact and call back conversions; and
3. Recommendations as to the number of calls that should be made to convert non-contacted households and those that requested to be called back, to complete recruitment interviews, is presented.

For a particular study, three types of initial contact were employed. These were:

1. Cold call – where the household(s) was simply called and asked to participate in the study without being given prior knowledge about the survey;
2. Pre-notified – where the household(s) was informed about the survey and a future recruitment call, in a letter stating the objectives of the survey; and
3. Intercept – where individuals were approached at bus stops and asked if their households would be interested in participating in a travel survey.

In Table 32, it can be seen that an association exists between the type of contact and the number of calls. The strength of this association, however, varies with contact type. The contact type "cold call" showed the strongest association (0.406), representing a moderate association. Overall, the results show that if a household had prior knowledge about the interview, then it required the least number of calls to reach a final call status. These results were expected and confirm what was found in the literature (Melevin *et al.,* 1998; Cook *et al.,* 2000; Kalfs and van Evert, 2003; Zmud, 2003).

[15] From the analyses of the call history files, it was discovered that for some non-contacted households, and some households that requested a call back, the number of subsequent call attempts conducted was three, whereas for other households, with the same disposition codes, subsequent call attempts conducted were as many as nine.

Table 32: Statistical Tests between Number of Call Attempts and Type of Contact, File 1

Contact type	*Chi –Square*	Df	*Cramer's V*
Cold call	*4917.93	19	0.406
Pre-notified	*4159.04	19	0.373
Intercept	*647.54	19	0.147

* significant at p=0.001

Given these results, it may be best for researchers to mail out advance letters to households, to inform households about the upcoming survey. This may "legitimize" the research survey process in the minds of respondents because cold call contacts may sound very much like marketing type interviews[16]. It will be interesting to see whether the *National Do Not Call Registry*, set up by the Federal Trade Commission (FTC) in the U.S. in late December, 2002 (CMOR News, 2003)[17], will have a positive effect on response rates to household travel surveys.

In the two call history files, between 10 and 11 percent of all refusals were initially call backs (350 out of 3279 in file 1 and 7,461 out of 76,612 in file 2). The more call backs are requested by respondents, the more likely the respondents are to refuse to participate in the survey. In the files investigated, this was especially the case if households requested two or more callbacks. These results support what was stated in the literature (Zmud, 2003). Of the 12,978 call backs requested by households in file 1, 2.2 percent (284) became refusers after subsequent call attempts. Of these, 41 or 14.4 percent of the 284 were converted from refusers to completing the recruitment interview. These represent only 0.3 percent of the total call backs. Finally, of the 41 who were converted to completing the recruitment, only 13 actually completed the household survey. The overall conversion is, thus, very small, with 0.1 percent of call backs to initial refusals eventually completing the entire survey.

Table 33 shows the number of call attempts needed for households that intially requested a call back, that then completed both the recruitment interview and the household survey. For call 1, the number of call backs to complete recruitment interviews is assigned "n/a", because it remains a call back, if the disposition code of the first call is a call back. It is only when two or more calls are made that the call disposition can change from a call back to, in this case, a complete interview (recruitment). For call 2, it can be seen that 612 of the call backs in call 1 were converted to complete recruitment interviews after the second call. However, of the total 855 complete recruitment interviews from call backs, 71.6 percent of these occurred when a second call was made to the household. From call numbers 7 through 10, no call backs were converted to complete recruitment interviews confirming what is reported elsewhere (Zmud, 2003).

Table 33: Call Attempts Required to Complete Interviews with Households Initially Requesting a Call Back (File 1)

Conversion	*Call Number*										*Total*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
Call Backs	4,292	2,881	1,885	1,199	984	558	386	336	296	161	12,978
Call Back to Complete Recruitment	n/a	612	136	52	37	18	0	0	0	0	855
Converted (%)	n/a	71.6	15.9	6.1	4.3	2.1	0	0	0	0	100%
Call Back to Complete Interview	n/a	209	46	12	7	2	0	0	0	0	276
Converted (%)	n/a	75.7	16.7	4.4	2.5	0.7	0	0	0	0	100%

[16] This depends on interviewer training and experience.
[17] This was not activated until early July, 2003 (Overington, 2003).

It is interesting to observe that of the 612 complete recruitment interviews achieved after a second call was made to the household, 75.7 percent, or 209 of these, were converted to complete household surveys. The percentages of conversions from call backs to complete recruitment interviews, and from call backs to complete recruitment interviews to complete household surveys, are almost identical for each call.

Table 34 shows the same information as Table 33 for file 2. It can be seen that 2,785 of the 41,467 call backs in call 1 were converted to complete recruitment interviews after the second call. However, of the total 3,958 complete recruitment interviews from call backs, 70.4 percent of these were converted to a complete interview when a second call was made to the household.

Of the 2,785 complete recruitment interviews achieved after a second call was made to the household, 1,151 (71.6 percent) were converted to complete household surveys. The percentages of conversions from call backs to complete recruitment interviews, and from call backs to complete recruitment interviews to complete household surveys are almost identical for each call.

Table 34: Call Attempts Required to Complete Interviews with Households Initially Requesting a Call Back (File 2)

Conversion	*Call Number*										*Total*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
Call Backs	41,467	23,021	14,764	9,250	5,784	3,313	1,938	1,048	536	18	101,139
Call Back to Complete Recruitment	n/a	2,785	762	259	87	39	16	5	4	1	3958
Converted (%)	n/a	70.4	19.3	6.54	2.2	0.9	0.4	0.13	0.1	0.03	100%
Call Back to Complete Interview	n/a	1151	308	103	26	17	2	1	0	0	1607
Converted (%)	n/a	71.6	19.2	6.4	1.62	1.0	0.12	0.06	0	0	100%

It is interesting to note that call back conversions to complete recruitment interviews occurred throughout the ten calls. However, the conversion of these to complete household surveys drops significantly after the second call is made. For example, the conversion to complete household survey for call number two is 71.6 percent, for call number three it is only 19.2 percent. The corresponding amount for file one, for call three is 16.7 percent. However, two call attempts should not be set as the call limit for households requesting call backs. The overall conversion to complete household surveys of households that requested to be called back is 276 (2.1 percent) for File 1 and 1,607 (1.6 percent) for File 2.

If a five-call limit had been set, then the numbers drop to 274 (2.1 percent) and 1,588 (1.6 percent), respectively. Thus, the overall conversion remains identical to the conversion rates with ten call attempts. Setting a call limit for call backs would, therefore save time and money, and allow resources to be diverted to convert refusal or non-contacted households.

Table 35 and Table 36 show the number of non-contacted households that were converted to complete recruitment interviews after subsequent call attempts, for call history files one and two. For both files, again it can be seen that overall conversion drops significantly after call two. The overall conversion rates for non-contacted households who went on to complete the recruitment interview, and later went on to complete the household survey are 5.4 percent for File 1 and 1.3 percent for File 2.

Table 35: Call Attempts Required to Complete Interviews with Households Initially Not Contacted (File 1)

Conversion	*Call Number*										*Total*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
Noncontacts	11,859	5,642	2,980	1,402	286	129	65	34	5	5	22,407
Noncontacts to	n/a	1,518	687	429	246	36	0	0	0	0	2,916

Complete Recruitment											
Converted (%)	n/a	52.1	23.6	14.7	8.4	1.2	0	0	0	0	100%
Noncontacts to Complete Interview	n/a	638	291	168	92	17	0	0	0	0	1,206
Converted (%)	n/a	52.9	24.1	14	7.6	1.4	0	0	0	0	100%

Table 36: Call Attempts Required to Complete Interviews with Households Initially Not Contacted (File 2)

Conversion	*Call Number*										*Total*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
Noncontacts	116,586	71,163	43,658	26,311	16,311	11,989	9,885	8,807	8,010	7,609	320,329
Noncontacts to Complete Recruitment	n/a	5,288	2,757	1,547	599	229	71	33	36	16	10,576
Converted (%)	n/a	50	26	14.6	5.7	2.2	0.7	0.33	0.33	0.15	100%
Noncontacts to Complete Interview	n/a	2,199	1,121	613	243	76	26	5	11	2	4,296
Converted (%)	n/a	51.2	26	14.3	5.7	1.8	0.6	0.1	0.26	0.04	100%

If only five call attempts were conducted, the overall conversion remains the same for file two, but drops by 0.07 percent for file one. This is not a significant loss, but given that six call attempts was the limit for re-calls to non-contacted households in study one, the cost saving is minimal. These results are similar to the results of a study conducted by Harpuder and Stec (1999). With this in mind, therefore, either five or six calls should be the call limit set to convert non-contacted households to complete recruitment and household interviews.

Motivators

As noted earlier, one of the methods that has been proposed and used in Europe is that of providing a motivator for each household. This is intended to increase the motivation of household members to complete the survey task, by building rapport between the motivator and the household members. In most current telephone surveys, each time the household is called, a different interviewer contacts the household, with the result that the survey may seem very impersonal, and the individual respondent may assume that his or her contribution is of relatively little value. The use of a motivator is one method to counteract the feeling of lack of importance, and of the impersonal nature of the survey.

As part of this project, Westat undertook a small pilot survey using an adaptation of the motivator procedure, devised by Socialdata (Moritz and Brög, 1999). Because of the nature of the CATI system used by Westat, and the availability of staff to act as motivators, Westat used a three-person team of interviewers for each household in a sample of 50 to 100 completed households. Respondents were provided with the names and phone numbers of each of the three interviewers, so that they could serve as motivators for the household and respond to questions from the household.

The pilot survey was undertaken as part of the Metropolitan Washington Council of Governments' (COG) longitudinal survey. This survey was a multi-contact telephone survey, using random digit dialing as the sampling procedure. There was a screener interview, followed by an extended interview to obtain trip data. The latter could sometimes require multiple calls to retrieve data from all household members. Three teams of three interviewers were used for the pilot survey, with each team including at least one bilingual interviewer, in case a Spanish-speaking household was encountered. There was little overlap between the three interviewers in a team, other than to brief the next shift's team member of any appointments that had been made for calls, and the status of each household.

Using this procedure, it would not be expected that much difference would occur in the initial screener interviews, since rapport was not yet established at that time. Also, because Westat used a manual dialing procedure for the pilot survey, compared to the automated call assignment system of the CATI software for the balance of the sample, it is possible that the initial screener interviews would be less successful than those not in the pilot survey. This was the case, although the reason for the lower response rate to the Screener Interview was principally in a larger proportion of no answers, answering machines, and reaching maximum number of call attempts without successfully contacting the household than in the main survey. There is no clear reason why this would have occurred, and it is not apparently due to the different methods of assigning calls to interviewers.

With respect to the completion of the Screener Interview, there was no statistically significant difference between the pilot survey and the main survey. It is worth noting that there was a slightly higher refusal rate in the pilot, which may have resulted from using no refusal conversion specialists in the interviewer teams, whereas such specialists are used in the main survey.

For the extended interview, there was again no statistical difference in the results from the motivator teams and the main survey. It was also noted that the average time spent on the phone was about 7 percent higher for the pilot survey than the main survey, although there was considerably more scheduling and down time for interviewers in the pilot survey than in the main survey, largely because of the small sample used, and the number of interviewers assigned to the pilot. Overall, the results of this test were inconclusive, and served to show that the automated system used by Westat was not able to respond readily to this different procedural design. It should also be noted that the method employed was not strictly the same as the method developed by Moritz and Brög (1999), and so results may not be reflective of the gains to be obtained from a more rigorous application of the motivator method.

Conclusion

Given the above results, and the results from other studies, it would appear that conducting no more than five call attempts to convert households that request to be called back, or non-contactable households, should be set as the call limit during recruitment, and retrieval (Harpuder and Stec, 1999). There is no significant reduction in non-response bias if more than five call attempts are made (Harpuder and Stec, 1999) and there are no real changes in the conversion percentages for households that requested to be called back, or non-contacted households, to complete household interviews.

Further research is also warranted on the motivator approach, which may serve to reduce termination rates and incomplete surveys, although it is felt unlikely to affect the initial response to the recruitment call. Although the Westat experiment was inconclusive on this point, there is enough indication in those results that a full-scale application should be attempted and compared to the conventional procedure. However, no recommended standards or guidelines can be proposed at this time on this specific issue.

Table 37 shows a proposed schedule of contacts and reminders, devised from the current state of practice of travel surveys. This is a proposed schedule; field work investigation is required before a standard can be devised. The recommendations for standardized procedures for number and type of contacts may be found in section 2.2.1 of the Final Report.

Table 37: Recommended Schedule of Contacts and Reminders

Ref.	***Day***	***Contact Type***	***Content***	***Received by Household***
1	Advance letter (R – 7)	Mail	Pre-Notification letter	A week before recruitment is scheduled to commence
2	Recruitment (R)	Telephone	Recruitment interview	Recruitment Day
3	R+1	Mail	Survey package sent out	R+3 to R+5
4	Day before Diary Day (D – 1)	Telephone	Pre-Diary Day Reminder (motivation call)	D-1

5	D+1	Telephone	Reminder to return completed survey (motivation call)	D+1
6	D+2	Mail	Postcard reminder/reset of Diary Day to D+7	D+4 to D+6
7	D+6	Telephone	Reminder and check on second opportunity for Diary Day	D+6
8	D+9	Mail	Postcard reminder and reset of Diary Day to D+14	D+11 to D+13
9	D+13	Telephone	Reminder and check on third opportunity for Diary Day	D+13
10	D+15	Mail	Re-mailing of Survey Package and reset of Diary Day to D+21	D+17 to D+19
11	D+20	Telephone	Reminder and check on fourth opportunity for Diary Day	D+20

5.2 D-3: PROXY REPORTING

5.2.1 Definition

In surveys that use telephone or personal interviews as the method to retrieve completed data, there is a continual issue regarding who provides the activity or travel information: the person performing the activity or travel (direct respondent) or someone else. Those instances in which the activities or travel are reported by someone other than the person who actually performed the activity are referred to as having been reported by "proxy".

5.2.2 Effects of Proxy Reporting

There is a relatively large body of research that concurs that the number of trips is lower when reported by proxies (e.g., Richardson *et al.,* 1995). Among recent travel surveys, the 1996 Dallas-Ft. Worth Household Travel Survey found that proxies reported statistically significant fewer activities than direct reports (comparing a mean of 11.4 activities from proxies to a mean of 12.3 activities from direct reports, $p<.0001$). The Bay Area Travel Survey 2000 also found lower trips from proxy reports, with an average of 3.8 trips on Day 1 (of a two-day travel diary) reported by proxy compared to 4.4 trips from direct reports. Both of these surveys permitted proxy reporting for persons under 18 years of age.

There have been other studies that have examined the types of trips that are more frequently differentially reported by proxies. Analyzing data from the 1995 Nationwide Personal Transportation Survey (NPTS), Greaves (2000) found that proxy reports tended to overestimate the trip rates for regular trips such as work and school trips, while severely underestimating the more spontaneous or discretionary trips such as non-home-based trips. Badoe and Steuart (2002) examined travel data collected in Toronto and found somewhat similar results, with proxy reports tending to underestimate home-based discretionary, and non-home-based, trips. In contrast to Greaves, however, they found that work and school trips were not over-reported.

To date, survey practitioners and local survey designers have developed their own rules and protocols for determining when proxy reporting is acceptable, and for reducing proxy reporting. As shown in Table 38, different household travel surveys have used slightly different guidelines for determining when a proxy report is acceptable, calculating the percentage of proxy reports, and methods for reducing the number of proxy reports. If, as is suggested elsewhere in this report, the percentage of proxy reports may be used as an indicator of survey method quality, then it is imperative that survey practitioners have a standard approach.

Acceptable Proxy Reports

There are clear instances in which having someone else report activities is not only appropriate, but desirable. Foremost among these instances is the reporting of children's activities or travel. The issue is whether proxy reporting should be required for certain ages and if so, what age categories should be used.

Table 38: Proxy Reporting Guidelines

Issue	*2001 National Household Travel Survey*	*Bay Area Travel Survey 2000*	*2000-02 Southern California Travel and Congestion Study*	*1996 Dallas-Ft. Worth Household Travel Survey*
Minimum Age Threshold	Proxy requested for all household members aged less than 16 years. Household members age 14 or 15 could respond for themselves if approval was obtained from an adult household member.	17 and under for proxy reporting; 18 and older for direct	None specified in documentation.	Aged 14 and under; always a proxy. Proxy permitted for ages 15-18; 19 and older for direct
How many times attempt on primary before accept proxy	We can speak directly to persons age 16 And older. However, a proxy for these individuals is acceptable beginning on the fourth day after the trip date.	If adult respondent not available for direct retrieval on initial call, and completed diary was available, could collect travel from proxy immediately.	None specified in documentation.	Initially, two attempts required before would accept proxy; this rule appeared to negatively impact completion rate, so was relaxed to one attempt halfway through survey.
% Proxy among Adults	16.9%	23.7%	Not reported in Final Report	19%
Coded whether respondent or proxy	Yes	Yes	Yes	Yes

The Federal Office of Human Research Protection considers research participants under the legal age of consent to be minors and therefore requires parental consent in most cases. Because the legal age of consent varies among the states (usually from 16 to 18), Human Subjects Guidelines have different procedures for respondents under 18 years of age (17 and under). In practice, most travel surveys in the United States have permitted adult proxies to report travel of children aged 14 and under. This matches the European practice, which is to use proxy reporting for persons aged 14 and under (CORDIS, 2003).

Practice varies as to the upper age limit, with some surveys accepting proxy reports from persons aged 16 and younger and others using 18 as the upper limit for acceptable proxy reporting. The following standards are recommended:

1. For persons aged 14 and under, require parental or other adult proxy reporting;
2. For persons aged 15 to 17, permit proxy reporting unless the individual is available to report their activities directly with parental permission; and,
3. All persons aged 18 or older should be asked directly for their activities or travel.

Among adult survey participants, there are other instances in which a proxy report might be appropriate, including when the individual is ill or physically or mentally unable to complete the survey. However, determination of these conditions requires the addition of at least two questions to the survey: one asking about long-term disabilities; and the other asking about short-term reasons for not responding

directly. There is a standard question recommended regarding long-term disabilities that would prevent an individual from traveling alone outside the home (section 4.3). This may be used to also assess whether a person is capable of responding directly. In cases where there was no travel outside the home on the travel day, it has also been recommended that a question be asked to probe for the reasons why, and temporary illness is one possibility (section 8.6). The responses to both these questions may be used to help determine whether a proxy report is acceptable.

Procedures for Reducing Proxy Reporting Among Adult Respondents

There is wide variation among survey practitioners as to the protocol, if any, used to reduce the number of proxy responses. The most common is to make repeated attempts to speak directly with the individual respondents. Both the 2001 NHTS and the 1996 Dallas-Ft. Worth Household Travel Survey included provisions that a proxy report was not accepted until a certain number of prior attempts had been made to reach the respondent directly by telephone.

The issue is often framed as being one of balancing the desire for higher quality data (obtaining activity or travel information from a direct report) with the desire for complete households (obtaining some data from all members of a household). In the Dallas-Ft. Worth survey, the requirement for at least two repeated attempts to reach the direct respondent was relaxed to require only one attempt during the study in response to perceptions that the protocol was leading to a lower completion rate than desired. However, the results were somewhat counter-intuitive: a higher percentage of households (78.9 percent) were complete prior to the relaxation of the proxy protocol than after (53.2 percent). While this finding may be confounded with the fact that the protocol change occurred roughly three quarters of the way through the study, and some of the later households may simply have been "abandoned" at the end of the survey period, it still provides some indication that additional attempts to reach the direct respondent does not necessarily impact household completion rates negatively.

Some survey practitioners accept as a quasi-direct response those instances in which an individual has written her/his activity or travel information in a dairy, and someone else in the household reports it during retrieval. However, Greaves' (2000) analyses showed that more trips were reported by proxies when a completed diary was present than when it was not; but, in both instances, the number of trips reported by proxies was less than the number reported by direct reports (even when the direct report did not bother to fill out the diaries). With this evidence, it is recommended that even when a completed diary is available for reporting by another household member, this should not be considered as a direct report. Only a direct response permits missing activities to be discovered and the full slate of trips/activities obtained. Direct reporting is especially crucial as survey designers choose not to include all of the desired information such as travel costs on the written diary form.

Recommendations on proxy reporting are provided in section 2.2.2 of the Final Report, while proxy reporting as a survey quality indicator is discussed further in section 10.4 of this Technical Appendix and section 2.7.4 of the Final Report.

5.3 D-4: COMPLETE HOUSEHOLD DEFINITION

5.3.1 Description

A complete household response is generally defined as a household in which complete information is obtained from all eligible household members (Stopher and Metcalf, 1996; Nustats International, 2000; Ampt and Ortuzar, 2004). The main problems that result from this rather stringent definition are:

1. Lower response rates; and
2. Exclusion of many households due to incomplete responses; larger and smaller size households are less likely to provide complete responses and this usually results in biased databases because demographic and travel characteristics of these households differ to those of completely responding households (DeHeer and Moritz, 1997; Kam and Morris, 1999; Richardson, 2000).

Other related issues include the accepted levels of proxy reporting and data imputation. Together, these troublesome issues, due to varying levels of acceptability across different surveys, raise the need for standardization of this survey element.

5.3.2 Review of Complete Household Definitions

Stopher and Metcalf (1996) found that 56 percent of recent travel surveys defined a complete household as one in which complete information was obtained from all eligible household members. In even more recent investigations, it was found that the definition of a complete household varied across nine metropolitan and national data sets from the U.S.

Table 39 provides a summary of the key features of the data sets in terms of complete household definition and response rates. For four studies, two of which employed travel diaries and the other two employed activity based travel diaries, a household response was considered complete if all household members provided all travel and all travel and activity information. Activity based travel diaries are popular because these prompt the respondent to recall travel undertaken between and or during activities, hence an expected lower incidence of item non-response. However, another two studies, that used activity based travel diaries, required complete information from all household members for all survey components- vehicle, household, personal and activity forms had to have complete information. Correspondingly, these two activity based travel diaries yielded low response rates for diaries of this type. This may also be because no partial responses were incorporated into the analyses as well as poorly designed survey instruments leading the respondent to believe that much effort is required to complete the diaries (high respondent burden). However, the lowest response rate was recorded for a study which used an activity based travel diary. This survey involved a recruitment and retrieval stage and thus attrition resulted in both stages leading to a low overall response rate.

Whether proxy reporting is permitted or not ultimately impacts how the research agency defines a complete household response. For example two studies (NYMTC and Bay Area Travel Survey) specified, in detail, the circumstances in which proxy reporting was accepted:

1. Proxy reporting accepted if an adult reporting on behalf of a minor, or for an adult that completed/returned the activity/trip diary (NuStats, 2000); and
2. Proxies were allowed if the subject was not capable of being interviewed because of an impairment or a language barrier, the interviewer was told that the subject would not be available for the entire six-day recall period, the interviewer was told that the subject would never participate, and the proxy was knowledgeable about the subject's travel on the assigned travel day, the interviewers attempted to reach the subject for the first three days of the six-day call-back period, and were not successful (U.S Department of Transportation, 2001a).

Table 39: Summary Features of Nine Data Sets Examined

Characteristic	*New York Metropolitan Transportation Council Household Interview Survey*	*Bay Area Main Travel Survey 2000,*	*Dallas-Fort-Worth Travel Survey*	*South East Florida Household Travel Survey*	*Broward Household Travel Survey*	*Oklahoma Kentucky Indiana Activity and Travel Survey*	*Little Rock Household Travel Survey*	*Yakima, Charleston and Wilmington*	*National Household Travel Survey*
Complete Response Definition	All records for all household members	All household members to provide travel and activity information	All records for all household members	All household members to provide travel information	All household members to provide travel information	All household members to provide travel and activity information	All household members to provide travel and activity information	All household members to provide travel and activity information	50% of adults in household complete the person interview.
Proxy Reporting	Accepted if an adult reporting on behalf of a minor, or for an adult that completed the activity/trip diary	Individuals unavailable at the time of the interview	Permitted	Permitted	Permitted	Permitted	Permitted	Permitted	Permitted
Eligibility	All household members	No one under 18	All household members	All household members	Household members over five years	All household members	All household members	All household members 16 years and over	All household members
Partial Response Definition	Complete information from all employed household members; partial responses excluded from analyses	Not defined	Not defined	Not defined	Not defined	Complete household responses except missing start and end of travel times	Not defined	Not defined	Not defined
Response Rate	26.2%	7.5%	37%	33%	33%	57%	n/a	n/a	36.8%

Source: Adapted from Carr Smith and Corradino (2000a, 2000b); Morpace International (1995); Morpace International (2002); Applied Management and Planning Group (1995); NuStats International (2000); NuStats International (2003a, 2003b); U.S. Department of Transportation (2001a).

In the documentation of another study, it was stated that proxy reporting was permitted so as not to reduce the response rate and discard part of the sample; high levels of unit and item non-response were expected. However, it was found that proxy reporting led to an underestimation of trip rates by as much as 0.43 for males and 0.69 for females (Morpace International, 2003). In addition, this study only sought travel and activity information from household members 18 years and over. This is an example of why the level of proxy reporting in the resulting data set has to be carefully examined (section 5.2 looks at proxy reporting in more detail).

A strict definition of a complete household response, permitting proxy reporting for certain cases only, and the elimination of partial responses from the final data set, resulted in a low response rate of 26.2 percent for the New York Metropolitan Transportation Council Household Interview Survey. The exclusion of these data is problematic for two major reasons. The first is the rising costs of data collection, and the second is that these data can be useful and provide insight into partial non-respondents.

In addition, the Bay Area Travel Survey allowed a high level of proxy reporting but used a stringent definition of a complete household response. The resulting response rate was 7.5 percent and the travel data obtained were relatively poor in quality.

The National Household Travel Survey employs the following definition of a complete household response: if fifty percent or more of adults within a household completed the person interview, which incorporates travel information and trip diaries, then the household response was considered complete. It has been widely documented that the characteristics of non-respondents to travel surveys are:

1. Very low and very high income;
2. High and low mileage drivers;
3. Young single males and females;
4. Zero vehicle use;
5. People residing in metropolitan areas; and
6. Households with children (De Heer and Moritz, 1997; Richardson, 2000; Kam and Morris, 1999).

Therefore, this rule was adopted to address the concern that larger households and low income households are less likely to have all household members complete the person interview and travel diary, due to complex travel patterns or the perception that their travel data are worthless to the data collection agency (Kam and Morris, 1999). The fifty percent rule aims to minimize non-response bias in travel surveys, thus obtaining a more accurate picture of people's travel behavior. However, despite the less stringent complete household definition and the permission for proxy reports for eligible household members, the overall response rate for the 2001 NHTS was 36.8 percent (U.S. Department of Transportation, 2001a). This demonstrates the problem of increasing non-response which adds to survey costs; this is addressed later in this report.

The NHTS definition of a complete household response does not incorporate important demographic characteristics of the household that may affect trip rates and the types of trips undertaken: household age structure could be problematic (U.S. Department of Transportation, 2001b). For example, the household may consist of adults only. Simply stating that only fifty percent of adults are required to provide all personal and travel information, for the household response to be considered complete, leads to a generalization that all household members, regardless of age, exhibit the same travel patterns and behavior.

For example, there is a marked difference in trips rates for these rather broad age groups, 18 to 64 years, 65 to 75 years, and over 75 years (Alsnih and Hensher, 2003). The difference between these age groups is even more apparent when looking at the activities undertaken. If the first age group is broken down into smaller categories, there are further differences in the type of activities and the number of trips undertaken. If all adults within the household fall within one age group, the problem posed by the fifty percent definition is minimal compared to the case where household members fall in all three broad age categories. For example, if there are six adults in the household and two adults fall in each of the three age categories described, the fifty percent rule as is, means that only three adults have to answer for the

household response to be considered complete. Thus, we may receive complete information for all adults in the 18-64 age group, receive information from only one adult in the over 75 age group, and obtain no information about adults in the 65-75 age group. Capturing information for some adult members in particular age groups and no information for household members in other age groups means that imputation of data will not provide accurate travel related information, at the household level. This clearly demonstrates the need to elaborate the fifty percent definition for a complete household response, to allow for varying household characteristics that are otherwise unaccounted for.

Certainly there are higher costs associated with a more stringent definition of a complete household response. In addition, it appears as though lenient definitions of both a complete household response and proxy reporting employed together in one survey do not boost response rates significantly and actually undermine data quality. Given this outcome, a lenient definition of a complete household response should incorporate a stringent definition of proxy reporting. Undoubtedly, the two standards are interdependent. Proxy reporting really should only be permitted when repeated attempts to obtain the information from the respondent in question have failed, and time and budget constraints require finalization of the data collection process.

Clearly, a more lenient definition of a complete household response would be less likely to result in bias in the data set because partial[18] responses would not be dropped (U.S. Department of Transportation, 2001a; Richardson and Meyburg, 2003). Suppose a study required a sample of 450 households, and expected a response rate of 30 percent. The sample size would have to be 1,500 households. If a lenient definition of a complete household response is adopted, then the 450 households would be relatively easy to obtain when compared with a stringent definition of a complete household response (that includes dropping partial household responses).

Standardized procedures that are recommended for complete household definition are provided in section 2.2.3 of the Final Report.

5.4 D-6: SAMPLE REPLACEMENT

5.4.1 Issues in Sample Replacement

Refusals result in lost sample and require some sample make up or replacement. Procedures for sample replacement are critical in preserving the integrity of the initial sample. Two questions arise:

1. When should a sampled household or person be considered non-responsive and a replacement make-up household or person be selected?
2. How should replacements for the sample be provided?

Quite frequently, the decision to make up sample is not seriously considered and additional samples are added after a relatively minor attempt to gain the original sample. This leads to the potential to create serious biases in the sample and is a practice that should be avoided.

In addition, due to high non-response rates and increasing problems with data integrity, the issue of sample replacement has become more important. This is because demographic characteristics and trip rates of the non-responding households are different to those of the households that participate in the survey (DeHeer and Moritz, 1997; Kam and Morris, 1999; Polak, 2000; Richardson, 2000; Kalfs and van Evert, 2003; Zmud, 2003).

In this section, how to provide replacement of the sample is discussed. Also, call history files are examined to determine the rate of refusal conversion for households that originally gave a “soft” refusal

[18] Partial response is defined as a household where at least one member did not provide any trip/activity information.

to participate in the recruitment interview. Further analysis is conducted to determine the overall conversion of these soft refusals to complete household survey responses.

5.4.2 Discussion, Review, and Analysis of the Issues

An important issue is the make-up of the sample, when there are refusals. Most surveys are based on anticipated response rates and set up samples that represent sufficient over-sampling to handle expected non-response. Two problems arise. First, if the sample is not a simple random sample, but is a stratified or other more complex sample, the over-sampling must account for varying non-response in different strata. This is not easy to anticipate. In a survey that stretches over several weeks of recruitment and retrieval, the final sample achieved in each cell of a stratified sample can be tracked and households can be sought that will provide the make-up sample in each cell that is falling short. However, to avoid a costly search for households in specific cells of the matrix, many surveys have diverged from the specified stratified sample to make up total sample without regard to the distribution of the final sample. It is possible that examination of previous surveys would indicate the relative sizes of non-response rates in different sampling cells, which could, in turn, allow for recruitment to over-sample at a rate that more nearly compensates for the eventual non-response levels. Alternatively, the level of over-sampling at recruitment may need to be increased, so that not all recruited households are used in the final sample.

Finally, sampling "on the fly" as a mechanism to make up the sample needs to be examined. In this case, new households are added to the sample as needed, whenever non-response drives the total sample below what is desired. However, this method has the probability of producing a very distorted sample, particularly when attempts to gain cooperation of respondents are not pursued aggressively.

Review of Recent Travel Surveys

After careful examination of a number of recent travel surveys, it was found that call attempts to households that initially refused to participate in the survey varied from zero to six. In other words, some surveys did not bother re-calling households that gave a soft refusal to participate during recruitment. Most surveys allowed the household to give a soft refusal once. However, often these households will respond, on subsequent call attempts, with hard refusals[19]. Some households, during subsequent call attempts, may refuse to answer the telephone, especially if they are expecting the call, and caller-id displays the origin of the call. These calls with a non-contact[20] call disposition remain unresolved until contact is achieved with the household. In other words, these households are usually called numerous times until contact is again achieved and the call resolved.

The next section describes the results of call history file analyses. The analyses show the maximum number of call attempts made, during the recruitment phase of recent travel surveys conducted in the United States, for households that initially refused to take part in the survey, but later went on to complete the recruitment interview.

Call History File Analyses

Analysis of call history files gives important information that is not found in any other data base. Two important pieces of information contained in the call history files are:

1. The call disposition codes for every call attempt made to a household; and

[19] Hard refusals – strong indication by the respondent that she or he does not want to participate. In this situation, a household is not called again

[20] Non-contacts include no answer, busy, and answering machine call disposition codes

2. The (implicit) pattern of initial response behavior.

In studying the response behaviors for households who initially refused to participate in one particular survey, but who later completed the recruitment, and eventually completed the household travel survey, it was found that the number of first refusals converted to complete recruitment interviews was 521 (22.5 percent of all first refusals). The overall conversion of first refusals to complete household surveys was 7.4 percent. In other words, if refusal conversion is not attempted, 172 complete household responses would have been lost. This adds to non-response bias given that refusers differ from respondents, especially in relation to the statistic of interest; mean trip rates. This confirms what is stated in the literature (Kam and Morris, 1999; Richardson, 2000; Kalfs and van Evert, 2003; Zmud, 2003).

Only 9 percent of households that initially refused to participate in the survey and which were non-contactable during subsequent call attempts, actually went on to complete the recruitment interview. Consequently, the overall conversion of these households to complete household responses is only 3.1 percent. These results give the impression that households that initially refuse to participate, and on later call attempts are not contactable, are much more reluctant to participate in the survey than households who initially refuse but are contactable during the next few round of call attempts. This type of response behavior is similar to that of households who request to be called back numerous times but during the final call, refuse to participate; these households eventually respond like outright refusers (Zmud, 2003). For example, for the households who requested to be called back, the conversion rate, to complete household response, was 2.1 percent. This is much lower than the conversion of first refusals.

Almost 16 percent of initial "soft" refusals become "hard" refusals on subsequent call attempts. This is a significant amount and reinforces the fact that it is much more difficult to get respondents to participate in surveys. For example, total hard refusals to this particular survey were 3,279, and the percentage of hard refusals that were originally soft refusals is 11.3 percent. However, 7.4 percent of soft refusals were converted to complete household responses.

In Table 40, which shows the number of subsequent call attempts made to convert households from initial refusals, 52 percent of first refusals required another call to be converted to a complete recruitment interview which later resulted in a complete household survey. However, 28 percent of first refusals required two call attempts.

Also in Table 40, 56 percent of first refusals, converted to a non-contact during the second call, required one more call attempt to be converted to a complete recruitment interview. The number of first refusals that were converted to non-contacts during intermediate call attempts and that were finally converted to complete interviews, drops significantly after two call attempts are made to convert the non-contact from the initial refusal. This means that, in total, these households required four calls to achieve a complete recruitment response. If only three call attempts are allowed after the first non-contact is recorded for households who initially refused, the overall conversion to complete household response is 3 percent; a drop of only 0.1 percent. This call limit may be proposed given the cost savings in relation to limited sample loss. However, further research is required to achieve some conclusive results.

Recommendations on sample replacement are provided in section 2.2.4 of the Final Report.

Table 40: Number of Call Attempts Required to Convert First Refusals to Complete Recruitment Interviews

Number of call attempts	*1*	*2*	*3*	*4*	*5*
Number of first refusals converted to complete recruitment interview	273	148	67	23	10
Percent	52.4	28.4	12.9	4.4	1.9
First refusals to non-contacts to complete recruitment interviews	96	49	19	6	2
Percent	55.8	28.5	11	3.5	1.2

5.5 D-7: ITEM NON-RESPONSE

5.5.1 Definition

Item non-response has been defined as "the failure to obtain a specific piece of data from a responding member of the sample" (Zimowski *et al.,* 1997a), or the "failure to obtain 'true' and complete data from each respondent" (Zmud and Arce, 2002). The latter definition draws attention to an important issue – item non-response occurs not only as a result of data being missing but also when incorrect data are provided. Within this context, Statistics Canada defines "incorrect" data as data that are either invalid or inconsistent (1998a, p. 38). Invalid data are data items whose values are beyond the possible or feasible range of that item. Inconsistent data are data items whose values are inconsistent with the values of other data items of the respondent.

Item non-response is closely linked to several other items discussed in this report. First, it is linked to the definition of a complete household addressed in Section 5.3, because it is only when item non-response is within tolerable limits that a responding household is considered complete. Second, it relates to survey design and survey execution, because the form in which the questions are posed and the manner in which the survey is conducted are known to have a significant impact on item non-response.

5.5.2 Analysis of Item Non-Response

The need for standardization in the identification and measurement of item non-response in travel surveys is motivated by the desire to achieve two features of future travel surveys: consistency among surveys so that meaningful comparisons can be made, and the potential to use item non-response as a measure of data quality.

One of the first needs in standardizing item non-response in travel surveys is to standardize the definition of item non-response so that a consistent interpretation exists among all travel surveys. There is general acceptance that any data item that is missing or whose value is incorrect (i.e., it is invalid or inconsistent, as defined in the opening paragraph of section 5.5.1 of this Technical Appendix) is an item non-response. However, looking over past travel surveys, some surveys provide response categories such as "don't know" and "refused" while others do not, and the number of missing item values are affected by the presence or absence of these categories. In a review of seven recent travel surveys shown in Table 41, four did not provide the option of responding to the question on household income with "don't know" and "refused". The results vary quite widely from survey to survey, but it is clear that "don't know" and "refused" has effectively replaced the missing values category in these surveys. Thus, it seems quite appropriate that "don't know" and "refused" responses be included as non-response items. Of course, other response options that may be provided, such as "not applicable" (see section 8.3), should not be counted as a non-response.

Table 41: Non-response on Household Income Among Several Surveys

Survey Data Set	*Date*	*Sample size*	*Household Income*	
			Percent missing	**Percent don't know or refused**
Regional Travel Household Interview Survey for New York and North Jersey	1997-1998	11,264	24.4	not included
Maricopa Regional Household Travel Survey	2001	4,018	0	9.9
Salt Lake City Survey	1993	3,082	0	4.8
Southeast Florida Regional Characteristics Study	1999	5,168	23.5	not included
Ohio-Kentucky-Indiana Survey	1990	3,001	0	8.6
Dallas Fort Worth Survey	1996	3,996	8.0	not included

Broward Travel Characteristics Study	1996	702	13.2	not included

In addition to the non-response on household income shown in Table 41, other items displaying high incidence of missing data in the seven data sets reviewed are driver license status of individuals (0-55 percent), travel mode (0-26 percent), start time of trip (0-24 percent), end time of trip (0-25 percent), travel time of trip (0-27 percent), and vehicle occupancy (0-35 percent). Because most of these variables are collected on a routine basis in travel surveys, they could feature as standard variables in the construction of a single measure of item non-response in a data set. That is, these variables, or a subset of them, could be used to establish a single statistic that reflected an overall measure of item non-response in data. No record of the establishment of such a single statistic of item non-response was encountered in the literature. Recommendations on standardized procedures are given in section 2.2.5 of the Final Report.

5.6 D-8: UNIT NON-RESPONSE

5.6.1 Definition of Unit Non-Response

A definition of unit non-response is the absence of information from some part of the target population of the survey sample (Harpuder and Stec, 1999; Black and Safir, 2000). However, what also needs to be outlined is the definition of a complete response. Are the travel data required from all of the household's members? If not, then the significance of unit non-response is reduced. What constitutes a complete household is discussed in Section 5.3 of this Technical Appendix.

5.6.2 Review and Analysis of Unit Non-Response

High rates of unit non-response are generally associated with non-response error. Non-response error is a function of the non-response rate and the difference between respondents and non-respondents on the statistic of interest (Keeter *et al.,* 2000). For example, characteristics of non-respondents to travel surveys are that they are more likely to be low and high income households and households with low or high mobility rates (De Heer and Moritz, 1997; Richardson, 2000). A lower unit non-response rate is desired because this reduces the incidence of non-response bias. Non-response rates are influenced by the survey topic, the number of call backs, the sponsor of the research, incentives, the number of follow-ups and the survey environment (Schneider and Johnson, 1994; Ettema *et al.,* 1996; Melevin *et al.,* 1998). Interestingly, it has also been stated that late respondents[21] to a survey actually resemble non-respondents (Richardson, 2000; Lahaut *et al.,* 2003). Essentially, had later waves not been conducted, these late respondents would actually have been non-respondents.

There are two broad categories for unit non-response. These are refusals (hard refusals, soft refusals, and terminations) and non-contacts (busy, no reply, and answering machines). In relation to call backs, if eligibility status is never determined and the household requested to be called back, but on subsequent call attempts no contact was achieved, this becomes a unit of unknown eligibility and cannot be regarded as a non-responding unit. However, if eligibility was determined and the household requested to be called back, but on subsequent call attempts no contact was achieved, this unit becomes a non-responding unit. To reduce unit non-response, in both the recruitment and retrieval stages of a two- or more stage survey (most travel surveys are two-stage surveys, wherein recruitment is conducted through RDD and retrieval is either through CATI, or mail back), the number of refusals, terminations, and non-contacts need to be reduced. In addition, the researcher may opt to employ refusal conversion techniques,

[21] Respondents who respond to a survey after numerous waves and reminders

if the survey environment allows for this. In terms of non-contacts, there needs to be greater effort to contact the difficult to contact.

Characteristics of non-respondents to travel surveys, found in numerous studies, are:

1. Very low and very high income;
2. High and low mileage drivers;
3. Young single males and females;
4. Zero vehicle use;
5. People residing in metropolitan areas; and
6. Households with children (De Heer and Moritz, 1997; Kam and Morris, 1999; Richardson, 2000).

Non-response bias is common in travel surveys and must be minimized to obtain a more accurate picture of people's travel behavior. The development of a standard on the definition of unit non-response that effectively incorporates the definition of a complete household response will enable comparability across different surveys and hence, provide a more accurate picture of what is actually happening to response rates.

It has been well documented that response rates have been declining (Atrostic *et al.,* 1999; Dillman and Carley-Baxter*,* 2000; Dillman *et al.,* 2001; Kalfs and van Evert, 2003; Richardson and Meyburg, 2003;). For example, in a study that compared data from 1976 to 1996, it was found that it took double the number of calls to complete an interview and the number of people not responding increased significantly; it took four calls to complete an interview in 1979 whereas in 1996, it took eight calls (Oldendick and Link, 1999; Curtin *et al.,* 2000). Also, given the high number of non-respondents reported for this study, it is not surprising that the rate of refusal conversion jumped from 7.4 percent in 1976 to 14.6 percent in 1996 (Oldendick and Link, 1999; Curtin *et al.,* 2000). The phenomenon of rising unit non-response rates may be attributed to the nature of the data collected requiring more time for the participants to complete (increased respondent burden), and more physical barriers inhibiting contact with the prospective participant, such as call screening devices (telephone surveys) and gated communities (face-to-face surveys) (Melevin *et al*. 1998; Kam and Morris, 1999; Oldendick and Link, 1999; Vogt And Stewart, 2001; Kalfs and van Evert, 2003). Also, the increasing number of marketing type surveys has led people to perceive increased respondent burden therefore these individuals no longer even consider participating (Kalfs and van Evert, 2003; Black and Safir, 2000). However, it will be interesting to see the effect of the *National Do Not Call Registry,* which allows respondents, who have placed their number on the registry, to permit only research surveys, or a selected few telemarketing surveys (chosen by consumers), to call their household. In relation to face-to-face surveys, another inhibiting factor is a decreasing number of potential respondents at home when the study is conducted.

Ways to overcome rising unit non-response rates have also been well documented (Schneider and Johnson, 1994; Melevin *et al.,* 1998; Cook *et al.,* 2000; Dillman *et al.,* 2001; Kalfs and van Evert, 2003; Zmud, 2003). To reduce the number of refusals and increase the chance of obtaining a complete interview, three commonly recommended strategies are:

- The use of pre-survey monetary incentives;
- The use of advance letters and reminders (follow–ups); and
- Special interviewer training (Ettema *et al.,* 1996; Leslie, 1997; Melevin *et al.,* 1998; Kam and Morris, 1999; Cook *et al.,* 2000; Kalfs and van Evert, 2003).

Incentives, especially pre-survey monetary incentives, are effective in increasing response rates by as much as twenty percent (Melevin *et al.,* 1998; Dillman *et al.,* 2001; Zmud, 2003). Self interest is a powerful motivator for respondents to participate in a study (Dillman *et al.,* 2001; Zmud, 2003). It was also found that pre-paid incentives have positive effects on response rates for short mail out surveys (Kurth *et al.,* 2001). Other ways to improve response rates and lower unit non-response include good

questionnaire design, and easy to answer questions, thereby decreasing respondent burden (Axhausen, 1999).

Evoking respondents' appeal (salience) to the research topic is associated with higher response rates: salience is a significant determinant of response rates (Cook *et al.,* 2000; Dillman and Carley-Baxter, 2000). Research sponsored by a government agency or academic institution yields higher response rates because respondents usually trust this type of research, especially in terms of confidentiality and privacy (Kalfs and van Evert, 2003). Scarcity (when a respondent belongs to an exclusive group of people being asked to participate in the study) is also associated with higher response rates (Kalfs and van Evert, 2003). This is an example of Social Exchange Theory (Schneider and Johnson, 1994; Kalfs and van Evert, 2003). Figure 5 provides a conceptual framework for survey cooperation, and Figure 6 depicts graphically how the interviewer may influence the rate of survey participation.

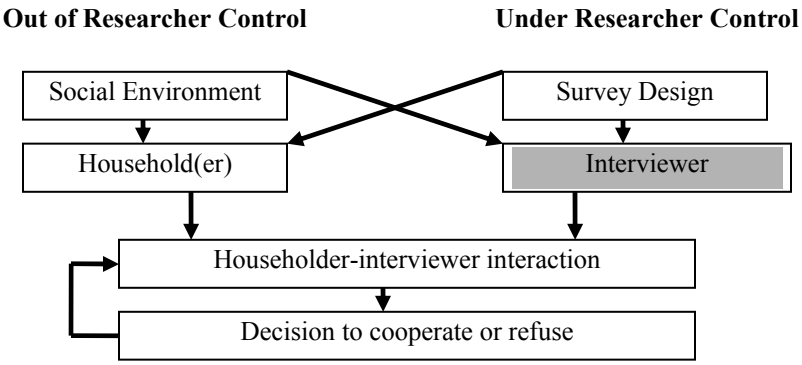


Figure 5: A Conceptual Framework for Survey Cooperation

Source: Groves and Couper, 1998.

An identified area that could be improved is the interaction between the interviewer and respondent (special interviewer training) (Groves and Couper, 1998; CMOR, 2000; Kalfs and van Evert, 2003). It has been acknowledged that the interviewer's behavior should be tailored to the social situation and the respondent. This will help to establish rapport quickly and avoid discomfort between the respondent and interviewer. This in turn explains why more experienced interviewers are more successful in obtaining higher response rates (Groves and Couper, 1998).

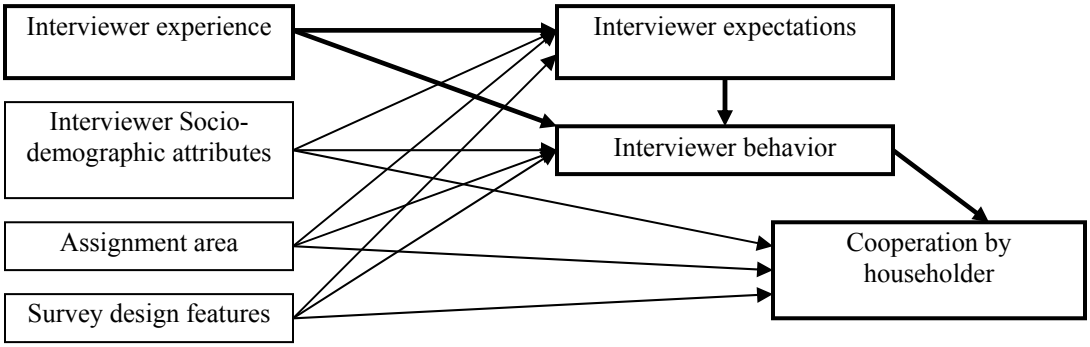


Figure 6: Interviewer Influences on Survey Participation

Source: Groves and Couper, 1998.

Refusal conversion may also involve changing survey mode from telephone to face to face interviews. However, this is more costly and it was found that the success of the second mode of survey

delivery in reducing unit non-response is very small (Dillman *et al.,* 2001). Given this information, however, changing survey mode along with the use of post incentives to induce response amongst non-respondents has not been tested for. This is addressed later in this section. In relation to reminders, according to Freeland and Furia (1999), telephone reminders to mail surveys did not significantly improve response rates. This, however, has not been borne out in a number of transport surveys, where telephone reminders for mail surveys have been found to be quite effective. For mail back surveys, if the person who initially contacted the household delivered the questionnaire and a post payment incentive was offered, the result was an overall increase in the response rate: personal delivery evokes reciprocity (Dillman *et al.,* 2001). Realistically, however, personal delivery of surveys to households is unlikely due to high costs.

In travel surveys, households with children are less likely to respond and if they do respond, this is after numerous mail outs of the original questionnaire and numerous reminder letters or postcards. These households are less likely to respond because of the complex structure of the travel diary; hence, the respondents perceive completion of the questionnaire as a cumbersome exercise. This perception is exacerbated by the complex nature of trips undertaken by these households (Kam and Morris, 1999). When these households eventually complete the travel survey, they tend to under-report trips due to their complex nature. Thus, even though response rates increase, this is quite often at the compromise of data quality (Kam and Morris, 1999).

In travel surveys, RDD is frequently employed to recruit households by telephone. This means that the location of households in the area under investigation is not known from the telephone number. However, telephone numbers are usually retained. Therefore, the researcher may call the non-responding household and ask for the address, ask about particular questions, mail out the questionnaire a second time, or schedule a face-to-face interview; the mode of delivery depends on the prospective respondent's preference. Another option is to devise a survey for non-respondents and this is described later in this section.

Non-contacts

As mentioned earlier, the main recruitment method in travel surveys is RDD. The problem is that non-contacts are increasing, adding to rising unit non-response rates. The number of non-contacts encountered in a survey is a function of repeated calls that interviewers make on these particular cases (Zmud, 2003). Addressing non-contacts is becoming more of an issue due to changing household structure, flexible work arrangements and physical and technological barriers; physical barriers are becoming more prevalent in today's societies and this makes it more time consuming and difficult for interviewers to reach prospective respondents. In travel surveys, non-contacted households may have higher mobility rates than households which refused to take part in the survey; therefore, if the researcher is unable to contact these households, it may result is an underestimation of trip rates (Zmud, 2003). Figure 7 explains the interactions between the influencing factors on ability to contact.

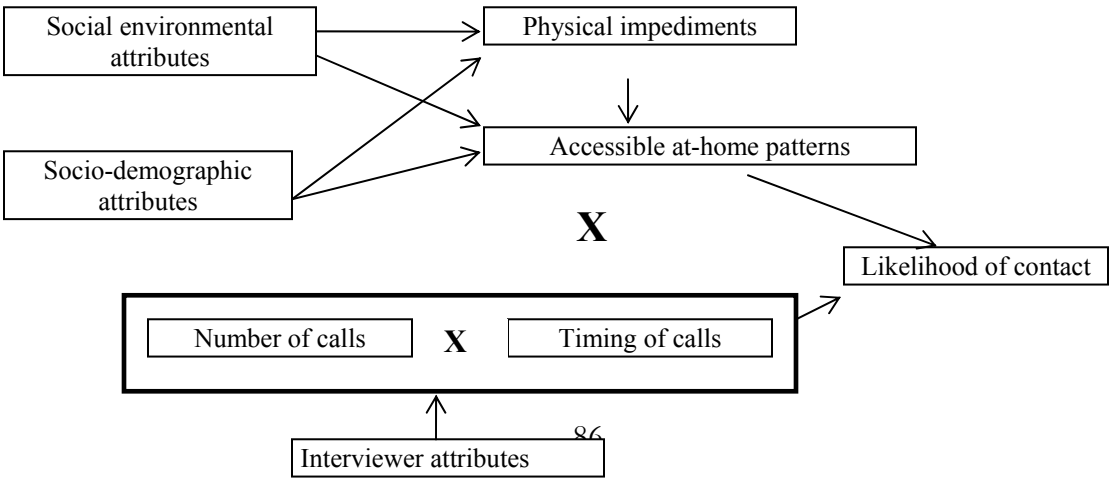


Figure 7: Influences on the Likelihood of Contacting a Sample Household

Source: Groves and Couper, 1998.

According to Groves and Couper (1998), households with members who have physical impediments should be called first because, on average, these households require more calls to obtain the first contact. This also applies to multi-unit dwelling structures and unlisted numbers. If these numbers are called first, it allows for more call attempts and more attempts at converting refusals. To enhance the rate of contact, four methods should be employed:

- Increase the number of calls for non-contacted units;
- Designate certain times for calling non-contacted units, e.g., Tuesday evenings;
- Expand the data collection period; and
- Conduct face-to-face interviews (Groves and Couper, 1998).

According to Dennis *et al*. (1999), Monday to Thursday evenings are the best time to contact households (conduct interviews to obtain complete recruitment and complete interviews) and it was found that the highest contact rates for first calls occurred for households with incomes between $25,000 and $35,000 (29.6 percent) on these evenings between 6 and 9 pm.

In relation to technological barriers, it was found that households with answering machines were just as likely to complete an interview once contact was established. Also, if a researcher leaves a brief message describing the purpose of the research, it gives the impression to the respondent that the researcher has gone to the trouble to contact them and therefore it is more likely that the person will participate in the study (reciprocity) (Kalfs and van Evert, 2003).

Non-contacts become problematic if the responses of non-contacts differ significantly from the responses of contacts because this will add to non-response bias (Zmud, 2003). For example, younger households and households with higher incomes required more calls to complete an interview due to telephone screening devices. These households also have higher refusal rates (Zmud, 2003). Also, non-contacts who become refusers, after subsequent call attempts, usually have the same socio-demographic characteristics as outright refusers (Zmud, 2003). Respondents who initially refused an interview but were later converted were predominantly of lower socioeconomic status and households with children, whereas the non-contact group was dominated by younger, higher educated and wealthier respondents: higher socioeconomic status (Stec *et al.,* 1999; Curtin *et al.,* 2000; Keeter *et al.,* 2000).

It is also important to acknowledge that non-contacts lead active lifestyles and are highly mobile. In travel surveys, absence of data from these households results in an underestimation of trip rates. In addition, potential refusers possess different demographic characteristics to non-contacts. Higher refusal rates have been found among the elderly and low educated persons (Kurth *et al.,* 2001). For this reason, it is important to distinguish between the two components of bias reduction (converting refusals and establishing contact with the difficult to contact group) when trying to improve response rates (Zmud, 2003). It has also been documented that respondents, who initially stated that they were too busy to participate and scheduled a call back, were more likely to be "refusers" than "participators" (Zmud, 2003). This raises the questions of whether these households should be recalled and, if so, what should happen if on subsequent calls they again schedule for a call back. This question is addressed in Sections 5.1 and 5.4 of this report.

Call History File Analysis

For households that initially refused, and for the households that were initially non-contactable but that later went on to complete the household travel survey, the call history characteristics were added into the household data base to compare the important characteristics of these households to those of the

entire sample. Table 42 shows the number of call attempts made to convert households who were initially non-contactable[22] for call history file 1.

Table 42 shows that households that required fewer call attempts to establish contact and result in a complete household response, differed, in terms of mobility (mean trips), to the entire sample. For non-contacted households that required 3 calls to become a complete household response, the mean number of trips was 8.56. For the entire sample, the mean number of trips was 8.47. However, for households that required 2 calls, or between 4 and 6 calls, the mean numbers of trips were 8.01, 8.13, 7.80 and 6.47, respectively. These results show that for the households that required more than 4 calls, the respective mean number of trips differed markedly to that for the entire sample. Also, it appears as though the non-contact conversions that required 6 calls consisted mainly of households without children and households with higher income. This is consistent to what was found in the literature (Colombo, 2000; Zmud, 2003). The most important result to come out of these findings is that it does not matter whether some households are easy or difficult to contact (in relation to the number of call attempts), bias is present, in terms of an important key statistic, mean number of trips. Also, it appears that the increase in response rates has led to a decrease in data quality in relation to mean trips rates, due to under-reporting. This confirms what was stated in the literature (Kam and Morris, 1999).

Table 42: Descriptive Statistics for Original Non-Contacts

Variable	*Call 2*	*Call 3*	*Call 4*	*Call 5*	*Call 6*	*Total Calls (2-6)*	*Sample*
One-Person HHs	32%	35%	42%	51%	47%	36%	27%
Two-Person HHs	34%	36%	32%	25%	24%	33%	35%
One Worker	43%	41%	51%	53%	53%	44%	40%
Two Workers	38%	40%	34%	29%	29%	37%	37%
One Car	37%	36%	43%	45%	47%	39%	33%
Two Cars	42%	44%	40%	34%	29%	41%	43%
Single Detached Dwelling	71%	69%	65%	59%	71%	69%	74%
Home Owner	68%	63%	60%	49%	53%	64%	68%
Mean Trips per HH	8.01	8.56	8.13	7.80	6.47	8.12	8.47
No Infants in Household (0-4yrs)	87%	90%	90%	88%	94%	88%	87%
No School Aged Children in HH	77%	77%	80%	84%	94%	78%	72%
One Adult Households	36%	29%	48%	53%	47%	40%	31%
Two Adult Households	54%	53%	45%	40%	29%	51%	56%
Income under $50,001	61%	60%	68%	67%	47%	62%	62%

Table 43 shows that the differences are even greater for households that initially refused to participate in the survey, despite that the mean number of trips for all the households, that were converted from refusals, was closer to the sample mean number of trips than the mean number of trips for all the households that were originally non-contacts: 8.24, 8.47 and 8.12 trips, respectively.

Regardless of the number of call attempts made to convert the households from refusals, the mean number of trips was different from that for the entire sample. However, the greatest difference was for households that required another call attempt to convert the refusal successfully. In addition, socioeconomic characteristics of refusers that required four conversion attempts (five calls altogether) appear to be lower than the socioeconomic characteristics for the non-contact conversions that required five call attempts. This also confirms what was stated in the literature (Stec *et al.,* 1999; Curtin *et al.,* 2000; Keeter *et al.,* 2000; Richardson, 2000; Zmud, 2003).

Table 43: Descriptive Statistics for Original Refusals

Variable	*Call 2*	*Call 3*	*Call 4*	*Call 5*	*Total Calls (2-5)*	*Sample*

[22] Original call dispositions include no answer, answering machine, fax line, and busy

One-Person HHs	19%	29%	18%	23%	22%	27%
Two-Person HHs	49%	48%	36%	23%	46%	35%
One Worker	36%	40%	55%	23%	37%	40%
Two Workers	34%	29%	45%	23%	33%	37%
One Car	25%	38%	18%	23%	28%	33%
Two Cars	51%	50%	55%	31%	49%	43%
Three or more Cars	19%	10%	27%	46%	19%	19%
Single Detached Dwelling	83%	74%	91%	85%	81%	74%
Home Owner	81%	79%	60%	62%	79%	68%
Mean Trips per HH	7.86	8.82	8.95	8.67	8.24	8.47
No Infants in Household (0-4yrs)	87%	92%	82%	92%	88%	87%
No School Aged Children in HH	79%	79%	55%	77%	77%	72%
One Adult Households	27%	35%	36%	23%	30%	31%
Two Adult Households	60%	60%	45%	38%	58%	56%
Income under $50,001	61%	68%	64%	50%	61%	62%

Table 44 shows the differences in the mean number of trips for households converted from non-contacts to complete household surveys, from that for the entire sample. The households that required from eight to ten calls to be converted, appear to have a higher socioeconomic status than households that required between two and seven calls. This again confirms the literature (Stec *et al.,* 1999; Colombo, 2000; Keeter *et al.,* 2000; Zmud, 2003). Employing refusal and non-contact conversion requires careful and thorough analysis of call history files, for both CATI recruitment and retrieval, because sufficient numbers of refusals and non-contacts must be successfully converted, for every call attempt, to reduce the incidence of bias in the data set. According to Polak (2002), households with more vehicles are more likely to be non-respondents, due to their high mobility rates. Therefore, exclusion of these households tends to lead to a downward bias in trip rates. This requires further investigation.

Table 44: Descriptive Statistics for Non-Contact Conversions (File 2)

Variable	*Call*									***Total Calls (1-10)***	***Sample***
	2	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***		
One Person	35%	39%	44%	43%	46%	46%	40%	45%	0%	38%	29%
Two Persons	38%	39%	35%	36%	42%	27%	20%	36%	100%	37%	38%
One Vehicle	36%	40%	45%	38%	46%	39%	40%	64%	0%	40%	33%
Two Vehicles	41%	38%	39%	43%	38%	42%	40%	27%	100%	39	43%
Single Detached Dwelling	63%	61%	54%	60%	59%	69%	60%	73%	50%	61%	66%
Owner/Occupier	67%	66%	60%	61%	54%	65%	60%	82%	100%	65%	69%
Mean Trips per HH	9.18	8.30	8.19	8.20	6.99	7.73	13.8	6.82	11	8.70*	9.11
Income over $40,000	77%	76%	74%	78%	74%	73%	80%	73%	100%	76%	77%

* Significant difference between the mean number of trips for households converted from non-contacts, to that of the sample, at P=0.05

Non-Response Surveys

There have been numerous mathematical equations to calculate non-response bias (Groves and Couper, 1998; Black and Safir, 2000). Also, given that late respondents to a survey after numerous mail outs have been conducted usually respond like non-responders (Richardson, 2000; Lahaut *et al.,* 2003), it may be best to reduce the number of mail outs due to decreasing data quality and adopt non-response surveys to correct for non-response bias. Non-response surveys are important because they enable the researcher to gain some knowledge about travel patterns of non-respondents and to determine if these differ significantly from respondents' travel characteristics. Non-response surveys also allow the researcher to understand why these individuals refused to participate in the original study as well as aid in the development of future travel surveys.

Calling non-responding households and reminding them to participate will be of no use if they have discarded or misplaced the survey package (Richardson, 2000). This may be why Freeland and Furia (1999) recorded no significant increase in response rates to a mail out survey when telephone reminders were made. However, a second mailing to hard-to-enumerate households resulted in increasing response rates (Whitworth, 1999). If this procedure does not yield a significant increase in response rates, then a face-to-face interview should be conducted using the original questionnaire or a non-response survey should be devised and either mailed, e-mailed, conducted by CATI or conducted by a face-to-face interview to non-responding households, depending on funds available to research agencies. It should be relatively short and ask questions about the number of trips undertaken by the household on an allocated day, the means of travel, household size and age structure, housing tenure status, type of dwelling, combined household annual income and employment status of the respondent. This survey reduces the perception of high respondent burden because questions asked are less complex, the survey form is shorter, thereby taking less time to complete, and the visual presentation of the survey is more "aesthetically pleasing." In addition, the respondent will notice the level of effort of interviewers to contact them; hence, they may be more inclined to participate, otherwise known as reciprocity (Kam and Morris, 1999; Kalfs and van Evert, 2003).

A non-response survey was devised to gain some insights about non-responding households to the 1997 Denver Region Travel Behavior Inventory Household Travel Survey. A two dollar incentive was offered and it was found to be very effective in reducing item non-response for the income related question (Kurth *et al.,* 2001). The results of this non-response survey found that more elderly households were among the non-contact and quick refusing households and, therefore, their trip rates were not accounted for adequately in the original survey.

Another non-response survey was conducted in Sydney, 2001, by the Transport Data Centre, NSW Department of Transport, to investigate non-response and its effects on data quality, in relation to the Sydney Household Travel Survey, as well as to test the telephone as an alternative data collection method to the costly face-to-face interview (TDC, 2002). Households that could not be contacted after at least five visits (non-contacts) and those that still refused after refusal conversion was attempted, were moved into the Non-Response Study. A full HTS telephone interview was offered first, if the main reason for non-response was unavailability for a face-to-face interview. If the non-respondents still declined, a shorter Person Non-Response Interview was offered. This only collected core demographic and trip information. If the non-respondent did not want to complete the Person Non-Response Interview form, a Person Non-Interview form was offered; information was collected by proxy. From the results of this study, TDC was unable to state with any confidence the relative accuracy of the telephone interview data to that of the personal interview (regular HTS), due to the insufficient sample size (TDC, 2002). However, the results of the non-response study conducted by TDC are useful for providing some insight into the characteristics of non-respondents to a face-to-face interview.

Table 45 shows some key characteristics of non-respondents. Interestingly, total household trip rates for non-responding households do not differ significantly from total household trip rates for responding households. However, use of train and walk transport modes were significantly higher for non-responding households compared to responding households. This is important information that is particularly useful in relation to the revision and planning of transport services in the area(s) under investigation, hence, the benefits of conducting follow-up non-response studies.

Table 45: Transport Data Centre Non-Respondent Summary Characteristics

Attributes	*Characteristics*
Dwelling Type	More likely to live in a unit or apartment
Housing Tenure	More likely to be renters
Age	Significantly over-represented in the 15-49 age group
Employment	60.2% full time workers, significantly different to responding adults reported as full time workers (43.2%)
Reason for not responding	60% stated that they were "not interested" and "did not want to" respond

Total Trip Rates	Not significantly different to responding households
Mode Use	Significantly higher walk and train trip rates than respondents

The following section describes the non-response surveys developed by the Institute of Transport Studies (The University of Sydney) and Louisiana State University, and conducted by NuStats, as well as the data analyses. The actual surveys are shown in Appendices A and B.

5.6.3 Non-Response Follow-Up Study.

It was decided that a non-response follow-up study to a recent travel survey would be undertaken to investigate the reasons why people do not respond to surveys and if there are any remedial steps that can be employed to lessen the numbers of non-respondents, and therefore, decrease the incidence of non-response bias. In addition, a Stated Choice experiment was devised and incorporated in one of the non-response surveys. This was considered important, because it allowed for the testing of various survey elements noted in the literature as significant in the determination of participation and response rates. Nustats, a survey research firm, conducted a recent travel survey in four regions in the United States: Wilmington, NC; Charleston, SC; Little Rock, AK; and Yakima, WA and, therefore, was approached to tackle the recruitment phase of the Non-Response Follow-Up Survey, for these four regions.

These surveys followed a similar general approach to the conduct of household travel surveys. Selected households received an advanced mailing, followed by a recruitment telephone call, the mailing of a travel diary package, and a telephone call to retrieve the travel diary information. The recruitment call also collected demographic information about the household and its members. All studies used sample that was generated via random digit dialing (RDD) techniques. In this respect, the sampling frames of the initial travel studies consisted of list-assisted 1+ sample in which only exchanges with at least one working residential telephone number were included in the universe. The sample was purged as much as possible in advance to identify nonworking and business numbers. The final sample was reverse address matched using Targus, the premier source of telephone and address match information, to identify addresses for the advance mailings.

In other respects, the initial travel surveys may have differed from each other, as noted in the details below:

- Little Rock:
  - Study area comprised Faulkner, Lonoke, Pulaski, and Saline, AR Counties;
  - Travel in April and May, 2003; and
  - Everyone in the household completes 24-hr travel log.
- Charleston:
  - Study area comprised Berkeley, Charleston, and Dorchester, SC counties;
  - Travel in April and May, 2003; and
  - Persons age 16+ in household complete 24-hour travel log.
- Wilmington:
  - Study area comprised New Hanover County, NC and a small portion of Brunswick County;
  - Travel in April and May, 2003; and
  - Persons age 16+ in household complete 24-hour travel log.
- Yakima:
  - Study area comprised Yakima County, WA;
  - Travel in April and May, 2003; and
  - Persons age 16+ in household complete 24-hour travel log.

Independent samples of non-completers were drawn from the sample of telephone numbers that was generated for each of the four target household travel surveys. This study focused on two categories of non-completes:

- Refusers: Those households that were contacted during the recruitment phase of the survey but refused to participate. Telephone numbers in the frame were eligible for selection into the Refuser category if the contact resulted in a Refusal (R1, RF) or Hang-Up (HU).
- Terminators: Those households that were recruited to participate in the household travel survey but did not complete the travel diary portion. Telephone numbers in the frame were eligible for selection into the Terminator category if they remained a non-complete (NC) subsequent to the retrieval phase of the survey.

Non-contacts were not considered in the main non-response study because of limited time and budget constraints. Certainly, non-contacts should be part of ongoing research in this field.

The research team felt it necessary to devise two different surveys for the two categories of non-respondents to be investigated, despite that both are types of refusers. Terminators, according to the definition, actually saw the original travel survey form; therefore, questions directly about the content and structure of the survey form could be asked. Also, given this fact, a Stated Choice experiment was included because various characteristics of the original travel survey could be tested. Each choice set described two surveys and respondents were asked to choose whether they would respond to the survey with a given set of characteristics, or whether they would choose the survey with another set of characteristics. Survey characteristics tested were: the recruitment method, the type of incentive offered, how and when the completed survey should be returned, and the length of the survey. Respondents were asked to answer two questions:

1. Which of the two surveys they would prefer to complete? and
2. If they were given this survey, would they actually complete it?

Thus, the first question related to a conditional choice, whereby respondents had to choose between the two surveys, and the second question gave respondents the opportunity to indicate that the survey was not something they would complete despite having selected this particular survey in the previous question. The survey for the refusers was shorter. The objective was to gain some insight into why these people refused to respond to the original travel survey and how they would like to be contacted in the future if they were to participate in travel surveys. A Stated Choice experiment was not included because there was no recent travel survey the respondents could refer to, having not seen the original travel survey. The two surveys are shown in Appendices C and D, respectively.

Table 46 shows the number and percentage of households that fall into the categories of non-completers in the original travel studies. Sample for the Non-Response Follow Up study (pilot and full study) was drawn from these groups.

Table 46: Population for Non-Response Follow-Up Study

Original Travel Studies	***Charleston***	***Little Rock***	***Wilmington***	***Yakima***
Total Sample Loaded	12,154	12,809	11,153	6,769
Refusers	4,212 (35%)	3,502 (27%)	3,543 (32%)	1,596 (24%)
Total Recruited Sample	1,369	1,366	1,420	1,505
Terminators	339 (25%)	306 (22%)	351 (25%)	371 (25%)

A random sample of cases with telephone numbers and addresses, fitting the definitions for Terminators and Refusers, were selected from the sampling frames from each target household travel survey. In total, 360 telephone numbers were selected to represent the Refuser category (90 from each

frame) and 640 numbers were selected to represent the Terminator category (160 from each frame). This sample was drawn equally across the four target household travel surveys.

The research team developed the instruments for implementation by NuStats. The content of the instruments is best described as follows:

- Refuser Instrument – 31 questions, covering reasons for not participating in study and importance of those reasons (four questions), preferred times and modes of contact (seven questions), household travel patterns (13 questions), and demographics (seven questions); and
- Terminator Instrument – 32 questions, covering reasons for not participating in study and importance of those reasons (three questions), preferred times and modes of contact (seven questions), stated preference choices (one question with 12 pairs of choices, one additional question), household travel patterns (13 questions), and demographics (seven questions).

The mail out/mail back questionnaires were produced by the research team and provided to NuStats "ready to go." The research team also produced the internet questionnaire. This instrument was "hosted" on the University of Sydney website. Potential respondents were given a NuStats-hosted URL that linked to the University of Sydney site. The telephone questionnaire was a revised version of the mail-out/mail-back instrument that was re-worked for telephone administration and programmed into NuStats' computer-assisted telephone interviewing (CATI) software system, VOXCO. The in-person instrument was the mail-out/mail back booklet, administered orally by the in-person surveyor.

Supporting respondent materials include:

- A cover letter to accompany the mail-out/mail-back booklet;
- 9 ½" × 6 ½" envelope to send the mail-out/mail-back booklet to respondents and another envelope (9" × 6") for respondent return of the booklet; and
- A reminder postcard.

NuStats conducted a pilot survey of the data collection activities. A specific number of cases, or pieces of sample, were selected to test each instrument type (i.e. mail, internet, telephone, and in-person). The pilot study was conducted from June 3 to June 25, 2003. The main consequence of the pilot test was the addition of incentives to the full study to increase the response rate among these known "non-responders."

To increase response rates, and to test for the effects of different post incentive levels on response rates, both pre and post incentives were used. A $2 bill pre-incentive was included with all mail-out booklets. Three levels of post incentives were used in the study: $0, $10 and $20. The sample was randomly assigned so that 45 percent of the total sample was offered $0 post incentive, 45 percent was offered $10 and 10 percent was offered $20. The cover letter told the respondent of the post incentive contingent upon receipt of their completed booklet or internet survey unless they were in the $0 incentive group, in which case no mention was made of the post incentive.

The full study methodology called for a hierarchy of interviewing modes beginning with mail (which also included the internet option), followed by CATI and then in-person interviewing. All 1,000 selected households (640 from the Terminator category and 360 from the Refuser category) were mailed the survey booklet, a cover letter, a return envelope and a $2 pre-incentive on July 29 and 30, 2003. The cover letter referenced the website so that respondents who preferred to complete the survey via the internet were able to do so. The cover letter also offered a toll-free number for inbound CATI surveying. Reminder postcards were mailed on July 31 and August 1, 2003. For the mail and internet portion of the study, 450 households were offered no post incentive, 450 households were offered the $10 post incentive and 100 households were offered the $20 post-incentive.

Households that did not respond to the survey via mail, internet or inbound telephone call (there were no inbound completed surveys) were eligible to participate in the CATI phase of the survey from September 9 to October 1, 2003. Due to budget limitations, the CATI portion of the study was restricted

to reaching a target number of completed interviews: 20 for the Terminator category and 10 for the Refuser category. Initially the CATI interviewing focused on Little Rock and was later expanded to all cities. At the start of CATI interviewing the respondents were offered the same incentive as they were offered in the mail/web portion of the study. Mid-way through interviewing they were all offered a $10 post incentive.

Little Rock was selected as the site for in-person interviewing. The intended in-person respondents received a Priority Mail advance letter informing them of the in-person interviewer's visit. A team of two in-person interviewers completed surveys in Little Rock from the September 25 to September 28, 2003. The instrument was the mail back booklet, administered orally by the in-person surveyor. All in-person respondents received a $10 post incentive for their participation.

Table 47 shows the number of responses by survey mode, while Table 48 and Table 49 show response rates by incentive for all survey modes; CATI and in-person respondents were all offered a $10 post-incentive for participation. The number of "Mail Back Booklets" reported in the tables includes partially completed booklets. Budget constraints limited the amount of CATI dialing and in-person interviewing that could be completed. According to Dillman *et al.* (2001), in relation to telephone surveys, the post incentive is not as effective as the pre-incentive. Unfortunately, this could not be tested in the Non-Response Follow-Up Survey.

Table 47: Response by Mode (Main Follow-Up Survey)

Group	*TOTAL SAMPLE*	*Mail Back Booklets*	*Web Complete*	*CATI Complete*	*In-Person Complete*	*TOTAL RETURNS*
Terminators	640	125	13	20	12	170
Refusers	360	92	1	10	6	109

Table 48: Terminator Completes by Incentive

Incentive	*Mail*	*Internet*	*CATI*	*Face-to-face*	*Total Sample*
$0	38	1	0	0	39
$10	67	11	20	12	110
$20	20	1	0	0	21
Total	125	13	20	12	170

Table 49: Refuser Completes by Incentive Amount

Incentive	*Mail*	*Internet*	*CATI*	*Face-to-face*	*Total Sample*
$0	44	1	0	0	45
$10	33	0	14	10	57
$20	15	0	0	0	15
Total	92	1	14	10	117

Table 50 shows the response rates, for the terminator and refuser surveys, for the pilot and main survey. By definition, all units are eligible if they are units of non-response; otherwise, these units would be units of unknown eligibility, and not units of non-response. Hence, the response rate calculation is simply the formula:

$$RR = \frac{CI}{Sample}$$

where:
RR = the response rate,
CI = the number of completed household interviews, and
Sample = the sample size.

Table 50: Response Rates for Terminator and Refuser Samples, Pilot and Main Survey

	Sample Size (Pilot)	*Complete (Pilot)*	*Response Rate*	*Sample Size (Main)*	*Complete (Main)*	*Response Rate*
Terminators	66	11	17%	640	170	27%
Refusals	30	8	27%	360	117	30%

Table 50 shows that respondents who initially refused to take part in the original travel survey do not appear to care about incentives as much as those who were classed as terminators (given the difference in response rate between the pilot and the main non-response survey). However, it must be noted that problems were encountered during the pilot stage because the timing of this survey coincided very closely with the timing of the original travel survey; some terminator non-respondents were confused and quite upset about being bothered to do the "same survey" again.

Table 51 shows the percentage of completed surveys for each survey mode, for both samples and shows that the mail survey mode was the dominant mode, as expected given the hierarchical application of the survey mode. However, the number of CATI interviews conducted was a function of budget and time, therefore the maximum permissible was 30. For a few of those respondents who did not respond to the CATI interview, a face-to-face interview was organized.

Table 51: Percentage of Completed Surveys for Each Survey Mode

Mode	*Terminators*	*Refusals*
Mail	73.5%	84.4%
Internet	7.6%	0.9%
Telephone	11.8%	9.2%
Face-to-Face	7.1%	5.5%

Table 52 shows the percentage of mail and internet responses given the post incentive amount offered.

Table 52: Mail and Internet Responses by Incentive Amount (Terminators)

Mode	*$0*	*$10*	*$20*
Mail/internet	39 (13.5%)	78 (27.1%)	21 (32.8%)
Sample size	288	288	64

The purpose of this analysis was to determine whether changing survey mode on subsequent waves would have an effect on response level, in terms of the post incentive level offered. As already mentioned, 45 percent of the terminator sample was given no post incentive, 45 percent was given a $10 post incentive, and 10 percent was given a $20 post incentive. This incentive structure was repeated for the refusers. It appears as though for the mail/internet survey mode utilized in wave one, the $20 post incentive was the most significant for terminator non-respondents. This is also the result from the Stated Choice analysis, described later in this section. Terminators were also least likely to respond to the survey if no post incentive was offered. This may be so because some of these individuals indicated that they did not have the time to do the survey; hence, they may have believed that a zero post incentive was not appropriate for their efforts if they were to make time to complete the survey. Table 53 shows the percentage of mail and internet responses given the post incentive amount offered for the households that refused to participate in the original travel survey.

Again, the highest percentage of responses is for the $20 post incentive. However, comparing this table with Table 52, refusers were more likely to respond to the survey than terminators if no incentive was offered, but less likely to respond than terminators, if a $10 incentive was offered. In this survey,

refusers are more likely to respond to the extreme levels of post incentive offered. Table 54 shows that the majority of terminator and refuser non-respondents would answer the telephone if their caller-id displayed a research institute, university, or a government agency, confirming other reports (Kalfs and van Evert, 2003). Also, the terminator and refuser samples are dominated by 1, 2 or 3 person households. However, two important differences between the characteristics of the terminators and refusers are that the terminator sample is younger than the refuser sample and that there is a higher proportion of female terminators than there are female refusers.

Table 53: Mail and Internet Responses by Incentive Amount (Refusers)

Mode	*$0*	*$10*	*$20*
Mail/internet	45 (27.8%)	33 (20.4%)	15 (41.7%)
Sample size	162	162	36

Table 54: Key Summary Statistics for Both the Terminator and Refuser Samples

Attribute	*Terminators*	*Refusers*
Percentage of 1,2 or 3 person households	70%	76%
Percentage of respondents who would answer the phone if their caller-id displayed the name of a research institute or university	93%	75%
Percentage of respondents who would answer the phone if their caller-id displayed the name of a government agency	77%	75%
Percentage of respondents who drive	91%	80%
Gender: female	64%	52%
Percentage of male respondents aged under 55 years	64%	41%
Percentage of female respondents aged under 55 years	67%	38%
Percentage of households with no vehicle	6%	12%
Percentage of respondents who rode a bus during the last weekday	3%	4%
Percentage of respondents who rode in a car during the last weekday	90%	84%
Percentage of respondents who did not ride in a car, bus or taxi during the last weekday	6%	12%
Percentage of households with a combined household income less than $50,000	65%	63%
Percentage of respondents who own or are buying the dwelling in which they reside	68%	77%
Percentage of respondents not employed	9%	5%

Comparing these results to those from the TDC Non-Response Study, 90 percent of refusals were 1 and 2 person households, and households with 2 adults and 2 or more children, whereas 76 percent of the refuser sample, of the Non-Response Follow-Up Study, were 1, 2 and 3 person households. The TDC results also showed that 7 percent of refuser households had no vehicle whereas 12 percent of refusers in the Non-Response Follow-Up Study had no vehicle. Unfortunately, due to different income categories used in both studies, comparison of income levels could not be made. A similar finding between the TDC Non-Response Study and the Non-Response Follow-Up is in relation to gender of refuser respondents: 53.3 percent and 52 percent females, respectively. Also, results of the terminator sample could not be compared to the results of the TDC Non-Response Study because this study did not classify refuser non-respondents in the manner that was described by the researchers, as defined earlier in this section.

Non Response Follow-Up Study Results

This section is divided into two sub-sections:

1. Terminator results – this includes results of the multidimensional scaling; background information about the type of model used in the analysis of the Stated Choice data, and the results of the stated choice experiment; and
2. Refusers results – this includes the results of the multidimensional scaling.

Terminators

The survey asked respondents to circle a number between 1 and 5 that showed how the respondent felt about each statement in terms of agreement and importance. The following three tables show the results. Table 55 shows the percentage of respondents who strongly disagreed and strongly agreed with the statements, in relation to the original travel survey.

The majority of respondents strongly disagreed with the statements "I didn't understand the questions being asked" and "The person on the phone put me off". The statements "You called me at a bad time" and "I didn't have the time to do it", incurred the highest percentage of respondents strongly agreeing: 30 percent and 29 percent respectively.

Table 55: Status of Agreement to Statements in Relation to Original Travel Survey (Terminators)

Agreement	*Strongly Disagree*	*Strongly Agree*
The survey form was too long	22%	18%
I don't care about transportation issues	44%	8%
You called me at a bad time	19%	30%
I didn't like the questions being asked	39%	12%
I travel too much	44%	10%
I didn't understand the questions being asked	59%	7%
I didn't have the time to do it	24%	29%
I travel too little to be of interest to you	38%	21%
I didn't want to say no to the interviewer	39%	13%
I don't do surveys	46%	11%
I couldn't get other family members to take part	34%	28%
I thought it was marketing deal or scam	37%	23%
The person on the phone put me off	60%	8%
I just couldn't be bothered to do it	32%	14%

Table 56 shows how important the statements were to the respondents, in their decisions not to participate in the original travel survey. The most important statements, in terms of the decision not to participate in the original travel survey, are:

- You called me at a bad time (31 percent); and
- I didn't have the time to do it (28 percent).

Table 56: Status of Importance of Statements in Terms of the Decision Not to Participate in Original Travel Survey

Importance	*Not at all important*	*Very important*
The survey form was too long	25%	18%
I don't care about transportation issues	28%	23%
You called me at a bad time	19%	31%
I didn't like the questions being asked	34%	16%
I travel too much	44%	13%
I didn't understand the questions being asked	47%	12%

I didn't have the time to do it	19%	28%
I travel too little to be of interest to you	34%	23%
I didn't want to say no to the interviewer	35%	17%
I don't do surveys	37%	17%
I couldn't get other family members to take part	33%	26%
I thought it was marketing deal or scam	37%	26%
The person on the phone put me off	52%	13%
I just couldn't be bothered to do it	28%	17%

This was expected given that almost the same number of respondents also strongly agreed with these statements. Table 57 shows the results of cross-tabulations for the same statements, in terms of agreement and importance. In Table 57, 12 percent of respondents strongly disagreed, and did not regard the statement "The survey form was too long", important in their decision not to participate in the survey, whereas 9 percent of respondents strongly agreed with, and thought the statement was important in their decision. Twenty one percent of respondents strongly disagreed, and did not regard the statement "I don't care about transportation issues" important in their decision not to participate in the survey, whereas only 3 percent of respondents strongly agreed with the statement and thought it was important in their decision.

Table 57: Cross-tabulation of Statements in Terms of Agreement and Importance

Statements	*Strongly disagree and not at all important*	*Strongly agree and very important*	*Undecided*
The survey form was too long	12%	9%	31%
I don't care about transportation issues	21%	3%	26%
You called me at a bad time	12%	19%	3%
I didn't like the questions being asked	25%	6%	22%
I travel too much	33%	5.%	18%
I didn't understand the questions being asked	40%	2%	15%
I didn't have the time to do it	13%	19%	22%
I travel too little to be of interest to you	25%	15%	20%
I didn't want to say no to the interviewer	23%	6%	27%
I don't do surveys	29%	5%	23%
I couldn't get other family members to take part	24%	18%	20%
I thought it was marketing deal or scam	25%	14%	20%
The person on the phone put me off	47%	4%	17%
I just couldn't be bothered to do it	19%	9%	30%

In relation to the statement "You called me at a bad time", 19 percent of respondents strongly agreed with it and regarded it very important in their decision not to participate in the survey, whereas 12 percent of respondents did not regard it as important, and strongly disagreed with it. Twenty five percent of respondents strongly disagreed with, and did not regard the statement "I didn't like the questions being asked", as important in their decision not to participate in the survey, whereas only 6 percent thought it was very important and strongly agreed with it. Nineteen percent of respondents indicated that they strongly agreed with the statement "I didn't have time to do it" and regarded it very important in their decision not to participate in the survey.

Multidimensional scaling analysis, using the *ALSCAL* procedure in *SPSS®*, was employed to determine whether the agreement statements could be grouped into "new" variables. Initially, the model was asked to create a matrix with a maximum of three dimensions. All stimulus coordinates in dimension three were not significant, hence the model was asked for a two dimensional matrix. The stress and R squared values for the desired matrix are 0.16807 and 0.85656, respectively, representing a relatively good fit model. (Lower stress values and higher R squared values are desired. These values depict the

goodness of fit of the model to the data.) Table 58 shows the results of the Euclidean Distance Model for the agreement statements.

Table 58: Euclidean Distance Model Results for Statements in Terms of Agreement

Stimulus Number	*Stimulus Name*	*Dimension 1 (Interest)*	*Dimension 2 (Survey Content)*
1	The survey form was too long	0.378	1.1763
2	I don't care about transportation issues	-1.2226	-.0860
3	You called me at a bad time	2.0040	0.2222
4*	I didn't like the questions being asked	-.3696	-.2416
5	I travel too much	-1.1001	1.6863
6	I didn't understand the questions being asked	-1.6755	-.2543
7	I didn't have the time to do it	1.8812	-.1415
8	I travel too little to be of interest to you	0.0974	-1.2900
9*	I didn't want to say no to the interviewer	-3649	-.3051
10*	I don't do surveys	-.4464	-.4028
11	I couldn't get other family members to take part	1.8821	0.4069
12	I thought it was marketing deal or scam	0.3940	-1.2412
13	The person on the phone put me off	-1.5287	-.0008
14*	I just couldn't be bothered to do it	0.0763	0.4716

* *not significant in either dimension in terms of agreement*

These results show that many respondents *disagree* with the statements "I don't care about transportation issues", "I didn't understand the questions being asked" and "The person on the phone put me off". These results confirm the results shown in Table 55. Also from the results shown in Table 58, the statements can be placed in two clusters (groups), based on their scores on the two dimensions: *survey content and interest*. Statements grouped under **survey content** are:

- The survey form was too long;
- I travel too much;
- I travel too little; and
- I thought it was a marketing deal or scam.

Statements grouped under **interest** are:

- I don't care about transportation issues;
- You called me at a bad time;
- I didn't understand the questions;
- I couldn't get other family members to take part;
- The person on the phone put me off; and
- I didn't have time to do it.

Statements that are insignificant in both dimensions for the original travel survey are:

- I didn't like the questions asked;
- I didn't want to say no to the interviewer;
- I don't do surveys; and
- I just couldn't be bothered to do it.

Similarly, multidimensional scaling analysis, using the *ALSCAL* procedure in *SPSS*®, was employed to determine whether the importance statements could be grouped into "new" variables. In this

case, the model was asked to create a matrix with a maximum of four dimensions. Some stimulus coordinates in dimensions three and four were significant, hence this model was retained for analysis. The stress and R squared values for the desired matrix are 0.10756 and 0.91684 respectively, depicting a good fit model.

Table 59 shows the results of the Euclidean distance model for the importance statements and shows four clusters (groups); *survey content, interest, respondent burden and communication.* Statements grouped under **survey content** are:

- The survey form was too long;
- I travel too much; and
- I travel too little.

Statements grouped under **interest**: are:

- You called me at a bad time;
- I didn't understand the questions;
- The person on the phone put me off; and
- I didn't have time to do it.

Table 59: Euclidean Distance Model Results for Statements in Terms of Importance

Stimulus Number	*Stimulus Name*	*Dimension*			
		1 (Interest)	*2 (Survey Content)*	*3 (Respondent Burden)*	*4 (Commun-ication)*
1	The survey form was too long	-.3348	1.0339	0.3373	-.9906
2*	I don't care about transportation issues	0.2825	0.4992	0.9963	-.6813
3	You called me at a bad time	-2.7390	0.0835	-.6107	-.0008
4 *	I didn't like the questions being asked	0.9365	0.0221	-.0902	0.1920
5	I travel too much	1.2248	1.9263	-1.0847	-.3396
6	I didn't understand the questions being asked	2.3208	0.1613	0.1866	-.2245
7	I didn't have the time to do it	-2.3830	-.6047	-.1692	-.5424
8	I travel too little to be of interest to you	0.3851	-1.6619	1.2350	-.3219
9	I didn't want to say no to the interviewer	0.4827	-.9596	-.0693	-1.0008
10*	I don't do surveys	0.4294	-.0264	0.2009	0.3620
11	I couldn't get other family members to take part	-1.6066	0.9637	1.6736	1.3719
12	I thought it was marketing deal or scam	-.0624	-.3550	-.6322	1.6571
13	The person on the phone put me off	1.7123	-.6372	-.9605	0.4732
14	I just couldn't be bothered to do it	-.6480	-.4453	-1.0529	0.0457

** not significant in any dimension in terms of importance*

Statements grouped under **respondent burden** are:

- I couldn't get other family members to take part; and
- I just couldn't be bothered to do it.

Statements grouped under **communication** are:

- I didn't want to say no to the interviewer; and
- I thought it was a marketing deal or scam.

Statements that are insignificant in any dimension in the decision to participate in the original travel survey are:

- I don't care about transportation issues;

- I didn't like the questions asked; and
- I don't do surveys.

In summary, the MDS for the terminator non-respondents showed that the following statements had positive values: respondents tended to *agree* with these statements rather than disagree, in relation to their decision not to participate in the original study. These statements are grouped under the following:

- Survey content:
  - The survey form was too long; and
  - I travel too much.
- Interest:
  - You called me at a bad time;
  - I didn't have the time to do it; and
  - I couldn't get other family members to participate.

Also, the terminator non-respondents tended to consider the following statements *important* rather than not important, in their decision not to participate in the original study. These statements are grouped under the following:

- Survey content:
  - The survey form was too long; and
  - I travel too much.
- Interest:
  - I didn't understand the questions being asked; and
  - The person on the phone put me off.
- Respondent Burden:
  - I couldn't get other family members to take part.
- Communication:
  - I thought it was a marketing deal or scam.

A stated choice (SC) experiment involving the decision to respond to alternative hypothetical surveys was conducted on the 640 terminators, 200 of whom completed the survey. The socio-demographic characteristics of the respondents are shown in Table 54. The choice experiment consisted of two unlabeled survey alternatives defined on five attributes described by eight, four, or two attribute levels. The attributes and attribute levels are reported in Table 60. A balanced main effects only orthogonal fractional factorial design was constructed with 24 treatment combinations. To minimize cognitive burden on respondents, each respondent was shown only 12 of the total 24 treatment combinations.

For each choice set, respondents were first asked to select to which survey they would be more likely respond, based on the attributes and attribute levels that defined each of two (unlabeled) survey alternatives. This represents a constrained choice, because respondents were not given the option of not responding. Next respondents were given the option not to respond, and asked whether they would respond or not to either survey. Figure 8 shows an example choice set.

Table 60: Choice Experiment Attribute and Attribute Levels

Attribute	***Attribute Levels***
Incentive offered	None, small gift, lottery ticket, major prize draw, $1, $2, $5, $10
Recruitment method	Telephone, e-mail, mail, face-to-face
Survey conducted by	Research institute, private firm, university, government

Who decides when the completed survey is returned	Respondent chooses, interviewer chooses
Who decides how the completed survey is returned	Respondent chooses, interviewer chooses
Length of survey	Less than 10 mins, 10 – 19 mins, 20 – 29 mins, more than 30 mins

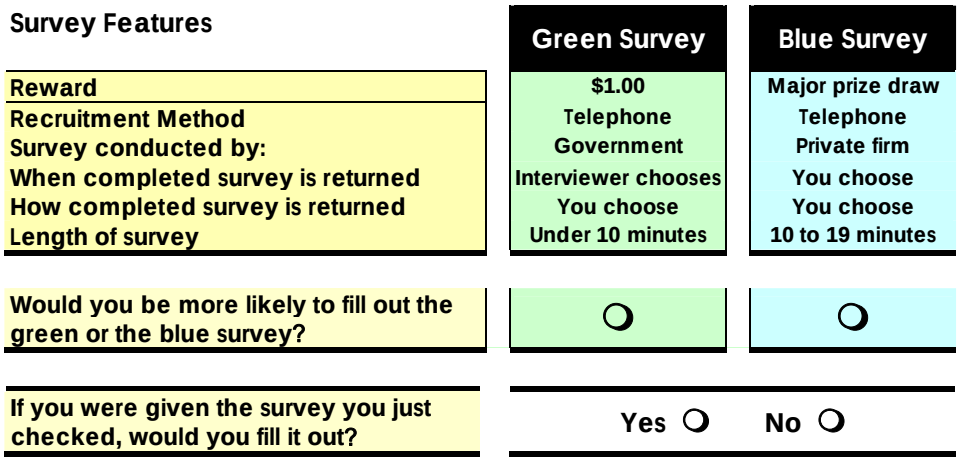


Figure 8: Example Choice Set

A number of models were estimated to assess the influence that various attributes and attribute levels play in the choice to respond to a travel survey. A more thorough review of the Mixed Logit model, used in this work, is given in Hensher and Greene (2003).

Consider a situation in which a sample of individuals is evaluating a finite number of alternatives, $j = 1, 2, \ldots, J$. Let subscripts i, j, and k refer to individual i, alternative j, and alternative attribute k. The utility for any given alternative may be written as:

$$U_{ij} = \beta_i' x_{ijk} + \varepsilon_{ji}$$

where:

U_{ij} = the utility possessed by individual i for alternative j,
x_{ijk} = a vector of explanatory variables observed by the analyst, which may include attributes of the alternatives, socioeconomic characteristics of the respondent, and descriptors of the decision context and choice task under consideration.
β_i = the weight (or parameter) associated with attribute x_{ijk}
ε_{ij} = the unobserved influences of sampled respondent i for alternative j.

Neither β_i nor ε_{ij} are observed by the analyst and hence must be treated as stochastic influences. Within the logit model framework, ε_{jq} is assumed to be independently and identically distributed (IID) extreme value type 1. The IID assumption derived through the use of the extreme value type 1 distribution allows for ease of computation (as well as providing a closed form solution). Nevertheless, as with any assumption, violations both can and do occur. When they occur, violations of the IID assumption mean that the cross-substitution effects observed between pairs of alternatives are no longer equal given the presence or absence of other alternatives within the model (Louviere *et al.,* 2000).

The Mixed Logit (ML) model relaxes the IID assumption by partitioning the stochastic component of the model additively into two parts. The first element of the stochastic component of the model is allowed to be correlated over alternatives and to be heteroskedastic. The second component maintains the IID assumption over alternatives and individuals; hence, the model remains within the logit family. We show this partitioning in the equation below.

$$U_{ij} = \beta_i' x_{ij} + [\eta_{ij} + \varepsilon_{ij}]$$

where:

η_{jq} = a random component with a zero mean and a distribution over individuals and alternatives dependent on the underlying parameters and observed sample data relating to alternative *j* and individual *i*.

The ML model assumes a general distribution for η_{ij} such that η_{ij} can take on any number of distributional forms such as normal, lognormal, uniform, or triangular. Within the ML framework, ε_{ij} is treated as a random term with zero mean that is IID over alternatives and which is independent of the underlying parameters or sample data.

We denote the joint density of $[\eta_{1i}, \eta_{2i}, \ldots, \eta_{Ji}]$ as $f(\eta_i | \Omega)$ where the elements of Ω are the parameters of the distribution (i.e., mean and standard deviation) and η_i denotes a vector of *J* random elements across the universal set of utility functions. Given ε_{ij} is distributed IID extreme value type 1, we are able to state that for any value of η_i, the *conditional* probability for choice *j* is logit. Hence:

$$L_{ij}(\beta_i / \eta_i) = \frac{exp(\beta_i' x_{ij} + \eta_{ij})}{\sum_j exp(\beta_i' x_{ij} + \eta_{ij})}$$

This equation is similar in form to the simple multinomial logit model differing only in that for each sampled individual we now have additional information with regard to the unobserved sources of influence as defined through the vector η_i. The unconditional choice probability is calculated as this logit probability integrated over all values of η_i and weighted by the density of η_i is as shown in the equation below (see Hensher and Greene, 2003):

$$P_{ij}(\beta_i / \Omega) = \int_{\eta^{1i}} \int_{\eta^{2i}} \ldots \int_{\eta^{Ji}} L_{ij}(\beta_i / \eta_i) f(\eta_i / \Omega) d\eta_{Ji} \ldots d\eta_{2i} d\eta_{1i}$$

An important output of the ML model is the standard deviation parameter of the model. The standard deviation of an element of the β_i (random) parameter vector, denoted σ_{ik}, accommodates the presence of preference heterogeneity in the sampled population around the mean of the random parameter. This allows for the exploration of possible sources of preference heterogeneity that may exist across sampled respondents. This is accomplished through the interaction of each random parameter with other attributes or variables that one suspects may be possible sources of preference heterogeneity (for example, if one suspects that observed heterogeneity in a price parameter may be the result of gender differences, one may interact the price random parameter with a variable indicating each respondent's gender to determine if this indeed is the case).

The model results for the constrained choice experiment are reported in Table 61. Two models are reported; a multinomial logit (MNL) model and a mixed logit (ML) model estimated using 500 Halton sequence intelligent draws. Given the qualitative nature of the attributes, each attribute was effects coded. Effects codes were used as opposed to dummy codes so as to avoid confounding the base attribute level with the average of the unobserved effects of the model's single utility function (because this is an unlabeled choice experiment, a single utility function is estimated to represent both unlabeled alternatives, see Hensher, Rose and Greene, 2004).

Table 61: Results of the Constrained Choice Experiment

Estimate Results – *Random Parameters*	*Model 1: MNL*	*Model 2: ML*
Survey length (<10 mins)		0.4957 (7.838)

Survey length (10-19 minutes)		0.1407 (2.261)
Non Random Parameters		
Survey length (<10 mins)	0.4881 (8.055)	
Survey length (10-19 minutes)	0.14 (2.269)	
Reward (No incentive)	-0.9116 (-8.29)	-0.9133 (-8.276)
Reward (Small gift)	-0.5516 (-4.427)	-0.5506 (-4.399)
Reward ($5)	0.2352 (2.308)	0.2342 (2.29)
Recruitment (Telephone)	0.3091 (2.43)	0.3077 (2.405)
Recruitment (Email)	-0.2253 (-3.399)	-0.2252 (-3.377)
Recruitment (Mail)	0.4025 (4.497)	0.4062 (4.496)
When to reply (1 = respondent determines)	0.2387 (6.006)	0.2398 (6.006)
How to reply (1 = respondent determines)	0.1537 (3.983)	0.15508 (4.000)
Survey conducted by Research institute	0.1559 (2.351)	0.1572 (2.355)
Survey conducted by University	-0.2448 (-2.433)	-0.2435 (-2.409)
Standard deviations of parameter distributions		
Survey length (<10 mins)		0.3966 (7.838)
Survey length (10-19 minutes)		0.0703 (2.261)
No. of observations	1879[†]	1879[†]
Constants only Log-Likelihood (β) at convergence	-1302.4236	-1302.4236
Log-Likelihood (β) at convergence	-1144.129	-1144.065
-2 Log-Likelihood	316.5892	316.7174
Degrees of freedom	12	14
Chi-square (χ2)	21.026	23.685

[†]Some observations were lost due to non response.

Insignificant parameter estimates were removed from the utility specifications of both models. The MNL model is statistically significant ($\chi^2 = 316.5892$ with 12 degrees of freedom) with a pseudo R^2 of 0.12. The parameter estimated for offering no incentive to complete a survey is statically significant and negative which is in the direction expected. Offering no incentive creates a disutility with regards to completing surveys. The parameter associated with offering small gifts is also statistically significant and negative, although the disutility is less than that associated with no incentive, suggesting that the offering of a small gift is preferred to the offering of no incentive, but less preferred to other reward strategies. Of the remaining reward strategies, only the parameter estimate for the $5 attribute was significant. As the other parameters removed from the analysis are set to zero, the estimate for the $10 attribute level is calculated as the sum of minus one times those attributes that remain. Thus, we calculate the parameter estimate for the $10 attribute level as 1.2297. The positive parameter estimates for the $5 and $10 attribute levels suggest a strong preference for relatively large monetary rewards for answering surveys.

In terms of recruitment strategies, the model suggests a strong preference towards phone and mail contact and a strong preference against e-mail contact. Calculation of the base recruitment attribute level representing face-to-face contact ($\beta = -0.4887$) shows an even stronger preference against such a method.

Respondents clearly prefer the option of determining how and when to reply to surveys. Not surprisingly, respondents also prefer shorter surveys than longer surveys, with surveys under ten minutes preferred the most. The model also suggests that respondents are more likely to respond to surveys being conducted by known research institutes and slightly less inclined to answer surveys instigated by government bodies ($\beta = 0.0863$), but are far less inclined to respond to university research efforts.

A number of sociodemographic variables were also tested within the utility function of the model. Household size, age, gender, number of drivers within a household, number of vehicles in a household, and type of contact used to recruit the respondent for the study were tested. In no instance were any of these variables statistically significant, and in several cases, actually produced worse model fits.

The ML model may be used to identify preference heterogeneity and possible sources of heterogeneity, should it be found. The ML model is statistically significant ($\chi^2 = 316.7174$ with 14

degrees of freedom) with a pseudo R^2 of 0.12. Given the additional degrees of freedom necessary for the estimation of the ML model, the ML model does not statistically represent an improvement over the MNL model reported earlier. Nevertheless, the survey length less than 10 minutes and survey length between 10 and 19 minutes attributes were estimated as random parameters with a constrained triangular distribution. The standard deviation of the survey length less than 10 minutes was constrained to be 0.8 of the population mean of the random parameter and the survey length between 10 and 19 minutes was constrained to be 0.5 of the population mean of the random parameter estimate. The mean population parameter of each attribute is statistically significant ($p < 0.05$) as also are the standard deviation parameters, indicating the presence of preference heterogeneity for these parameter estimates. An interaction between the mean estimate of each of the random parameter estimates and each of the sociodemographic variables previously mentioned were tested within the model. Such interactions are equivalent to revealing the presence or absence of preference heterogeneity around the mean of each random parameter estimate (Hensher and Greene, 2003). In all cases, no statistical significance was discovered suggesting that these variables are not the source of the observed preference heterogeneity within the model. As such, the model suggests the existence of preference heterogeneity, but the source of this heterogeneity is yet to be determined. With the exception of the presence of preference heterogeneity, not detectable within the MNL model framework, the remaining non-random parameter estimates of the ML model are similar to those of the MNL model.

Table 62 shows the model results for the unconstrained choice experiment where respondents were able to choose to not respond to either unlabeled survey alternative. The "not respond" alternative is treated as the base alternative in both models. Both the MNL and ML models are statistically significant ($\chi^2 = 332.1052$ with 10 degrees of freedom and $\chi^2 = 359.5484$ with 13 degrees of freedom for the MNL and ML model respectively with pseudo R^2 of 0.082 and 0.088). As with the two models estimated on the conditional choice experiment, insignificant parameter estimates were removed from the both models.

The results for the MNL model suggest a strong preference against e-mail as a recruitment strategy and a strong preference towards telephone and mail recruitment. The MNL model also suggests a strong preference against offering no incentive for completing a survey as well as a preference against offering small sums of money. Larger sums of money when offered as an incentive to complete a survey are strongly preferred with the $10 incentive preferred (calculated as $\beta = 0.8217$) to $5 as might be expected. The model suggests that the offering of lottery tickets and small gifts will be a disincentive to reply relative to larger cash payments.

Table 62: Results of the Unconstrained Choice Experiment

Estimate Results – Random Parameters	***Model 3: MNL***	***Model 4: ML***
Recruitment (Email)		-0.215 (-2.203)
Reward (No incentive)		-1.1656 (-4.783)
Survey conducted by private firm		0.1387 (1.819)
Non Random Parameters		
Recruitment (Email)	-0.209 (-2.966)	
Reward (No incentive)	-0.5918 (-5.137)	
Survey conducted by private firm	0.1031 (1.873)	
Reward (Lottery ticket)	-0.3432 (-3.366)	-0.4354 (-3.107)
Reward ($2)	-0.3527 (-3.681)	-0.3778 (-2.895)
Reward ($5)	0.466 (4.936)	0.7869 (5.91)
Recruitment (Telephone)	0.2596 (3.528)	0.2992 (3.11)
Recruitment (Mail)	0.3275 (4.844)	0.4992 (5.248)
How to reply (1 = respondent determines)	0.1014 (2.665)	0.1383 (2.805)
Survey length (<10 mins)	0.7106 (12.627)	0.9338 (10.157)
Standard deviations of parameter distributions		
Recruitment (Telephone)		2.3821 (3.533)
Reward (No incentive)		4.8953 (4.958)
Survey conducted by private firm		2.3774 (3.696)

No. of observations	1829†	1829†
Constants only Log-Likelihood (β) at convergence	-2035.7286	-2035.7286
Log-Likelihood (β) at convergence	-1869.676	-1855.954
-2 Log-Likelihood	332.1052	359.5484
Degrees of freedom	10	13
Chi-square (χ2)	18.307	22.362

†Some observations were lost due to non response.

When respondents are allowed to choose not to respond, the *when to respond* parameter estimate becomes insignificant. The *how to respond* parameter, however, remains statistically significant such that respondents are more likely to respond when given the opportunity of selecting how they do so. Further, when respondents can choose not to reply there exists a strong preference for short surveys (less than 10 minutes) but an indifference to longer surveys, *ceteris paribus*.

The e-mail recruitment, no incentive, and survey conducted by private firms were estimated as random parameters in a ML model. This is shown as model 4 in Table 62. Each random parameter was drawn from an unconstrained triangular distribution using 500 Halton sequence intelligent draws. The population means of the e-mail recruitment and no incentive random parameters are statistically different from zero ($p < 0.05$). The mean of the survey conducted by private firms random parameter estimate is not statistically different from zero. The standard deviation parameters of all three random parameters are statistically significant indicating the presence of preference heterogeneity around the population mean parameter estimates. As with the constrained choice ML model, various socio-demographic variables, interacted with the mean parameter estimates, were investigated to determine possible sources of the observed heterogeneity, none of which were found to be statistically significant determinants. This suggests the need for further research efforts to determine the possible sources of the observed heterogeneity. The remaining non-random parameter estimates are similar in size and magnitude to those of the MNL model.

Refusals

The survey for the refusers also asked respondents to circle a number between 1 and 5 that showed how the respondent felt about each statement in terms of agreement and importance. The following three tables show the results. Table 63 shows the percentage of respondents who strongly disagreed and strongly agreed with the statements about the original travel survey.

Table 63: Status of Agreement to Statements in Relation to Original Travel Survey

Attribute	*Strongly Disagree*	*Strongly Agree*
You called me at a bad time	17%	51%
I don't do surveys	27%	30%
I didn't have the time to do it	14%	40%
I thought it was a marketing deal or scam	13%	57%
The person on the phone put me off	4%	13%
I don't care about transportation issues	38%	14%
I just couldn't be bothered to do it	19%	36%

Table 63 shows that the majority of respondents strongly agreed with the statements "You called me at a bad time" and "I thought it was a marketing deal or scam". Also, a relatively high percentage of respondents also strongly agreed with the statements "I didn't have the time to do it" and "I just couldn't be bothered to do it": 40 percent and 36 percent respectively. The TDC Non-Response Study indicated

that 57 percent of refusers stated that the reason for not responding to the Sydney Household Travel Survey was they were "Not interested/didn't want to" and 17 percent indicated that they "Had no time/ were too busy". The results are very different to the results shown in Table 63. This was expected given that the original data retrieval methods for both surveys are different; the Sydney Household Travel Survey employs face-to-face data retrieval whereas NuStats used telephone interviews (CATI) to retrieve household travel information.

Table 64 shows how important the statements were, to the respondents, in their decisions not to participate in the original travel survey. The most important statements, in terms of the decision not to participate in the original travel survey are:

- You called me at a bad time (49 percent); and
- I thought it was a marketing deal or scam (58 percent).

This was expected given that almost the same number of respondents also strongly agreed with these statements.

In Table 65, 34 percent of respondents strongly agreed, and regarded the statement "You called me at a bad time", important in their decision not to participate in the survey, whereas two percent of respondents strongly disagreed with, and thought the statement was not important in their decision. Twenty-one percent of respondents strongly disagreed, and did not regard the statement "I don't care about transportation issues", important in their decision not to participate in the survey, whereas only seven percent of respondents strongly agreed with the statement and thought it was important in their decision. However, 40 percent of respondents were undecided about this statement, in relation to agreement and importance.

Table 64: Status of Importance of Statements in Terms of the Decision Not to Participate in the Original Travel Survey

Importance	*Not at all important*	*Very important*
You called me at a bad time	15%	49%
I don't do surveys	14%	30%
I didn't have the time to do it	12%	31%
I thought it was marketing deal or scam	14%	58%
The person on the phone put me off	34%	8%
I don't care about transportation issues	31%	17%
I just couldn't be bothered to do it	19%	27%

In relation to the statement "I thought it was a marketing deal or scam", 45 percent of respondents strongly agreed with it and regarded it very important in their decision not to participate in the survey, whereas only two percent of respondents did not regard it as important, and strongly disagreed with it. Twenty-one percent of respondents indicated that they strongly agreed with the statement "I didn't have time to do it" and regarded it very important in their decision not to participate in the survey; however, 26 percent of respondents were undecided. Also, 21 percent of respondents strongly agreed with the statement "I just couldn't be bothered to do it" and regarded it as very important in their decision not to participate in the original travel survey. Surprisingly, though, 38 percent were undecided in relation to whether they agreed or regarded the statement as important in their decision not to participate in the study. There was a much higher incidence of respondents being undecided about how to rate this statement in relation to agreement and importance compared to the terminator non-respondents.

Table 65: Cross-tabulation of Statements in Terms of Agreement and Importance

Statements	*Strongly disagree and not at all important*	*Strongly agree and very important*	*Undecided*

You called me at a bad time	2%	34%	17%
I don't do surveys	7%	23%	27%
I didn't have the time to do it	2%	21%	26%
I thought it was marketing deal or scam	2%	45%	11%
The person on the phone put me off	20%	8%	18%
I don't care about transportation issues	21%	7%	40%
I just couldn't be bothered to do it	12%	21%	38%

Multidimensional scaling analysis, using the *ALSCAL* procedure in ***SPSS®***, was employed to determine whether the statements in terms of agreement could be grouped under "new" variables. Initially, the model was asked to create a matrix with a maximum of three dimensions. All stimulus coordinates in dimension three were not significant, hence the model was asked for a two dimensional matrix. The stress and R squared values for the desired matrix are 0.01157 and 0.999886 respectively – a good fit model[23]. Table 66 shows the results of the Euclidean Distance Model for the Statements in terms of agreement, which indicate that many of the respondents *disagree* with the statement "I just couldn't be bothered to do it". Also Table 66 shows that the statements can be placed into two clusters (groups); *interest* and *communication*. The statement placed in **communication** is:

- I thought it was a marketing deal or scam.

Statements grouped under **interest** are:

- You called me at a bad time;
- I didn't have time to do it; and
- I just couldn't be bothered to do it.

Table 66: Euclidean Distance Model Results for Statements in Terms of Agreement

Stimulus Number	***Stimulus Name***	***Dimension 1 (Interest)***	***Dimension 2 (Communication)***
1	You called me at a bad time	2.0160	-1.0624
2*	I don't do surveys	0.4664	0.0748
3	I didn't have the time to do it	-1.2716	0.5556
4	I thought it was marketing deal or scam	-1.1576	1.3347
5*	The person on the phone put me off	-.5451	-.7277
6*	I don't care about transportation issues	-.5537	-.7105
7	I just couldn't be bothered to do it	-1.2697	-.5355

* *not significant in either dimension in terms of agreement*

Statements which are insignificant in both dimensions, in terms of agreement, in relation to the original travel survey, are:

- I don't do surveys;
- The person on the phone put me off; and
- I don't care about transportation issues.

Similarly, multidimensional scaling analysis was employed to determine whether the statements, in terms of importance, could be grouped under "new" variables. This time the model was asked to create a matrix with a maximum of three dimensions. Some stimulus coordinates in the third dimension were

[23] Lower stress values and higher R squared values are desired. These values depict the goodness of fit of the model to the data.

significant; hence, this model was retained for analysis. The stress and R squared values for the desired matrix are 0.00215 and 0.99996 respectively, depicting a good fit model. Table 67 shows the results of the Euclidean Distance Model for the importance statements, from which there are seen to be three clusters (groups); *interest, communication, and respondent burden.* Statements grouped under **interest** are:

- You called me at a bad time; and
- The person on the phone put me off.

The statement placed under **communication** is:

- I thought it was a marketing deal or scam.

Finally, the statement placed under **respondent burden** is:

- I don't do surveys.

Table 67: Euclidean Distance Model Results for Importance Statements

Stimulus Number	***Stimulus Name***	***Dimension 1 (Interest)***	***Dimension 2 (Communication)***	***Dimension 3 (Respondent Burden)***
1	You called me at a bad time	1.7576	-.6586	1.3510
2	I don't do surveys	0.3991	-.2625	-1.4623
3*	I didn't have the time to do it	0.6752	0.6527	-.6832
4	I thought it was marketing deal or scam	-1.3681	-2.0009	-.0321
5	The person on the phone put me off	-1.7468	1.3143	0.6665
6*	I don't care about transportation issues	-.2080	0.3844	.1066
7*	I just couldn't be bothered to do it	0.4918	0.5706	0.2667

** not significant in any dimension in terms of importance*

In summary, the MDS analysis, for the refuser non-respondents, showed that the following statements depicted positive values; respondents tended to *agree* with the statements rather than disagree, in relation to their decision not to participate in the original study. These statements are grouped under the following:

- Interest:
  - You called me at a bad time.
- Communication:
  - I thought it was a marketing deal or scam.

Also, the refuser non-respondents tended to consider the following statement *important* rather than not important, in their decision not to participate in the original study. This statement is grouped under the following:

- Interest:
  - You called me at a bad time.

Conclusion

Addressing the non-respondent issue will become increasingly difficult in the future due to the following:

1. Higher levels of multiculturalism and multiple languages spoken within urban areas.
2. Less free time for individuals who are therefore more reluctant to devote limited spare time completing surveys.
3. Advances in communication will enable people to become even more selective in terms of who they communicate with. However, the introduction of the *Do Not Call Registry* (Federal Trade Commission, 2003) may benefit researchers because households on this registry will no longer think that calls from an unknown source are telemarketers hence, these households will be less likely to avoid incoming calls (higher contact rate).
4. Introduction of more restrictive privacy legislation in many countries.
5. Less public funds available to conduct research (Griffiths *et al.,* 2000).

There will always be a percentage of non-respondents to surveys regardless of the recruitment and retrieval methods employed. However, the purpose of this research was to gain some insight about the demographic and travel characteristics of non-respondents, why they did not respond, and if there are any particular elements in survey design and execution that would appeal to non-respondents. A summary of the overall results is described below.

The unconstrained stated choice model for the terminator sample showed that respondents were strongly against e-mail recruitment, $10 was the most preferred incentive level (this was the highest offered in the choice sets. Preference towards this incentive amount for terminator non-respondents was also found in the descriptive data analysis, (results shown in Table 54), terminator non-respondents were unlikely to respond if small gifts, lottery tickets or small cash payment incentives were offered. *How to respond* became a significant parameter to induce response, and terminator non-respondents preferred shorter surveys (under ten minutes). This result was one of the results of the multidimensional scaling analysis: the length of the original survey was an important factor in the non-respondent's decision not to complete the original travel survey. Therefore, the results indicate that to reduce the number of terminator non-respondents a $10 cash post incentive should be offered, mail and telephone contact and retrieval methods should be employed, (contrary to popular belief), and shorter surveys should be devised.

For the refuser sample, appropriate time of contact will likely invoke interest in the survey topic. Refusers believed that they were contacted at a bad time; hence, interest in the survey topic was reduced or non-existent, resulting in an outright refusal. Even though research has investigated the optimal time to contact respondents, no research has investigated the best time to contact non-respondents, such as refusers. It may be that there is no particular time slot suitable to contact refusers because at every given time slot, a percentage of respondents will refuse. However, research is needed to confirm or deny this.

From the MDS analyses of the agreement and importance data for the terminators and refusers, it can be seen that survey content, interest, communication and respondent burden are significant influences in the respondents' decisions to participate in the original travel survey. With this in mind, therefore, survey design should carefully incorporate these elements to increase response rates, by decreasing the number of terminator and refuser non-respondents. In essence, good survey design and experienced interviewers (if data retrieval is through CATI; personal interviews were not preferred), will more likely lead to higher response rates.

In the future, the use of internet and multimedia techniques will increase and so will the use of GPS devices to accompany surveys. This will enable the collection of more accurate data (Griffiths *et al.,* 2000). Consequently, a thorough understanding of the response behavior to the new technology needs to be investigated before these instruments can be used. For example, Bosnjak and Tuten (2001) have discovered seven distinct response behaviors in web-based surveys. These are:

1. Complete responders – view and answer all questions;
2. Unit non-responders – do not participate in the survey. Two types of non-responder, technically hindered from participating or purposely withdraws;
3. Answering drop-outs – provide answers to questions but drop out before completion;

4. Lurkers – view all of the questions but do not answer any questions;
5. Lurking drop-outs – represent a combination of answering drop outs and lurkers;
6. Item non-responders – view all of the survey but only answer some of the questions; and
7. Item non-responding drop-outs – a mixture of answering drop-outs and item non-responders.

These different response behaviors need to be investigated more thoroughly especially if this medium is to be used more regularly for research purposes. Recommended standardized procedures and guidelines on unit nonresponse are found in section 2.2.6 of the Final Report.

5.7 D-10: INITIAL CONTACTS

5.7.1 Item Description

The subject of this section is the first contact made with a potential respondent in a survey. Contact can be by telephone, mail, e-mail, or possibly, even personal interview. In telephone surveys and personal interviews, it involves the very first few words uttered following contact with a prospective respondent. When the initial contact is by mail, it is the envelope in which the material is mailed, the documentation in the envelope, and the opening sentence on the cover letter.

5.7.2 Importance and Nature of Initial Contact

The primary need is to design the introduction to surveys in such a fashion that refusals are avoided as much as possible. Currently, the proportion of refusals that occur during initial contact is surprisingly high. In the pretest of the National Household Travel Survey (NHTS) in 2000, 83 percent of the refusals occurred before the introduction was complete (McGuckin *et al.*, 2001). Those conducting the National Survey of America's Families report that "more than 80 percent of the refusals occur during the introduction or first question" (Vaden-Kiernan *et al.,* 1997, p. 2-3).

The number of refusals as a fraction of the number of calls made varies considerably with the type of survey and sampling frame. A political polling company using the telephone to conduct their poll has estimated that they need to make 15 calls for each successful contact, and that the contact rate is declining as resistance to telemarketing grows (Lessner, 2000). Resistance to telemarketing may be understood when the extent of its penetration of the market is understood: a national survey among registered voters showed that almost three-quarters of the sample had been called in the past to participate in a poll or product survey (Lessner, 2000). However, in the National Household Travel Survey, only nine percent of eligible households were, in the end, refusals.

The factors that influence the rate at which people hang up seems to have received relatively little research in the past. One study experimented with different opening scripts and observed a "cooperation rate" that varied between 53 and 64 percent (Vaden-Kiernan *et al.,* 1997). Cooperation rate was defined as the percentage of the calls in which the person picking up the phone listened to the entire opening message and permitted the interviewer to determine the eligibility of the household (i.e., establish that the household contained at least one person between the age of 18 and 64). The survey was conducted in areas with a high concentration of low-income households and, therefore, the results cannot be generalized. However, what is interesting is the results of the experiment they conducted into identifying the impact of various features of the opening message on cooperation rate.

A pretest experiment was conducted using sample sizes varying between 100 and 200 observations per changed feature in the introductory message. Features tested included variations in the length of the introduction, inclusion of a $5 incentive in the opening statement, identification of the organization sponsoring the survey, altering the first question from a screening question (i.e., "are you a

member of the household 18 years of age or older?") to requesting their opinion on ways to improve education, and inclusion of a statement assuring the respondent that no money was being solicited. It was found that brevity in the opening message was important although the difference between long and short messages was not statistically significant with the sample sizes considered. In this experiment, the $5 incentive was placed toward the end of a relatively long introductory message and it was found that it had no positive impact on cooperation rate, possibly because many respondents terminated the call before they learned of the incentive. Identification of the organization sponsoring the survey had a mildly positive impact on cooperation rate. In this survey, altering the first question from a screening question to one where the person's opinion was immediately elicited did not alter the cooperation rate. On the other hand, including a statement on non-solicitation seemed to improve cooperation rate although the improvement, like all the comparisons in this study, was not statistically significant.

In general, the conclusions of the experiment were that the introduction should be brief, state the purpose of the study, identify official sponsorship of the survey, and make it clear no funds were being solicited. The introductory text ultimately selected from the pretest experiment was (Vaden-Kiernan *et al.,* 1997):

> "Hello, my name is (NAME), and we are preparing to do a study for private foundations interested in education, health care, and other services in (STATE). The study has been endorsed by state governments concerned with how recent changes in policies affect people's lives. I am not asking for money – I'd only like to ask you a few questions."

However, the introduction was later changed in response to comments from interviewers who felt that a shorter introduction would be better (Vaden-Kiernan *et al.,* 1999). Information on the purpose of the survey was withheld unless it was specifically requested. The amended introduction was:

> "Hello, this is (NAME) with the National Survey of America's Families. I am not asking for money – this is a study for private foundations on education, health care, and other services in the state of (STATE).
> [IF ASKED: This study is to see how recent changes in federal laws affect people's lives in your community.]"

In the NHTS pretest it was found that most refusals involved the recipient terminating the call while the following message was being conveyed (McGuckin, Liss, and Keyes, 2001):

> "Hello, my name is _____ and we're conducting a survey for the Department of Transportation...".

Considering that, in this case, very limited information was conveyed before the call was terminated, it is interesting to speculate in the context of the NSAF pretest findings which words were responsible for this response. When comparing the opening statement used in the NHTS pretest with the final text used in the NSAF survey, at least three differences are apparent. First, starting with the phrase "..my name is.." rather than "..this is.." may convey the caller as a stranger more readily. Using the introduction "my name is" implies that the caller is unknown to the person being called. On the other hand, if a caller says, "..this is so-and-so from XYZ", it is a more neutral statement in which the caller is merely identifying herself or himself and the caller could be known or unknown. Introductions such as this are frequently used in business calls among acquaintances and strangers alike. Second, the word "survey" immediately conveys the purpose of the call, and suggests an activity that few people enjoy. Hanging up is an easy and non-confrontational way to avoid participating in a time-consuming and unrewarding experience. When comparing this to the NSAF text, the word "study" is used in place of "survey", which is probably a less evocative word. Third, the NSAF text assures the person being called

that no money will be solicited which distinguishes the call from telemarketing. In the actual 2001 NHTS, the introduction was changed to:

> "Hello, this is _____ and I'm calling for the U.S. Department of Transportation. We are conducting the National Household Travel Survey."

These changes were instituted because the company conducting the survey felt this was an improvement over the pretest, and the low refusal rate may have been due in part to that change. While there was much debate among the survey team over whether to use the word "study" or "survey" in the mail-out material and the questionnaire, "survey" was ultimately used because it was felt that it was a more straightforward presentation of the truth. The NHTS study team were of the opinion that the low refusal rate was likely due to these changes and effective interviewer training and refusal conversion efforts (Freedman, 2003).

Firm research findings on the subject of appropriate introductory text for travel surveys could not be found in the literature. It has become increasingly important in recent years due to the rise in telemarketing and the general decline in survey participation rates. The topic is likely to become an active area of research in the future.

Initial contact in mail surveys is closely associated with some other topics addressed in this document, namely "Mailing Materials" (section 8.2) and "Incentives" (section 5.8). Publicity surrounding the survey is also likely to impact the extent to which respondents open and read survey material. If the population is informed of the survey through television, radio, or the press, and the survey is presented as an activity worthy of support, it is likely to have a positive impact on the cooperation rate. This is likely to be true of personal interviews as well, but insufficient research has been conducted to make definitive statements. Conclusions on initial contacts are provided in section 2.2.7 of the Final Report.

5.8 D-13: INCENTIVES

5.8.1 Review of Incentives

Incentives are offered in some surveys to induce respondents to complete the survey. Many surveys do not offer incentives, but among those surveys where incentives are offered, considerable variability in type and magnitude are found.

There is considerable difference of opinion among transportation professionals as to whether incentives should be offered or not. The review of recent practice (chapter 2 of this Technical Appendix) showed that generally less than one quarter of surveys in the 1990s used incentives, while the TTI scan of surveys showed a slightly higher rate of the use of incentives[24] (almost 35 percent). There is also substantial diversity in what is offered for an incentive. Incentives have ranged from a gift to a significant payment of money ($10 and more per household, particularly for GPS surveys, where incentives as high as $50 have been offered), and some are offered only to those completing the survey while others are offered to all potential respondents. The only extensive review of the use of incentives in transportation surveys was performed in the mid-1990s by Tooley (1996), who concluded that "…general survey literature supports the use of monetary pre-incentives as being the most effective incentive method." She also noted that the general survey literature also supported non-monetary incentives, but found them less effective than money, while the same literature is not supportive of post-incentives of any form. In general, one could conclude from this that the general survey literature would rank monetary pre-incentives as the most effective, followed by non-monetary pre-incentives, and then, as least effective, by

[24] Informal presentation made to the mid-year meeting of the TRB Committee A1D10 on April 22, 2001 by David Pearson of TTI.

any form of post-incentive. The transportation profession appears to remain generally unaware of this and post-1995 surveys have still offered post-incentives, and also offered non-monetary incentives.

In spite of the findings of Tooley (1996), it yet remains unclear how much of an effect incentives have on response rates from surveys, because of the lack of controlled experiments. A major problem here is that comparisons of different incentives are confounded by design differences in the surveys, differences in publicity, survey technique, etc. There are only two known cases in which comparisons have been made of incentives for the same instrument and same population, both of which occurred in pilot tests (Stopher, 1992; Goldenberg *et al.,* 1995). In these cases, there were clear indications that incentives improved response rates, although it must be noted that, here again, other design changes may have had effects on the results obtained. Zmud (2003) provides more concrete evidence, however. She states:

> "One of the most compelling principles is reciprocation. The rule requires that one person try to repay, in kind, what another person has provided. Cialdini said the rule is extremely powerful, often overwhelming the influence of other factors (Cialdini *et al.,* 1975). This principle underlies the large literature that finds consistent positive effects of incentives on survey cooperation. Monetary incentives for participation have long been used in surveys, including both pre-paid and promised incentives and contributions to charity. Kropf *et al.* (1999) conducted an incentive analysis using the survey administration opportunity from an annual National Omnibus telephone survey. They found, as have other researchers, that a pre-paid incentive is more effective than the promise of an incentive. Offers of a charitable contribution did not appear to motivate participation in the survey. Self-interest, as noted by Dillman above, is a very compelling factor in survey participation." (Zmud, 2003, p. 93)

Similarly, Kalfs and van Evert (2003) discuss the use of incentives as a means to reduce unit nonresponse. They note that response rates to postal surveys can be increased significantly if incentives are offered (Dillman, 1991). They also note that financial remuneration generally works better than other incentives, such as gifts, although gifts tailored to specific target populations, or ones that are related in some way to the survey objectives are an exception to this rule. They also note that incentives provided in advance work better than those that are promised in return for a completed survey. Importantly, Kalfs and van Evert (2003) note that, if the value of the incentive is too high, it will have an adverse effect on response.

Dillman (1978) has explained that these results come about because people will respond if the psychological costs and benefits are in balance. "[T]he social standard of reciprocity only works if the gift or favor received is seen as fair; if it is seen as an attempt to coerce the respondent, make him feel guilty, or bribe him, the gift has an adverse effect." (Kalfs and van Evert, 2003). There is also reciprocity in that interviewers who know that they can do something nice for respondents are more likely to be assured and convincing in their approach to potential respondents. They are more persuasive.

While Kalfs and van Evert (2003) refer principally to postal surveys, they also note that incentives are used frequently in face-to-face surveys, while their use in telephone interviews (with no postal component) has been rare and there is no literature on the effects. Of course, in such surveys, an advance incentive will not normally be possible.

It is quite clear that consistency on incentives would be helpful. Standardization should address whether or not incentives should be offered, whether incentives should be pre- or post-incentives, and what form incentives should take. Consistency would also be useful on how to present the incentive to prospective respondents, because Tooley (1996) points out that the wording used in offering a pre-incentive is almost as important as the incentive itself. She suggests that the incentive be provided explicitly in return for the respondent completing and returning the questionnaire, rather than in appreciation for the respondent's time and effort in completing the survey.

Incentives are clearly cost-effective, even when only modest gains are obtained in response rates. As an illustration, consider the following case. Suppose a survey recruits 6,000 households, which comprise 15,000 individuals, and a $2 incentive is paid to each recruited individual. This will cost $30,000. If the average cost of a completed household survey is $200, the incentive would need to change only 150 households from refusals to responses to pay for itself. Furthermore, in the context of a survey that may cost $600,000 or more, expenditure of $30,000 on incentives is a small amount to pay to assure a higher response rate.

An alternative way to see the value of incentives is to consider the recruitment requirements. Suppose that, without incentives, 40% of recruited households will respond, while 45% will respond with an incentive. Suppose that a final sample is required of 3,500 households. With a 40% response rate, this will require 8,750 households to be recruited, while the 45% response rate will require 7,780 households to be recruited. Assuming that recruited households that do not respond cost approximately $25 per household to contact and attempt to complete, the non-incentive recruitment will cost $24,250 more than the incentive-based recruitment. The cost of a $1 per person incentive in the latter case will be on the order of $19,500, representing a savings of $4,750. In addition, there are further savings from a probably less-biased response of 45% compared to 40%. Furthermore, these figures are very conservative, since anecdotal reports suggest that the increased response rates may be closer to 10-25 percent higher with incentives than without, and the estimated cost of a recruitment that fails to yield a survey could be much higher if ten or more attempts are made to collect the data from non-responding households.

Recommendations for consistent approaches to incentives are given in section 2.2.8 of the Final Report.

5.9 RESPONDENT BURDEN

5.9.1 Definition

Respondent burden is both tangible and intangible. In tangible terms, it can be measured as the amount of time, cost, etc. that is involved in a respondent complying with the requests of a survey. It could also be measured in terms of the number of times a respondent is contacted and asked to provide information. The intangible aspects of respondent burden are much less easily measured, and may be subsumed under the general title of perceived burden.

There is general agreement that efforts should be made to reduce the data collection burden for respondents to travel surveys. There is less agreement as to what constitutes respondent burden, and how reductions in burden may be achieved. Respondent burden is examined here in terms of the measured burden (amount of time, cost, etc. to complete a survey) and the perceived burden. Thus, standardized procedures are needed on how to measure burden and on how much burden is too much.

5.9.2 Assessing Respondent Burden

Measured Respondent Burden

The Paperwork Reduction Act (PRA) of 1995 says that a United States federal agency may not conduct or sponsor the collection of information unless the agency has submitted, in advance, material to the Office of Management and Budget (OMB) certifying that the proposed data collections “reduce burden to the extent practicable” and “use information technology to reduce burden and improve quality.” According to OMB guidelines (OMB, 2004), respondent burden is defined as the “time, effort, or financial resources” expended by the public to provide information to or for a federal agency, including:

- "Reviewing instructions;
- Using technology to collect, process, and disclose information;
- Adjusting existing practices to comply with requirements;
- Searching data sources; completing and reviewing the response; and
- Transmitting or disclosing information." (OMB, 2004)

Burden is estimated in terms of the "hour burden" that individuals expend in filling out forms, and in terms of the "cost burden" derived from electronic recordkeeping and reporting.

Of the larger household travel surveys conducted in the United States within the past decade, only the National Household Travel Survey (NHTS) has undergone a review by OMB. NHTS estimated the total reporting and record keeping burden per household at 52 minutes: 8 minutes for the household interview (screener); 30 minutes per household for the person level interviews (assuming 2.5 persons per household at 12 minutes each); plus 14 minutes of record keeping and recording odometer readings NHTS (2001f).

For travel surveys conducted using CATI systems for recruitment and retrieval, it is possible to obtain the actual average duration of the telephone calls. Table 68 presents the average duration (in minutes) of the telephone calls in some of the more recent travel surveys that have used telephone for both recruitment and travel diary retrieval. Of the surveys represented, the average household respondent burden varied from 32.6 minutes in the 2001 California Statewide survey, to 77.1 (estimated) minutes in the 1996 Dallas-Fort Worth survey. The 2001 NHTS was estimated to actually require 41.8 minutes per household (based on average household size) for the telephone portion.

Table 68: Measured Respondent Burden in Terms of Average Call Duration, for Telephone Recruitment and Retrieval

Survey	*Recruitment/ Screener Call*	*Reminder Call*	*Retrieval Call*	*Total Call Portion of Respondent Burden (per household)*
2001 NHTS	7.8	Not Reported	14.8 minutes per person (Using 2.3 persons/ useable household, estimated total household time: 34.0 minutes)	41.8 minutes[25] [26]
2001 California Statewide Survey	15.6	Not reported	17.0 minutes/household	32.6 minutes[24]
2002 Regional Transportation Survey, Greater Buffalo-Niagara Regional Transportation Council	21.2	Not reported	25.5 minutes/household	46.7 minutes[24]
1996 Dallas-Ft. Worth Household Travel Survey	8	3.6	33.4 minutes for household info; plus 13.2 minutes per person (Using 2.4 persons/household retrieved, estimated total household time: 65.5 minutes)	77.1 minutes

Ampt (2000) has suggested that respondent burden is more than just the measured burden in terms of minutes but that it depends on the "perceived difficulty" of a survey and, as a perception, can vary for different people. She suggests that response burden is perceived as being less when:

[25] Does not include reminder call average duration.

[26] Does not include separate calls to household to collect odometer readings.

- The respondent has greater influence in choosing the time (and perhaps the place) to complete the survey;
- The survey topic or theme is important or relevant to them and/or their community;
- The questionnaire design is as simple as possible, to minimize perceived difficulties (physical, intellectual, and/or emotional);
- Negative external influences (other people) are avoided, and/or positive external influences are enhanced; and
- The survey appeals to the respondent's sense of altruism.

Perceived Respondent Burden

Many of the suggested approaches to reducing perceived respondent burden are addressed directly or indirectly in other sections of this report. These include such measures as providing respondents with information about the importance of the survey topic and designing the questionnaire layout and wording to be as simple as possible.

Among the key suggestions is to provide for a variety of response options (mail-back, telephone, in-person, Internet) so that respondents can direct the how and when of completing the survey. Recent household surveys have offered respondents the option of mail-back, telephone, or Internet retrieval. The option of in-person has almost completely disappeared in the United States, usually because of cost and security considerations. It must be noted that in-person is, however, still the preferred method in several countries such as New Zealand, Australia, and the U.K.

Methods of Reducing Measured Respondent Burden

The methods proposed specifically to reduce measured respondent burden include:

1. Reduce the number of questions (Murakami, 2000). This is the simplest method of reducing respondent burden, and yet the one that is used the least. In many of the recent household surveys, the respondent burden has been increased by asking for multiple days of travel instead of one, or asking for detailed information about in-home activities instead of simple trip purpose. While these may be fascinating data, respondent burden can be viewed as the fulcrum between more data and higher response rates.
2. Reduce the sample size. This has the effect of reducing the respondent burden as measured across all respondents, but not necessarily reducing the burden on any given respondent.
3. In CATI retrieval, use automated techniques such as "trip rostering" to reduce the need to ask the same questions of all household members. Trip rostering involves collecting information regarding trips for household members who traveled together during the travel day (or survey period) in detail from only one household member. The trip would be entered into a "roster," and for the other household members participating in the same trip, the interviewers would merely confirm that the household member had indeed made that same trip. The full trip detail would then later on be copied into each household member's trip record. The 2001 NHTS uses trip rostering (NHTS, 2001f).
4. Use split questionnaires, where each respondent is only asked a statistically selected subset of the overall survey. This approach has been successfully used in studies of education and health-care, but has not been used in household travel where the insistence has been on full data from each household or respondent. The most predominant use of this approach has been in stated preference surveys, which have generally been focused on asking about perceived travel.
5. Use administrative or census data to impute or estimate non-travel household characteristics instead of asking respondents. For example, instead of asking a series of questions to elicit

household income, census data could be used to derive an expected income level for households within a defined geographical area.

6. Use the variability in travel patterns from previously conducted surveys to model statistically the travel for different types of households. This is similar to the second option above in suggesting the use of smaller samples, but goes further in suggesting that not only are large samples not necessary, but that perhaps the collection of additional primary travel data is not necessary. Using statistical modeling techniques on the vast array of household travel data already collected, both travel patterns and the variability therein could be closely estimated.

The last three options for reducing the time incurred by the participants in responding to household travel surveys may require additional research before they can be fully implemented.

Respondent burden, whether measured or perceived, is widely regarded as one of the key factors contributing to the decline in response rates to travel surveys. While many of the standards discussed in this report may assist in reducing the perceived respondent burden, it is impossible to recommend a standard for measured response burden. Until there is further evidence, it is impossible to suggest that no survey require more than, for example, 40 minutes per household from respondents. Accordingly, the recommendation for standardized procedures focus on the need for consistent reporting of measured respondent burden. These are provided in section 2.2.9 of the Final Report.

CHAPTER 6

6. Pilot Surveys and Pretests

6.1 P-2: REQUIREMENTS FOR PRETESTS OR PILOT SURVEYS

6.1.1 Definition

Pretests and pilot surveys are the process of testing various aspects of the survey design, protocol, instruments, analysis, etc. on a small sample of the population, prior to fielding the main survey. The intention of pretests and pilot surveys is to determine whether or not everything in the intended survey will work and produce the expected results. In some instances, pretests or pilot surveys may be conducted to compare two or more methods for some element of the survey process, and to determine which to choose. In other cases, there is no comparison test involved, although it may be anticipated that some refinements to elements of the survey process will result.

6.1.2 Review and Discussion

Various reviews of travel surveys showed that carrying out pilot surveys or pretests is by no means a universal practice. Yet, evidence shows that when pretests or pilot surveys are carried out, they usually lead to changes and improvements in the survey instrument or procedures. It appears that many agencies commissioning surveys are unaware of the importance of pretests and pilot surveys, and that neither time nor budget is usually provided for these activities. As a consequence, there are a number of cases in which data have been collected at considerable cost, only to be found to be inadequate for the intended task. Given the expense normally associated with a household travel survey, this is a serious problem, representing a substantial waste of public resources, and usually making it impossible to collect additional data in that region for that purpose for some years into the future.

Although it is unlikely that thirty or forty years of mislabeling can be corrected by the results of this project, it is worthwhile to distinguish between a pilot survey and a pretest. The two terms are used interchangeably in the transportation profession. However, the survey literature distinguishes between them in that a pretest is a test of one or a few elements of the survey, usually without testing other elements, while a pilot survey is a complete run through of the survey (i.e., a dress rehearsal), including analysis of the results. In general, a pretest is necessary when any element of a survey has been changed from an earlier version that has been applied to essentially the same population. A pilot survey should usually be done each time a new survey is designed, or a survey performed on one population is to be performed on another population. It is most important to note that, when the pilot survey reveals the need for significant changes to one or more elements of the survey, the changed elements should be pretested again before full fielding of the survey.

The fact that pretests and pilot surveys are not routinely included in the study design, schedule, and costs, and the fact that such failures often lead to some level of failure of the main survey, demonstrates that a standard is required that would specify that pretests or pilot surveys are normally to be done, and that may specify under what circumstances this step might be skipped. Yates (1965) states, in reference to the questions that should be answered at the planning stage of censuses and surveys:

> "If prior knowledge in these matters is not available a *pilot* or *exploratory survey* will be necessary. Even if there is adequate knowledge of the statistical properties of the material, pilot surveys are frequently advisable in large-scale surveys in order to test and improve field procedure and schedules, and to train field workers." (Yates, 1965, pp.48-49)

Cochran (1963) similarly states:

> "It has been found useful to try out the questionnaire and field methods on a small scale. This nearly always results in improvements in the questionnaire and may reveal other troubles that will be serious on a large scale, for example, that the cost will be much greater than expected." (Cochran, 1963, p.8).

Kish (1965) also states:

> "To design efficiently a large sample in an unknown field, *a pilot study may be conducted prior to the survey, to gain information for designing the survey.*" (Italics in original, p. 51)

Yates (1965, p.99) goes on to describe some of the roles of pilot surveys, and specifies these as:

- Providing information on the various components of variability within the subject population;
- Development of fieldwork procedures;
- Testing questionnaires;
- Training interviewers;
- Provision of data for estimating survey costs; and
- Determining the most effective type and size of sampling unit.

While these authors of basic texts in Survey Design do not specify that pilot surveys *must* be undertaken, taken together, these statements clearly indicate that pilot surveys should be considered to be essential unless there is considerable prior survey research experience with the subject population. They also indicate that large-scale surveys need pilot surveys. While large scale is never defined in these texts, the type of survey usually undertaken in a metropolitan region, where the sample is several thousand households, probably meets the implied definition of a large-scale survey.

Dillman (2000) states "Pilot studies frequently result in substantial revisions being made in the survey design, from adding additional contacts or an incentive to improve response rates, to eliminating or adding survey questions." (pp. 146-147). The AAPOR Quality Guidelines as quoted by Biemer and Lyberg (2003) have, as their sixth point, the following:

> "6. Pretest questionnaires and procedures to identify problems prior to the survey. It is always better to identify problems ahead of time rather than in the midst of the survey process." (p.364)

Biemer and Lyberg (2003) also introduce some differences in their definition of the terms relating to pilot studies, pretests, etc. They define pretests as "…small studies using informal qualitative techniques…" that are used to acquire information that helps in the design of the survey. They define pilot surveys as surveys "…to obtain information that can improve the main survey." They then define *Dress Rehearsal* as "…a miniature of the main survey, conducted close to the main survey to reveal weaknesses in the survey design…" and generally to perform those functions described previously in this section for a pilot survey.

A further type of preliminary test is a *rolling pilot survey* (Pratt, 2003). This is defined as using the first two or three days of surveying to ensure that the survey is proceeding as intended. Minor adjustments can often be made at this stage, whether to survey instruments, procedures, or other aspects of the survey. This is particularly useful when both time and money are limited, and a full pilot survey cannot be undertaken. Depending on the extent of changes that are made at this point, the surveys from these first few days may still be used in the main survey, or may be discarded, with a subsequent adjustment of the final sample size.

There are limited circumstances under which a pilot survey or pretest could be considered unnecessary. A full pilot survey is unnecessary only when the survey being conducted is essentially unchanged from one that has been conducted successfully in the past, so that instruments, sampling procedures, protocols, analyses, and reporting from the survey are essentially the same as another survey and that the population on which the survey is to be conducted is similar in most respects to the population on which the survey has been conducted previously. Under these circumstances, it can be assumed that the correct questions, phrased in appropriate ways, are already included in the survey, that it is known that the analysis of results will work with this design, and where there are no new difficulties in drawing the sample, recruiting respondents, etc. Under these circumstances, a pretest is also not necessary. Yates (1965, p.99) also states that pilot surveys will not normally be required for surveys of populations "…on which there is considerable previous survey experience." While his focus was largely on agricultural surveys, where the population may remain unchanged for many years, it is necessary to keep in mind that human populations may undergo substantial change in relatively short periods of time, so that a survey at a location ten years ago does not provide the "considerable previous survey experience" noted by Yates.

It is, of course, of value to point out that, in the rare event that a pilot survey or pretest leads to no substantive change in design, the data collected could become part of the main survey data, provided only that the sampling for the pilot survey or pretest has been done in a way that is consistent with the main survey and will not add bias to the overall sample. Recommendations on standardized procedures for Pilot Surveys and Pretests are provided in section 2.3.1 of the Final Report.

6.2 P-3: SAMPLE SIZES FOR PRETESTS AND PILOT SURVEYS

6.2.1 Description

As defined in the preceding section, pretests are tests of one or more individual components of the survey process, while pilot surveys are a complete run through or dress rehearsal of the survey. Because it was recommended that pretests and/or pilot surveys be conducted in all future travel surveys, it is appropriate to establish the required sample size of these initial tests or surveys.

6.2.2 Analysis

In the Atlanta Household Travel Survey, one of the questions asked of the panel of experts that was overseeing the project, was what sample size should be adequate for the pilot survey. The decision made was to use a sample of 50 households. There was no unanimity of the transportation experts on the panel on the sample size. In contrast to this decision, the NPTS in 1995 used a pilot survey sample of over 2,000 households for what was eventually a 42,000 household survey. Similarly, the 2001 NHTS used a pilot survey sample of 2,740 households for the eventual 69,817 households survey. These recent experiences highlight the need for guidance on the sample sizes required and the rationale behind them. There is, in fact, little guidance in the literature on this. Biemer and Lyberg (2003) note that "The design

and use of pilot studies are sadly neglected in the survey literature." Further, they state "The same casual treatment that pilot survey design has received in the literature is also seen in the surveys themselves." However, having said this, and because Biemer and Lyberg are not writing about survey design, *per se*, they do not suggest what might be appropriate sample sizes.

It seems likely that the sample sizes needed for true pretests – that is, the testing of a single element of a survey, such as a redesign of certain questions – would be able to be done effectively with a very small sample of households, such as 25 to 50 households. However, before adopting such a sample size range, it is necessary to see if there is anything in the general survey literature that addresses the issue, or provides any guidance on the size of pretest samples. If not, then a rationale needs to be found for specifying the sample size. For pilot surveys, it would seem likely that a larger sample should normally be necessary. Again, however, a rationale for this is needed. It appears that present practice in choosing such sample sizes is no more than a "thumb in the air."

This topic addresses not only the size of the samples required for pretests and pilot surveys, but also the composition of the sample and how the sample should be drawn. There are no clear statistical procedures for determining the sizes of samples for pretests and pilot surveys. Clearly, the first issue must be one of what is desired from conducting the pretest or pilot survey. Since this will vary from survey to survey, it is possible that no standard can be set, but only guidance offered. However, some fundamentals can be considered here. Kish (1965) notes that "If the pilot study is too small, its results are useless, because they are less dependable than the expert guesses we can obtain without it." (p.51). Dillman (2000) suggests that a pilot survey should have a sample size of 100 to 200 respondents in general, and notes that the size may be larger than this, if resources allow. He also states that "…entering data from 100-150 respondents allows one to make reasonably precise estimates as to whether respondents are clustering into certain categories of questions." (p.147).

Another important area to consider here is how the samples are to be drawn for pilot surveys and pretests. It is clear that we do not wish to survey the same households in the main survey as were surveyed in the pretests or pilot survey. To do so would generally produce an unacceptably low response rate and would also be likely to cause significant adverse publicity for the survey. Therefore, those households that are used in the pilot survey and/or pretests should be excluded from the main survey. If, however, these samples are drawn at the outset of the study, and are then excluded for the drawing of the main sample, a bias has been introduced. Random sampling which is essential for representativeness of the sample, requires that all households have an equal probability of being sampled. If households used in the pilot survey or pretest are excluded, then representativeness is compromised, even if only slightly.

To avoid any possibility of compromising the main survey, the main sample should be drawn first. Then the pretest samples and pilot survey sample can be drawn from those households not included in the main survey. There is a problem, of course, in this if one of the purposes of the pretest or pilot survey is to gauge nonresponse levels and determine the size of the needed recruitment sample. In this case, the potential to bias the sample is probably unavoidable. In all other cases, however, the pretest and pilot samples should be drawn after the main survey sample. In those cases where this cannot be done, great care should be taken to draw the pretest or pilot survey samples in a completely random process and to exclude all attempted households, irrespective of outcome from further consideration in the main sample.

For example, a pretest is often desired to find out what the response rate will be. One might ask if a sample of 50 attempts is sufficient to determine this. Let us suppose that, using 50 telephone numbers, an attempt is made to recruit households to undertake the survey. Suppose that 20 households agree to be recruited, representing a recruitment rate of 40%. We can ask what the confidence is that the actual recruitment rate will be 40%. The sampling error on this figure will be ±7%. This means that, with 95 percent confidence, the recruitment rate will lie between 26 and 54 percent. This is probably not very adequate. Furthermore, if 8 households actually complete the survey, representing a response rate of 40 percent of the recruited households, this would lead to the statistical conclusion that the response rate in the main survey from the recruited households would range, with 95 percent confidence, from 17 to 63 percent. Thus, with a final total response rate from attempted households of 16 percent (40% times 40%),

the pretest on 50 households would indicate that, with 95 percent confidence, the overall response rate would appear to lie between 4 percent and 34 percent. Supposing that the survey firm has performed the pretest in order to determine how many samples to draw for recruitment, and that a final sample of 3,500 households is required, then this result would define that the number of households that must be drawn in the sample would range between 10,300 and 87,500. This seems unlikely to be of sufficient precision to benefit the survey design.

In this same example, suppose that the number of households sampled for recruitment was increased to 250, with the same 40% response rate, followed by a further 40% response rate for completion of the survey. This would result in 40 households completing the survey. Now the 95% confidence figures on the response rates change to a recruitment rate of between 34 and 46 percent, and a completion rate of between 30 and 50 percent. The overall response rate would now appear to lie between 10 and 23 percent. With the same overall sample aim, the number of households to draw for the recruitment would range between 15,250 and 35,000. In this case, the survey firm may opt for the most conservative figure and purchase a sample of 35,000 households. This result is clearly much more useful to the survey firm than in the prior case, where the conservative figure would be to purchase a sample of 87,500 households.

We perform similar computations to determine the minimum sample sizes that are likely to be required in order to answer certain typical questions that are usually asked as part of a pretest or pilot survey. This includes estimates of the average household trip rate and its sampling error, in order to confirm the sample size, determining the expected response rate and hence the total recruitment sample size needed, as well as providing information on how well various questions are answered, how well procedures work, and whether or not analysis can be completed as desired. For example, suppose that one of the items being tested is a question on household income, and it is decided to use the item non-response rate as the measure. Similar computations to those reported in the preceding paragraphs could be done using whether or not a response was obtained to the income question for computing sampling error and a 95 percent confidence on the outcome.

The minimum sample sizes required for different possible outcomes from a pilot survey or pretest are shown in Table 69. These sample sizes are all based on the assumption that the relevant statistic of concern to the pretest or pilot survey is to be known with the specified level of accuracy at a 95 percent confidence level. If the confidence level is lowered to 90 percent, the sample sizes reduce, while they increase if the confidence level is raised to 99 percent or higher.

Table 69: Sample Sizes Required for Specified Levels of Accuracy

Measure	*Assumed Value*	*Desired Accuracy*	*Sample Size*	*Measure*	*Assumed Value*	*Desired Accuracy*	*Assumed Variance*	*Sample Size*
Response Rate	50%	±5%	384	**Household or Person Trip Rate**	10	±1	100	384
	50%	±10%	96		10	±2	100	96
	50%	±15%	43		10	±3	100	43
	50%	±20%	24		10	±4	100	24
	60% or 40%	±5%	369		10	±1	50	192
	60% or 40%	±10%	92		10	±2	50	48
	60% or 40%	±15%	41		10	±3	50	21
	60% or 40%	±20%	23		10	±4	50	12
	75% or 25%	±5%	288		7	±0.5	70	1076
	75% or 25%	±10%	72		7	±1	70	269
	75% or 25%	±15%	32		7	±1.5	70	120
	75% or 25%	±20%	18		7	±2	70	67
Nonresponse to a Question	10%	±3%	384		7	±0.5	50	768
	10%	±5%	138		7	±1	50	192
	10%	±8%	54		7	±1.5	50	85
	10%	±10%	35		7	±2	50	48

	20%	±3%	683		4	±0.4	40	960
	20%	±5%	246		4	±0.8	40	240
	20%	±8%	96		4	±1	40	154
	20%	±10%	61		4	±1.5	40	68
	30%	±3%	896		4	±0.4	16	384
	30%	±5%	323		4	±0.8	16	96
	30%	±8%	126		4	±1	16	61
	30%	±10%	81		4	±1.5	16	27

To use Table 69, the following example is provided. Suppose a pilot survey is to be done in which it is desired to determine the response rate to within ±10 percent accuracy, where it is expected to be 40 percent, to determine the non-response rate to the income question to ±5 percent, when it is assumed that the level will be 20 percent, and to estimate the household trip rate, expected to be around 10 with a variance of 100, to within ±2 trips per household per day. Entering the table first for the response rate, this shows the need for a pilot survey sample of 92 completed households. Entering the table for the income nonresponse yields a sample size of 246 households, and for the trip rate, a sample size of 96. The critical element proves to be the non-response to income, which requires a sample size of 246 households.

If we now suppose that, based on this, and the scarcity of resources, it is decided instead to reduce the desired accuracy on the non-response to income to ±8 percent, then the sample size for this is seen to be 96, which is the same as that for the trip rate, and only slightly larger than that required for the response rate. Based on this, the decision would be to obtain a completed sample of 100 households, which, assuming the response rate to be 40%, would require contacting and attempting to recruit a total of 250 households.

Recommended approaches to sample size estimation for pilot surveys and prestests are to be found in section 2.3.2 of the Final Report.

CHAPTER 7

7. Survey Implementation

7.1 E-2: ETHICS

7.1.1 Definition

Ethics describe minimum acceptable standards of conduct or practice. In travel surveys, this relates to how a survey agency conducts itself with respect to those interviewed, the client, any subcontractors, and the public as a whole. It also relates to a survey agency's actions following the data collection process when data are cleaned, coded, analyzed, and archived.

Ethics reflect what all stakeholders may consider "fair" or "reasonable" conduct by those involved. In practical terms, the application of ethics involves implementation of precautions to protect those affected from adverse effects. Ethics protect the rights of individuals and groups and serve to reduce public disapproval and criticism of what is done.

7.1.2 Review of Survey Ethics

Several survey research associations have established regulations, codes of practice, guidelines, or ethical standards that their members are expected to maintain (CASRO, 1997; ESOMAR, 1999a; MRA, 2000a). However, there is no assurance that members of these associations abide by these standards. In addition, while the ethical standards are similar among these associations, they are not identical, meaning that there is no standard code of conduct in the travel survey industry. Establishing a standard code of conduct that would apply to the entire travel survey industry, would:

- Bring all future travel survey practice under a single, uniform standard;
- Provide a reference that survey respondents, survey clients, and survey practitioners can refer to, evaluate, and update;
- Facilitate publicizing the standard; and
- Make it easier for organizations commissioning travel surveys to require that surveys comply with these standards.

Recommended ethical conduct is described in section 2.4.1 of the Final Report.

7.2 E-3: MAILING MATERIALS

7.2.1 Background

Most surveys involve some activity of mailing materials to respondents, whether this is just an initial contact letter telling about the survey to be done, the sending of recruitment materials, or the full survey form. There is evidence to suggest that the materials used to mail to households, as well as materials for households to mail back, have an effect on response rates. Some survey practitioners

maintain that the appearance of mailing materials is of considerable importance for households to take a survey seriously (Dillman, 2000). This is particularly relevant in North America, where the amounts of "junk mail" received by most households has become excessive, and anything that appears to be another item of such junk mail is likely to be discarded without being opened.

7.2.2 Discussion and Review of Literature

Both the survey profession and the direct mail advertising industry are facing the problem of declining response rates. In the direct mail advertising business, industry publications and journals have devoted a fair amount of space to discussing the benefits of appearance (Cavusgil and Elvey-Kirk, 1998; Vriens *et al.,* 1998; Graham, 2002; Selzer and Garrison, 2002). Figure 9 shows the interrelationships between the motivating constructs to response behavior and their operationalization. These are the basis for the following set of questions (and potential solutions written in italics in the parentheses that follow):

- Does the mailing have eye appeal? Will the recipient take it seriously or will the recipient discard it in the same way as cheap and poorly-presented junk mail? *(envelope type, personalization)*
- Does the mailing create the right impression with regard to content and origin of the enclosed content? *(source, envelope type, postage)*
- How is the material being mailed to the recipient? Are the materials being mailed out as bulk mail, or rather first class or express mail? *(postage, envelope type)*
- How easy is it for the recipient to respond? Does the package contain a prepaid return envelope? Does the survey participant have the opportunity to respond in any other form, e.g., faxback forms, web-interface or a toll-free number? *(follow-up, postage)*

The suggested solutions above were drawn from what has been observed to work in practice as documented by Dillman in his two books, *Mail and Telephone Surveys; The Total Design Method* (Dillman, 1978), and *Mail and Internet Surveys; The Tailored Design Method* (Dillman, 2000). For example, it is suggested that letterhead stationary is important because it is integrated with personalization and this may evoke feelings of importance. These feelings, together with the acknowledgement that researchers have taken some effort to select and contact these households, may make respondents feel comfortably obliged to participate in the survey. This is otherwise referred to as reciprocity, which is believed to have a positive effect on response rates (Kalfs and van Evert, 2003; Zmud, 2003).

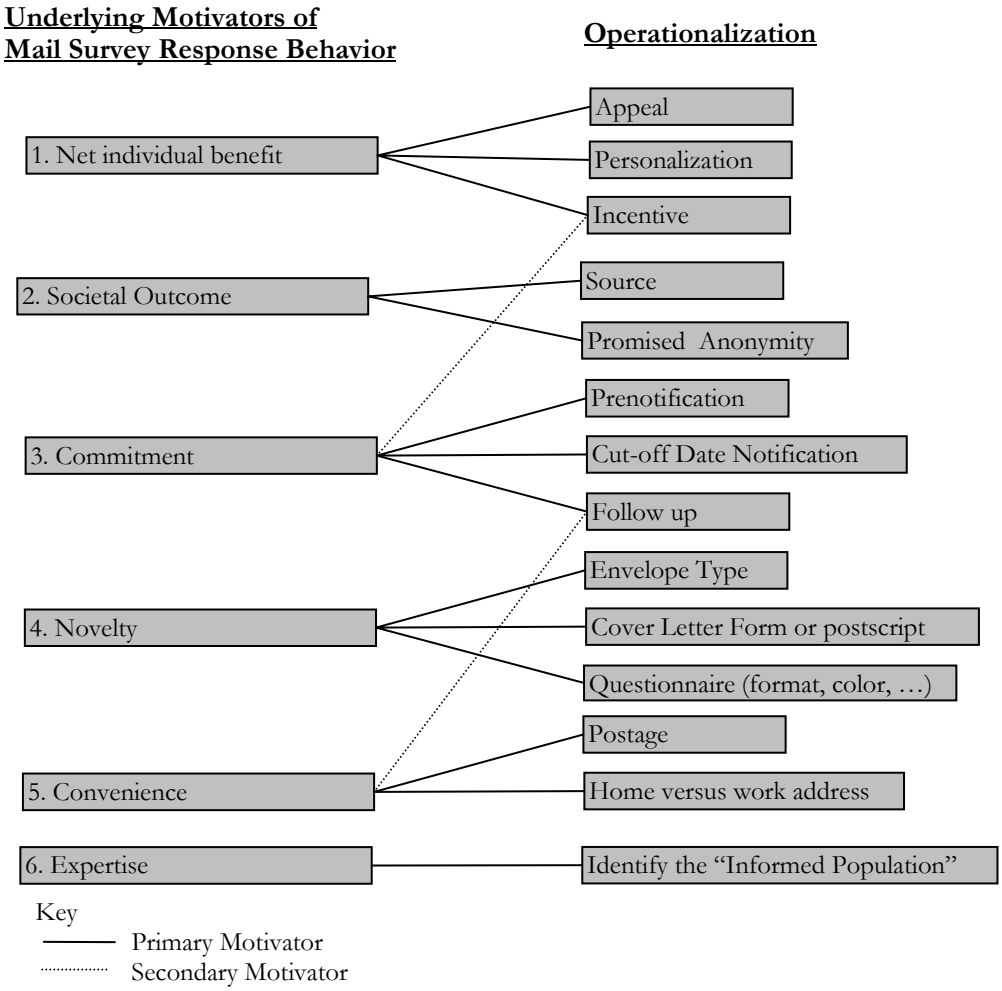


Figure 9: Motivators of Mail Survey Response Behavior and their Operationalization

Source: Cavusgil and Elvey-Kirk (1998)

The appearance of the mailing package should not resemble marketing material. For example, it should not be overly colorful so that on first glance it is confused with "junk mail". On the other hand, Dillman (2000) has suggested that unusual packaging will draw attention to the package, but states that the color of the outer envelope should be white or off white. Postage stamps should be unique or commemorative (not bulk mail or pre-printed bulk-mail) because this reinforces personalization and heightens the novelty motivator (Dillman, 1978; Cavusgil and Elvey-Kirk, 1998). This is also related to the use of stamped return envelopes which, in turn, is interrelated with the convenience motivator (Cavusgil and Elvey-Kirk, 1998; Dillman, 2000).

Recommendations for mailing materials are provided in section 2.4.2 of the Final Report.

7.3 E-4: RESPONDENT QUESTIONS

7.3.1 Introduction

In virtually any travel survey, respondents have concerns regarding the legitimacy of the survey and those conducting it. While some of these concerns may be addressed in a cover letter, the typical survey has more nuances than may be explained in a single (or even double) page letter. The state of the practice has evolved three methods for respondents to verify the survey, and obtain answers to frequently asked questions. These include the use of a:

- Telephone Contact Number;
- Informational Brochure, with Frequently Asked Questions (FAQs); and
- Internet Web Site.

The use of each of these methods to answer respondent questions, and the potential to standardize aspects of these methods, are discussed below.

7.3.2 Elements for a Consistent Approach

Telephone Contact Number

As respondents find the typical list of questions asked in a travel survey to be more and more invasive, it is essential that the legitimacy of the survey be established. In addition to stating the authority under which the survey is being conducted in the cover letter, it is essential that respondents be provided with at least two telephone contact numbers: one for the sponsoring agency, and one for the data collection entity.

The purposes of the telephone number for the sponsoring agency are threefold:

- To provide a direct line to a designated employee of the sponsoring agency (survey spokesperson) who is knowledgeable about the survey effort and who can address public concerns regarding the survey (and survey firm's) legitimacy;
- To provide answers to basic respondent questions regarding how to complete the survey; and,
- To serve as a quality assurance mechanism to address complaints (if any) regarding the survey staff.

This telephone number should ideally be toll-free to all potential respondents in the survey area. However, a regular number to the designated employee's desk is equally effective, because most of the respondents are likely to be local and thus not incur large long-distance charges. Care must be taken to ensure that the personnel who answer the main number for the sponsoring agency are informed about the survey so that they may route calls to the designated in-house spokesperson.

Some agencies have connected toll-free hotlines to a telephone answering system that permits brief messages regarding the survey to be played for callers, and then provides callers with a menu of options enabling them to listen to recorded messages with answers to frequently asked questions, record a message, or transfer to the designated survey spokesperson (DRCOG, 1998).

It has become standard practice for the survey data collection entity, whether inside the sponsoring agency or another contracted entity, to provide a toll-free telephone number for survey respondents to call for assistance in completing the survey. Respondents also use this number to call to request a change in travel days or to change a scheduled appointment for data retrieval. A summary of

hotline activity was presented in the *Dallas-Fort Worth Household Travel Survey Report on Survey Methods* (NCTCOG, 1996). The hotline received 621 calls over a six-month period. Of these, 66.5 percent were responding households indicating they had completed data collection and were awaiting a retrieval call. Another 10.8 percent of the calls were attempted refusals, which were referred to the survey data collection firm. Of the remaining calls, 7.4 percent were respondents with questions or requesting assistance.

Informational Brochure/Fact Sheet

Most household travel surveys conducted since the mid-1990s have included a separate informational brochure or fact sheet that contains frequently-asked questions and responses to them. The purpose of the brochure or fact sheet is to encourage respondents to participate in the survey, and to provide more detail than could otherwise be provided in a cover letter. This brochure or fact sheet is mailed out to respondents along with any other materials provided for respondents to use in the survey.

The frequently asked questions (FAQs) that have appeared on informational brochures or fact sheets include:

- Who is conducting this survey?
- What is the survey about? (Why?)
- How long does the survey take?
- How did you choose me? (How was I selected?)
- What kinds of questions will you be asking?
- Why are you asking about my income?
- Why are you asking for the names of people who live here?
- What if I don't travel much?
- What if I drive for a living?
- Why do you need to know where and how my children travel?
- What about privacy?
- Will we ever know the results?
- How do I get help in answering a question?

Much effort has gone into ensuring that the brochures or fact sheets are easy to read. Often, the brochure is a simple tri-fold, printed on both sides. Fact sheets are usually unfolded single sheets printed on one or both sides. Color and graphics are frequently used to help clarify a point, or brighten the display. Despite the prevalence of the use of informational brochures or fact sheets, there are no documented studies of their impact on response rate. Sample brochures available on the Internet include:

- National Household Travel Survey 2001 (NHTS, 2001d; NHTS, 2001e);
- 1997/98 New York Metropolitan Transportation Council's Regional Travel Household Interview Survey (RTHIS); and
- Perth and Regions Travel Survey, Government of Western Australia (PARTS, 2001).

Internet Web Site

Almost all of the major household travel surveys conducted in the United States within the past three years have provided survey respondents with one or more website addresses for the purposes of survey verification, frequently asked questions and, in some cases, on-line responding. Web sites may include pages that:

- Provide general information about the survey and survey status;

- List Frequently Asked Questions;
- Provide email addresses and telephone contacts for assistance or for further information;
- Provide the ability to download survey materials;
- Permit respondents to complete the survey on-line (in some instances); and
- If the web site is provided by the survey data collection entity, link to the websites of the sponsoring agencies (or agency).

There has been no systematic reporting to date (2003) of such web site usage. However, counters on various websites indicate an average of slightly more than 30 hits per month.

Standardized procedures for respondent questions may be found in section 2.4.3 of the Final Report.

7.4 E-5: CALLER ID

7.4.1 Description

Caller ID, Caller Line Identification, and Caller Display are different names for the service provided by many telephone companies that allows the customer to see the telephone number, and sometimes the directory listing, of the person who is calling. With the addition of Call Blocking, telephone customers may automatically block incoming telephone calls that do not permit the display of a telephone number. A recent industry survey estimated that 41 percent of all households in the United States subscribed to Caller ID (ATA, 2002). According to this study, age was one of the best indicators of whether a household subscribed to Caller ID services. Of those 18-24 years old, 57 percent subscribed to Caller ID, and of those 25-34, 54 percent subscribed. Only 26 percent of those 65 or older subscribed.

7.4.2 Impact on Surveys

In light of the general decline in telephone survey response rates, it is incumbent upon legitimate survey researchers to provide any information that may encourage responses from the full range of households. One of the primary uses of Caller ID is for households to screen out unwanted telephone calls by simply ignoring calls that do not display a known number or identity of the caller. In one telephone company study, nearly 70 percent of the company's Caller ID users reported that they considered the ability to screen calls the most important attribute of Caller ID, and 15 percent said they had not answered their phones based on information displayed on their Caller ID screen (Southwestern Bell Telephone, 1998). A more recent study (Tuckel and O'Neill, 2001) showed similar findings, with 33.2 percent of households reporting they were "frequent screeners."

Use of Caller ID to Screen Calls

The issue for transport surveys is whether households use Caller ID to screen out calls from survey researchers. A study by Link and Oldendick (1999) found that households that used Caller ID to screen calls tended to be younger, and from higher income levels than those that did not screen. However, they also found reported call screening behavior did not significantly increase the number of attempts or number of days needed to complete interviews with these respondents, nor was screening behavior significantly related to the likelihood of encountering a refusal before completion. They concluded that the increasing incidence of nonresponse to telephone surveys "does not appear to be driven by an increase in screening behavior..."

Caller ID Listing

It has been suggested that any impact call screening does have on response rates could be improved if the Caller ID were to display the name of the agency commissioning the survey, or even a name of state government, or other entity involved in funding or commissioning the survey. In a survey conducted through a state university, Link and Oldendick (1999) asked their respondents what was displayed as the Caller ID listing. They found that the university name was displayed for 14.7 percent of the calls, "state government" was displayed for 26.6 percent of the calls, and the remainder got no specific listing, just an "out-of-area" or "listing unknown" message. Of those who saw a particular listing, 17.6 percent of those who saw the university name, and 20.7 percent of those who saw the "state government" listing, said the listing made them more willing to answer the call. More of those who saw "out-of-area" or "listing unknown" said it made them more hesitant to answer (26.9 and 22.3 percent, respectively). However, in each case the majority indicated that the particular listing made no difference at all (64.2 to 76.5 percent). The study authors concluded that their survey was helped, at least marginally, by being identified as either "university" or "state government."

This raises the question of whether a household travel survey could be conducted so that the sponsoring agency's name appeared as the Caller ID listing. The technological (and legal) answer is that the caller listing must be the directory listing of the telephone that the call originates from. Technically, if all calls were routed through the sponsoring agency's telephone system via some very sophisticated routing, the listing that might appear to respondents would be that of the sponsoring agency. There was mention on the Internet of a market research survey conducted by a private survey firm in which the outgoing calls were routed through a private advertising agency, so the advertising agency's name came up on the Caller ID listing instead of the survey firm's.

Practically speaking, however, there are several reasons why this approach would not be fruitful for public or government agencies sponsoring travel surveys. First, most government agencies cannot accommodate such re-routing for security and legal reasons. Second, it is not a given that a specific Caller ID listing would consistently be displayed to all respondents. The listing displayed depends on the respondent's service level and equipment (not all display names along with number) and the vagaries of the long-distance telephone routing system. Long-distance routing may switch providers when lines become congested in order to maintain a certain level of line efficiency. The Caller ID listing that shows depends on the listing available in that provider's directory. Thus, the Caller ID listing displayed on a given respondent's telephone could differ for the same number, or could come up as "unknown" or "out-of area." Finally, some telephone firms route calls over 2 lines through Predictive or Power dialers, and these types of hardware do not "pulse out" digits that Caller ID devices can read.

Call Blocking

Many telephone companies offer their customers the option of electronically blocking the receipt of calls that are either not from a list of approved telephone numbers, or do not provide a telephone number. This service, which is referred to as "Privacy Manager" is a fairly recent call screening service that works with Caller ID to identify incoming calls that have no telephone number provided and which are identified as "anonymous", "unavailable", "out-of-area", or "private." The caller hears a message such as: "The person you are trying to reach does not accept unidentified calls. Your Caller ID was not received. To enter an access code, press 1. Or, to record your name so that we may announce your call, press 2." If the caller provides a name, the customer then has the option of taking the call, or rejecting the call with a message to either call back at another time, or a message warning that this number does not accept telephone solicitations.

To examine the extent to which such Privacy Manager devices impact survey response, data from the Bureau of Transportation Statistics (BTS) of the U. S. Department of Transportation were examined. BTS has been conducting a monthly, nationwide Omnibus Survey of customer satisfaction with

transportation issues. Detailed information on the call dispositions of each monthly survey is posted on the BTS website (BTS, 2002). Table 70 shows the percentage of eligible telephone numbers that were placed in the disposition category "Scope Undetermined" due to Privacy Manager devices and answering machines or voice mail in the six-month period from March through August, 2002.

As shown in Table 70, one percent of telephone numbers were categorized as "Scope Undetermined" due to the use of Privacy Manager devices in a six-month period. While data regarding the characteristics of households that use Privacy Manager devices was not found, the distribution has to reflect those who purchase Caller ID, because Caller ID is a prerequisite for Privacy Manager. Thus, the households that could not be reached in the BTS survey due to Privacy Manager were more likely to be disproportionately composed of younger persons.

Table 70: Percentage of Unresolved Telephone Numbers Due to Privacy Manager and Answering Machines/Voice Mail

	March, 2002	*April, 2002*	*May, 2002*	*June, 2002*	*July, 2002*	*August, 2002*	*Six Month Total*	*Percent of Eligible Numbers*
Telephone Numbers Dialed	3,511	3,645	3,871	3,559	3,512	3,339	21,437	
Eligible Numbers (Total Numbers Dialed minus Out-of-Scope Numbers)	2,778	2,834	3,006	2,953	2,622	2,450	16,643	
Scope Undetermined Due To:								
Answering Machine	331	355	473	438	82	50	1,729	10.4%
Privacy Manager	52	36	34	12	23	13	170	1.0%

Recommendations for standardization on caller ID are offered in section 2.4.4 of the Final Report.

7.5 E-9: ANSWERING MACHINES AND REPEATED CALL-BACK REQUESTS

7.5.1 Introduction

There are two related issues encountered by every telephone-based survey: first, when an answering machine is reached, does it assist completion rates if a message is left? Second, when a household requests an interviewer call them back at another time, is there a point beyond which repeated call backs do not increase completion rates? Each of these issues is discussed in the following section.

7.5.2 Discussion of Issues

Leaving Messages on Answering Machines/Voice Mail

There are several points in the typical telephone-based survey in which a potential household maybe contacted:

- During initial screening/recruitment;

- As a reminder in advance of their assigned travel day; and
- During the process of retrieving travel information.

A review of recent household travel surveys indicates that the practice of leaving a message when an answering machine was reached on the initial screening call varied, but that all left messages during the reminder and retrieval phases. While there has been no systematic study within the transportation field of the effectiveness of leaving a message on an answering machine in terms of impact on completion rates, there have been studies in other areas. The National Immunization Survey compared completion rates among households that had, and had not, had a message left in response to an answering machine (Kochanek, *et al.,* 1995). When examined across different time periods of survey implementation, the results were inconclusive with response rates fluctuating in different directions – sometimes in favor of leaving messages and other times, not. The authors concluded, however, that "when used properly, answering machines can achieve a higher cooperation rate."

Among transportation surveys, the practice appears to be to leave messages at least once during the initial recruitment/screening. The Bureau of Transportation Statistics (BTS), in their Omnibus Surveys (Bureau of Transportation Statistics, 2002), required interviewers to leave messages on answering machines the seventh, fourteenth, or twentieth time an answering machine was reached. The message included the call center's toll-free number to arrange for interviewing appointments. The rationale was that, given the dialing schedule, households with answering machines might be dialed two to three times per day, so that leaving a message on each call might contribute to potential respondents feeling "harassed." Thus, BTS left a message for the first time at the seventh call.

Other surveys have required a message be left on the third, and sometimes the first, contact with an answering machine (NuStats, 2003a). Anecdotally, there have been concerns raised over interviewers having to "start out on the defensive" after finally reaching a household where a message has been left (NuStats, 2003a).

On the recruitment/screening call, the structure of the message generally includes the name of the sponsoring organization, the nature of the survey and the purpose of the call. In transportation surveys, a toll-free number to call for participation is left very rarely, because experience has shown that only extremely rarely do households call to volunteer. It should be noted that this is not the experience in other types of surveys, particularly health care surveys, which routinely leave a toll-free number and recruit slightly less than one percent of their respondents through volunteers (McGuckin *et al.,* 2001).

Within the transportation survey arena, there are some data that speak to the effectiveness of leaving a message on an answering machine during the reminder call. In the Dallas-Fort Worth Household Travel Survey, of those households for which an answering machine message was left during the reminder process, 43.2 percent ultimately completed the survey (Applied Management and Planning Group, 1996). This was much higher than the completion rate of 32.1 percent for households that did not receive any reminder contact, as shown in Table 71. Once a household has been recruited, leaving messages when an answering machine is reached is routine during the retrieval process.

Repeated Call Back Requests

There are two types of call back requests. The first is an unspecified call back request, in which the person answering the telephone or the door (for a face-to-face interview) indicates that this is not a convenient time to respond to the survey, and requests that the interviewer call back at another time. No specific time is suggested. Of course, this may be a subtle refusal that is difficult to convert to a full response because repeated call back requests are not usually categorized as "soft" refusals.

Table 71: Survey Completion for Households Receiving an Answering Machine Message During the Reminder Call (Dallas-Fort Worth 1996 Household Travel Survey)

Type of Reminder Contact	*Number*	*Percent of*	*Percent Retrieved*

		Reminder Calls	*Completely*
Spoke with Household	6,051	67.5	49.2
Answering Machine Message	1,272	14.2	43.2
Other (Refused to participate, disconnected number, language barrier, etc.)	593	6.6	0
Attempted-No Contact	1,055	11.8	32.1
No Contact Attempted	427	--	30.2
Total:	9,398	100.0	

A recent study of non-response in the National Household Travel Survey (NHTS) pretest (McGuckin *et al.,* 2001) found that 24 percent of the households that requested a call back at least once eventually completed the survey successfully. Table 72 presents the final disposition of all households that requested a call back at least once during the survey process. This means, however, that in roughly three-quarters of the households, repeated requests for a call back are a form of "soft" refusal.

The issue then becomes: how many times should a household that has requested a call back be called? The survey protocol for the NHTS called for at least eight attempts (2001 National Household Travel Survey, 2003). BTS left call back attempts in excess of seven to the discretion of the interviewer based on his/her perception of the likelihood of completing the interview. The basis of the interviewer's perception was, in part, determined by how vigorously the interviewer was being encouraged to call back to complete the interview by the potential respondent or another member of the household.

Table 72: Of Households Requesting a Call Back, Percentage Completing Survey

National Household Travel Survey, 2000 Pre-Test

Final Disposition Once a Household Requested a "Call Back"	***Percentage of "Call Back" Households***
Completed	24.0
Refused	18.5
Requested another "call back"	47.3
Never spoke to the household again (ring/no answer)	10.2

In light of the general decline in telephone survey response rates, anything within reason that can be done to encourage response should be done. Unless or until there is clear evidence that leaving a message when an answering machine is reached does more harm than good, messages should be left. Similarly, survey researchers should treat call back requests as a standard part of the survey process. Treating each request as if it was genuine, and honoring the request, appears to encourage potential respondents to participate. Recommended procedures are provided on this topic in section 2.4.5 of the Final Report.

7.6 E-10: INCORRECT REPORTING OF NON-MOBILITY

7.6.1 Description

In any travel survey, it is to be expected that some portion of respondents will not have traveled from their home during the survey period. However, a claim of non-mobility on the diary day or days also may be a form of non-response. Some potential respondents may realize that a claim of non-mobility will shorten significantly the length of the interview. The issue addressed in this section is to reduce the incorrect reporting of non-mobility that is made as a form of non-response.

7.6.2 Genuine and False Non-Mobility

Users of travel survey data frequently assume that a high percentage of reports of non-mobility is an indicator of poor survey technique. To use reliably the percent of non-mobile surveys as an indicator of survey quality, a standard set of questions must be asked and, at a minimum, the percent of non-mobile persons be routinely reported.

Legitimate Non-Mobility

A preliminary analysis of reported non-mobile persons in a sample of about 400 travel surveys from around the world, conducted by Madre, Axhausen and Gascon (2003), found the average share (percent) of non-mobile persons-days was 17 percent. The authors suggested this figure was high, because it included surveys that extended over a period of several weeks. The authors suggested that the "true" range of daily non-mobile persons (immobility) should be in the 8-15 percent range.

The 2001 National Household Travel Survey (NHTS) found 11.8 percent of surveyed persons reported that they stayed in one place/home the entire travel day, which is well within the range suggested above. The 2001 survey included a step in which persons who reported they stayed in one place/home were asked to confirm this. An analysis of the characteristics of these non-mobiles (shown in Table 73) revealed:

- 31 percent also reported they were retired;
- 22 percent also reported having a medical condition that made travel difficult; and
- 10 percent were aged four or younger.

Note that this analysis is based on a review of the characteristics of non-mobile persons, not on what their reported reasons were. Only recently have questions been included in travel surveys asking why a person did not leave home during the travel day.

Table 73: Non-Mobile Persons (Unweighted): 2001 National Household Travel Survey

Statistic	***Number***	***Percent of Total***	***Percent of "Stayed in Same Place/Home"***
Total Persons	60,282	--	--
Total Reporting "Stayed in same place/home" all day	7,141	11.8%	--
Also reported having a medical condition that made travel difficult	1,537	--	21.5%
Were aged 4 or less	730	--	10.2%
Also reported being retired	2,226	--	31.2%
Also reported being temporarily absent from a job or business	246	--	3.4%

Methods for Reducing Spurious Reports of Non-mobility

There have been two approaches to reduce non-response through spurious reports of non-mobility:

- Some surveys have included a question in which respondents who reported no out-of-home trips or activities were asked to verify that they did not leave the house the entire day (verification question);

- In a few surveys, all or a sample of persons who reported no trips received a follow-up telephone call for verification; and
- Other surveys have asked respondents to provide reasons why they did not leave the house on the diary day (gently challenging questions).

Table 74 presents a review of the percent of non-mobile persons in several recent U.S. household travel surveys, and the methods (if any) used to reduce spurious reporting of non-mobility. As may be seen from the table, the NHTS reduced the percentage of non-mobile persons from 25 percent in 1995 to 11.8 percent in 2001. It is difficult, however, to attribute all of this difference to the introduction of a verification question, because there were many other methodological changes made at the same time. Recommendations of strategies relating to false reporting of non-mobility are provided in section 2.4.6 of the Final Report.

Table 74: Summary of Approaches to Reduce Incorrect Reports of Non-Mobility

Survey	***Percent of Persons Reporting Zero Trips***	***Verifying/ Challenging Question Asked?***	***If asked, wording:***
2001 National Household Travel Survey (U.S.)	11.8%	Yes	Does this mean {you/SUBJECT} stayed at {the same place/home} all day?
1995 National Person Travel Survey (U.S.)	25%	No	
2001-2002 Southern California Association of Governments	Data Not yet Available	Yes	So,<YOU >made no trips, including for work or school? (Asked in CATI) Also, for each student and employee/worker in the household that reported not going to school or work on the travel day, the interviewers were instructed to record the reason why on the sample sheet.
2000 Bay Area Travel Survey	10.1%	No*	*Separate telephone calls were made to verify reports of non-mobility
1996 Dallas-Ft. Worth Survey	8.6% in pretest	Yes	I want to confirm that you (he/she) stayed at home during the whole diary day. If yes, Why were you at home during the whole diary day? 01 Temporary illness 02 Child/other household member was ill/needed care at home 03 Homebound (does not leave the house-includes newborns/infants) 04 Fulltime homemaker 05 Employed and worked at home 06 Home school 07 Day off 08 Vacation day 09 Other (specify): Zero trip diaries were flagged for review by a supervisor

7.7 E-11: RECORDING TIME OF DAY

7.7.1 Definition

This item refers to coding time of day values for database entry. This item relates to how data are recorded (i.e., entered by the interviewer) and stored, rather than how respondents provide the information.

7.7.2 Discussion

Although time of day reporting may seem to be a trivial issue, the way times are recorded can lead to the estimation of negative travel or activity times. Travel or activity diaries tend to start at 3 a.m. or 4 a.m., and end at the same time one or more days later, depending on the design of the survey. Standard practice in most travel surveys is to transform a.m. and p.m. times into military time. This is an appropriate practice, and should, theoretically, allow elapsed durations to be obtained by subtracting the start time from the end time. However, the problem arises with a diary that starts at 3 a.m. on one day and ends at 3 a.m. on the second day. By using military time alone, the first day runs from 03:00 to 23:59 hours, and the second day runs from 00:00 hours to 03:00 hours. While this means there is no duplication of hours, it results in a problem for any activity that spans midnight, where the subtraction of a time before midnight, such as 23:30, from a time after midnight, such as 00:30, results in a negative time. Using a format such as elapsed time in minutes would alleviate this problem, but the time of day would not be easily apparent from looking at the raw data. The same applies to a modified military time that adds 24 hours to the times on each additional day (e.g., 01:30 on the second survey day would be written as 25:30).

In most modern database environments the time of day can be saved in conjunction with the date, thus allowing the application of a time difference function that takes the date into account. This would be the most practical way of storing times, but has the potential to slow down the entry of data, as has the elapsed time or modified military time method. This is especially a problem in the case of face-to-face or CATI data collection, where the additional time required to enter the date or convert the time adds to interviewer time, respondent burden, and costs. Also, including the date, especially if the data are to be released for public use, may result in some confidentiality problems. Therefore, a simpler, but easy to process format for data entry seems appropriate. This is recommended in section 2.4.7 of the Final Report.

7.8 E-12: TIME OF DAY TO BEGIN AND END REPORTING

7.8.1 Description

Surveys use various different times at which to start and end the time for a 24-hour (or longer) diary. The aim is usually to choose a time that is expected to interrupt relatively little travel, so that respondents will not be put in the awkward situation of trying to respond about travel that had started before the start time of the diary. However, there is wide discrepancy in the selection of this time, which appears to range anywhere from midnight to 5 a.m.

7.8.2 Analysis

Standardizing the time of day to begin and end reporting is more a convenience to make surveys clearly compatible and comparable, and probably has little overall effect on survey quality. However, some diaries fail to specify start and end times, or only a start time and not an end time, leading to problems as to the actual period of reporting. Generally, diaries tend to start around 2 a.m., 3 a.m., or 4 a.m. Ideally, start and end times should be selected so that there is little likelihood of beginning and ending in the middle of travel, or any other activity other than sleeping. Average hourly traffic volumes from highways and roads in North America, as well as in Great Britain and Australia suggest that the lowest volumes consistently occur between 3 a.m. and 4 a.m.

A review of recent data sets in the U.S. generally confirms that the optimal time to start a diary is between 2 a.m. and 4 a.m. Figure 10 through Figure 21 show the distribution of trip start and end times from six recent surveys. Table 75, Figure 22, and Figure 23 provide a summary of the information for the hours from midnight to 4 a.m. From this, it is clear that the hour from 2 a.m. to 3 a.m. has the lowest percentage of both trip starts and trip ends. Therefore, a start time between 2 a.m. and 3 a.m. will have the least chance of intercepting a trip in progress. There is also little variation in this from region to region, in the surveys analyzed. A recommendation for standardization on this is provided in section 2.4.8 of the Final Report.

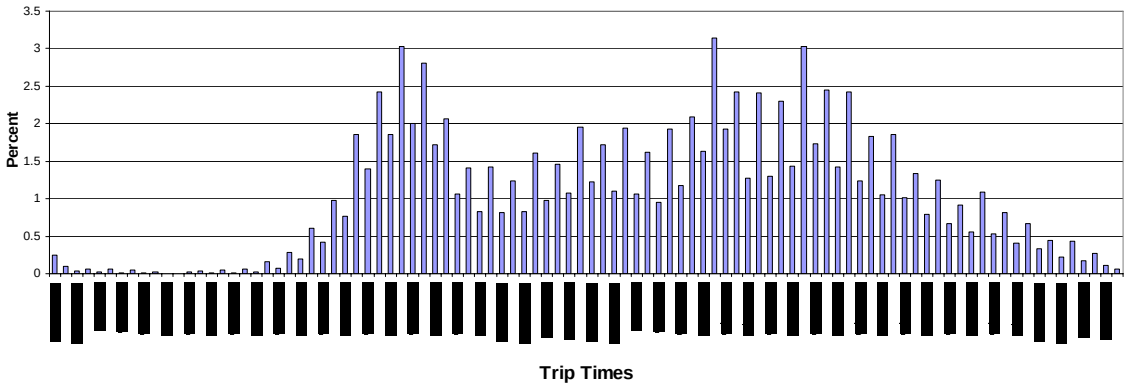


Figure 10: Trip Start Times for New York City

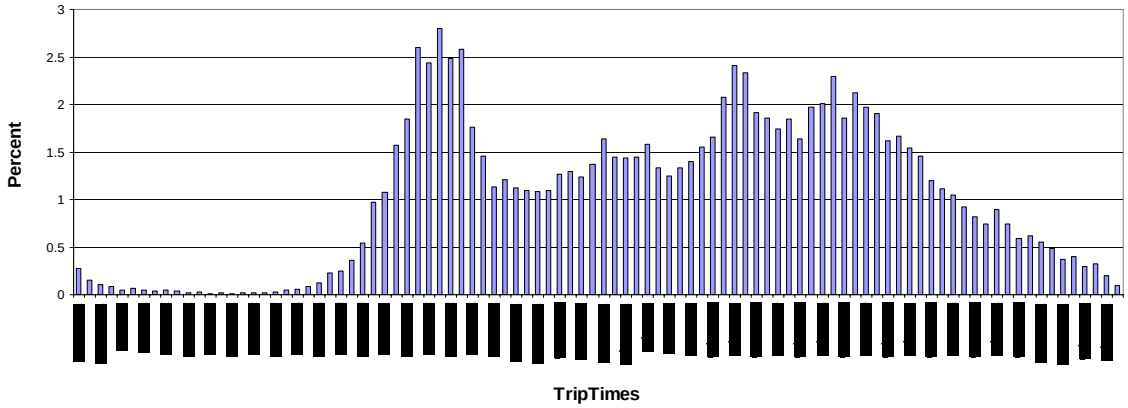


Figure 11: Trip End Times for New York City

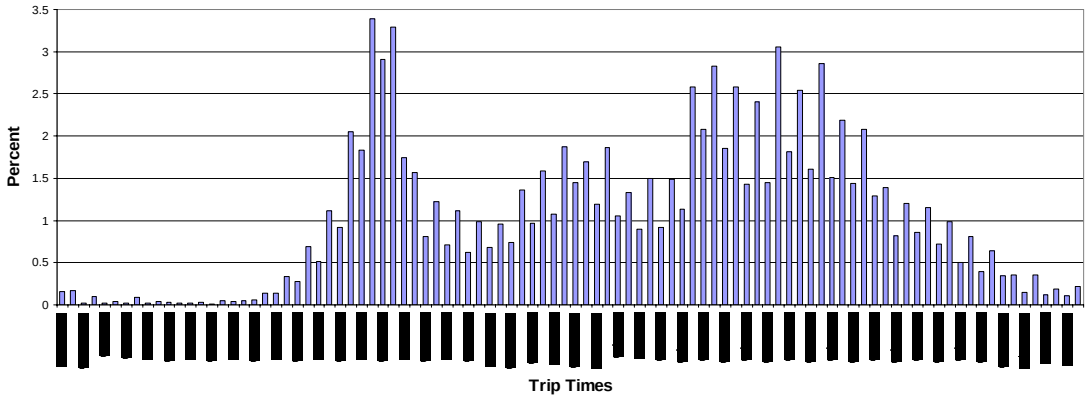


Figure 12: Trip Start Times for Dallas-Fort Worth

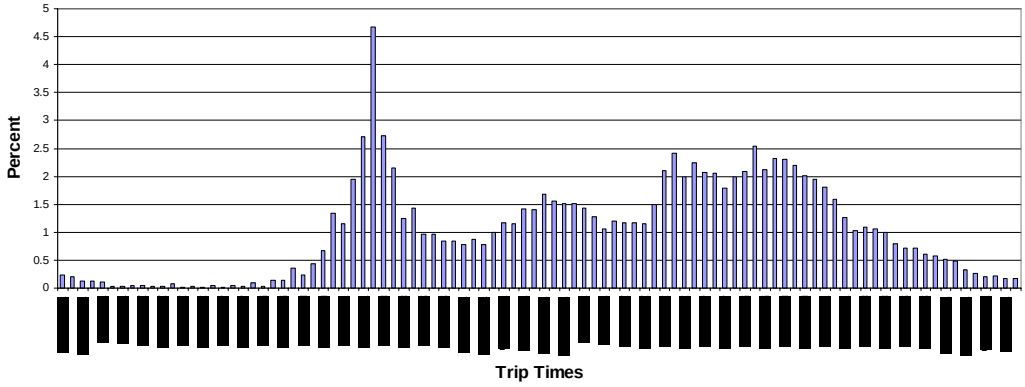


Figure 13: Trip End Times for Dallas-Fort Worth

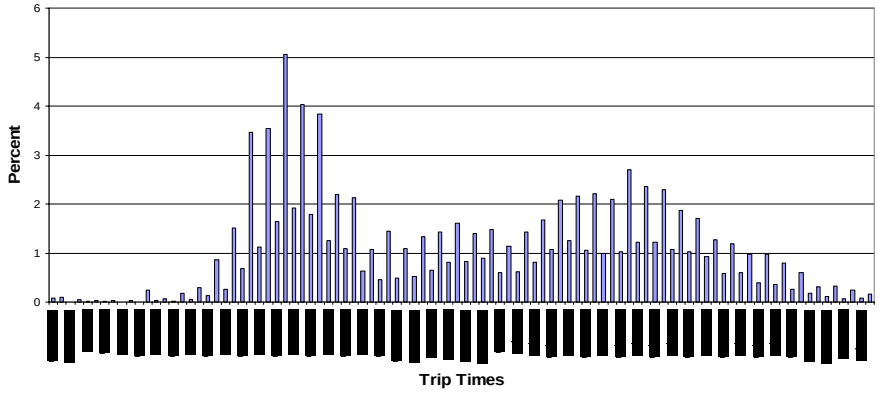


Figure 14: Trip Start Times for the Ohio-Kentucky-Indiana Area

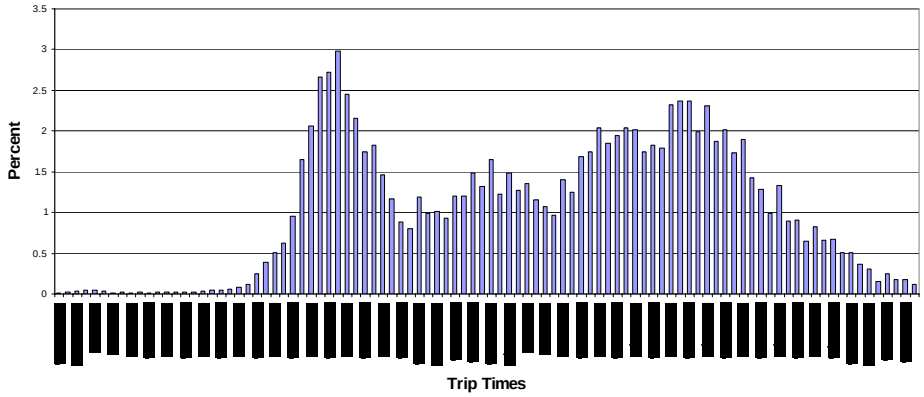


Figure 15: Trip End Times for the Ohio-Kentucky-Indiana Region

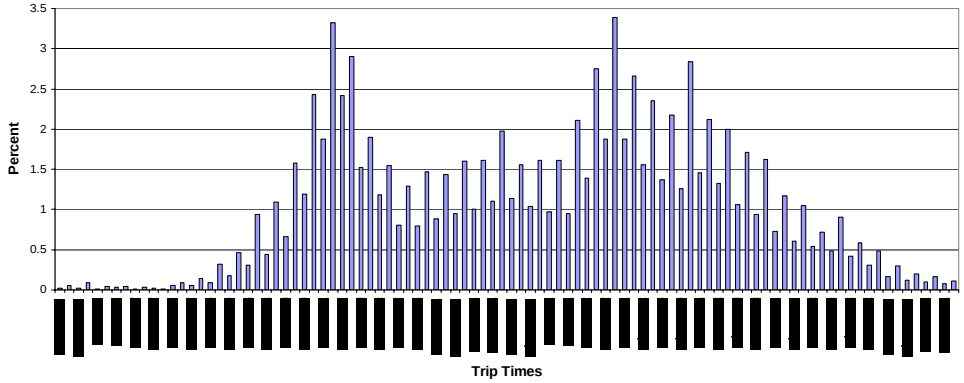


Figure 16: Trip Start Times for Phoenix

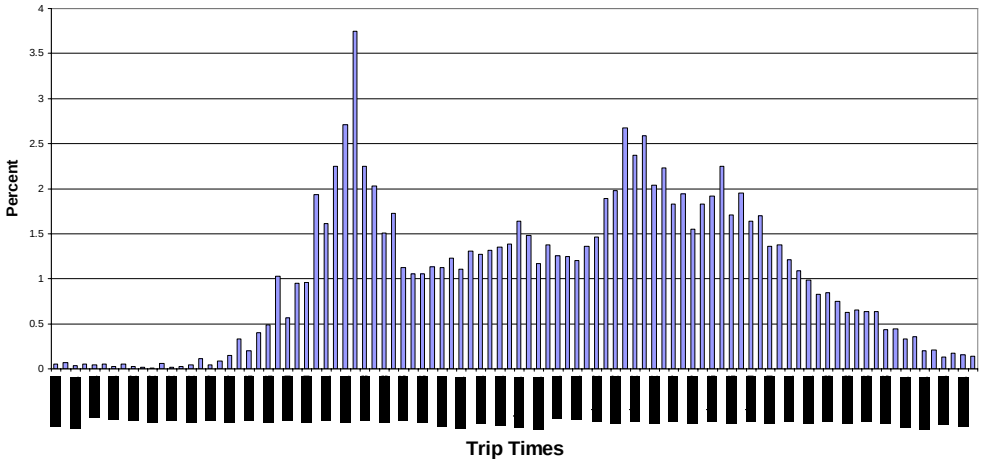


Figure 17: Trip End Times for Phoenix

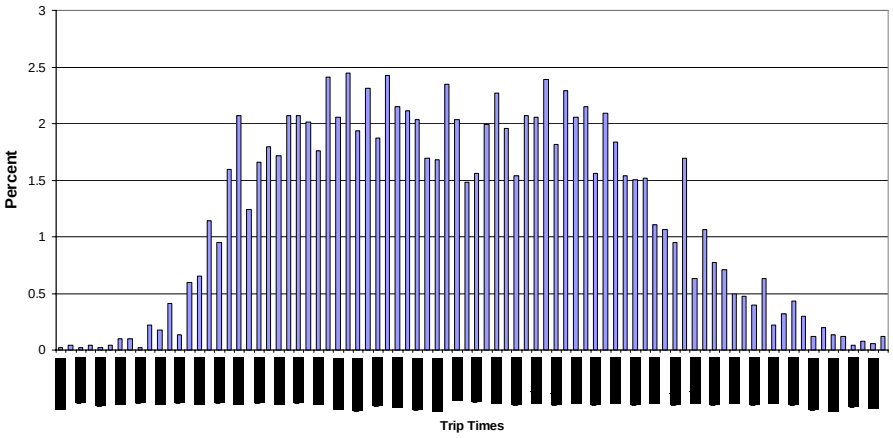


Figure 18: Trip Start Times for South East Florida

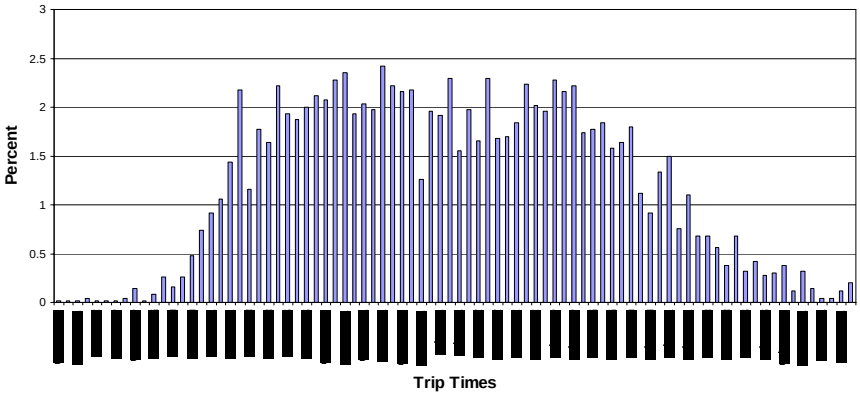


Figure 19: Trip End Times for South East Florida

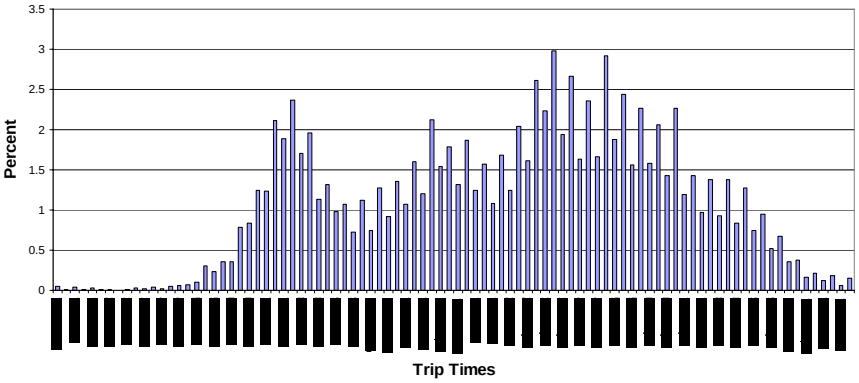


Figure 20: Trip Start Times for Salt Lake City

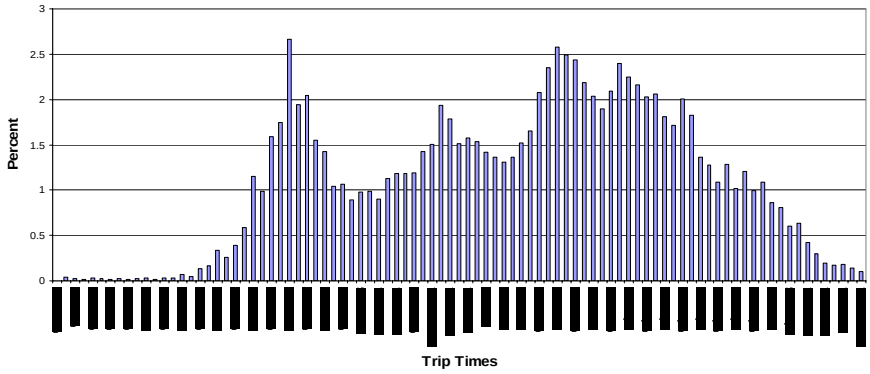


Figure 21: Trip End Times for Salt Lake City

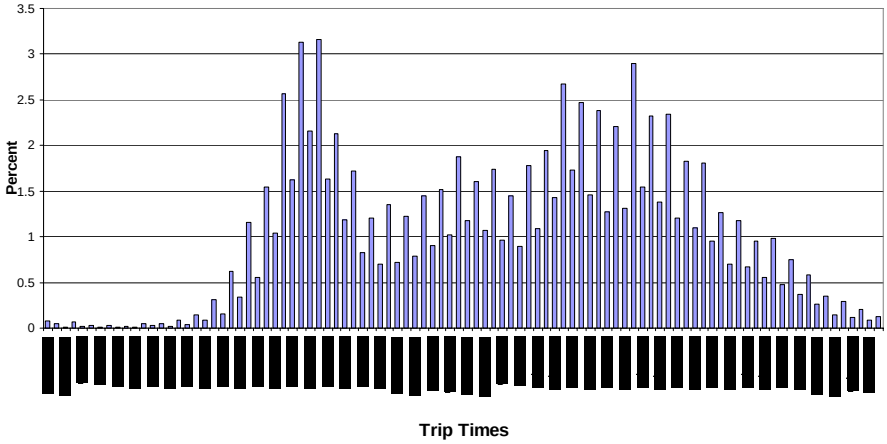


Figure 22: Trip Start Times for Merged and Weighted Files

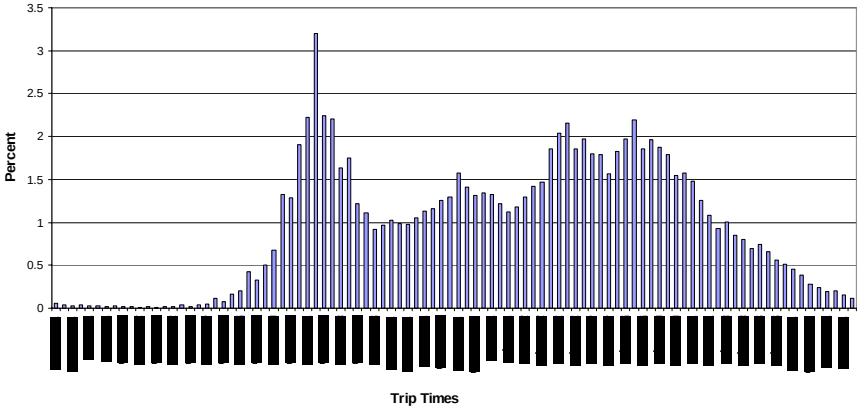


Figure 23: Trip End Times for Merged and Weighted Files

Table 75: Percentages of Trips Starting and Ending in the Early Morning Hours

Trip Times	*NYC*		*Phoenix*		*DFW*		*OKI*		*SEF*		*SLC*		*Merged*	
	Start	**End**	**Start**	**End**	**Start**	**End**	**Start**	**End**	**Start**	**End**	**Start**	**End**	**Start**	**End**
12:01-1:00am	0.5	0.6	0.2	0.2	0.5	0.7	0.2	0.1	0.4	0.3	0.3	0.4	0.3	0.4
1:01-2:00am	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2
2:01-3:00am	0	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.1	0.1	0.03	0.1	0.1	0.1
3:01-4:00am	0.1	0.1	0.3	0.2	0.1	0.1	0.3	0.1	0.2	0.1	0.1	0.1	0.2	0.1
Total	***0.8***	***1.0***	***0.7***	***0.7***	***0.9***	***1.2***	***0.9***	***0.4***	***0.8***	***0.6***	***0.5***	***0.8***	***0.7***	***0.8***

7.9 E-13: CREATION OF ID NUMBERS

7.9.1 Introduction

Each completed survey requires a unique identification number. In addition, if data are retained on incomplete households, then all contacted households require a unique identification number.

7.9.2 Need for Standardized Procedures

The primary issue with respect to identification numbers is that the numbers should permit ready retrieval of specific records, and should provide a unique identification for each unit in the survey. In addition, there is the potential to provide some additional information through the identification number, such as the membership in a specific sampling category, thereby permitting easy checking of the sampling progress during the survey and ready identification for purposes of expansion and weighting after the survey is completed.

Specifically in some CATI programs, a new ID number is assigned each time that a call attempt or reminder is made. This should be avoided at all costs in personal travel surveys. Some surveys assign ID numbers only to completed households and not to incomplete households. This should also be avoided, particularly if the standardized procedure is adopted to retain data on incomplete households.

There are two alternative procedures that can be used for creating ID numbers. The first is to create the ID number by starting with a number indicating the day of the week on which the diary was started (e.g., 1 for Monday, 2 for Tuesday, etc.). The second, third, fourth and fifth digits would consist of the date of recruitment of the household. Thus, a household recruited on March 15, with a diary day of Tuesday would have an ID number that would begin with 20315. The remainder of the number would be a sequential number that can optionally be sequenced through the entire survey or restarted on each day of the survey. In the former case, if the above household was the 1,537th household recruited since the beginning of the survey, and if the total number of households to be recruited exceeds 9,999, the household ID number would be 2031501537. In the latter case, if this household was the 38th household recruited on that day, and no day would have more than 150 households recruited, the ID number might be 20315038.

The second procedure, where stratified samples are drawn, is to use the initial digits to indicate the stratum to which the household belongs, and the remainder of the number to be a sequential number assigned as each interview or contact is completed. Suppose a survey is undertaken in which households are stratified by county of residence, household size, and vehicle ownership. The household of the

previous example is drawn from the county that is coded 3, is a 4-person household with 2 cars. The ID number could be either 34201537 or 342038.

In surveys where different sources are used to generate the sample, a digit in the ID number may be used to indicate the source of the sampling unit, e.g., RDD or a bus intercept survey. Thus, in the previous example, if the household had been obtained through RDD, and this is coded as 1 for the first digit, the ID number would become 134201537 or 1342038. Similarly, if the date-based ID number was adopted, then the ID number would be either 12031501537 or 120315038.

Again, it would be helpful if all personal travel surveys used the same procedures for assigning identification numbers to survey units, because this would mean, first, that complete and incomplete households were always handled identically, and second, that if information is encoded into the ID number, this would be done consistently in all surveys. Such consistency would allow standard processing software to be set up that would utilize the information in the ID number. Recommendations on this are included in section 2.4.9 of the Final Report.

CHAPTER 8

8. Data Coding Including Geocoding

8.1 C-1: GEOCODING STANDARDS

8.1.1 Introduction

Geocoding is the process of identifying the geographic location of a trip end and coding a number, such as a traffic analysis zone (TAZ), Census tract or block, or latitude and longitude, to represent that location (TMIP, 1996). This item is concerned with developing standards for the methods used to geocode travel data in household travel surveys. Recommendations are made about spatial units that should be adopted in geocoding and more general steps that should be taken to maximize the quality of geocoded data.

8.1.2 Need for Standardized Procedures

Despite advances in technology, geocoding continues to be an expensive and problematic activity in most household travel surveys. Until quite recently, most geocoding was done manually. This would generally involve a team of coders looking at maps to find address information recorded in surveys, and then transcribing this information into a corresponding trip file. The shortcomings of this approach have been well documented by Cambridge Systematics (1996) and Greaves (1998, 2003). Manual geocoding is labor intensive and tends to be inaccurate and subjective. The high cost associated with this approach has meant that zonal-based spatial units (e.g., TAZs, zip codes) have generally been favored over latitude and longitude values. One of the main limitations in using zonal boundaries is that TAZs and census boundaries are subject to change and often become obsolete. In addition, zonal boundaries tend to be difficult to analyze against other geographic data sources (TMIP, 1996). Geocoding to latitude and longitude, however, allows intra-zonal travel activity to be accounted for in travel models and provides flexibility, because trip ends can always be aggregated and analyzed according to any type of zonal boundary. The development of address matching programs within desktop Geographic Information System (GIS) software packages during the 1990s reduced much of the burden associated with manual geocoding, and has made it easier to geocode travel survey data with latitude-longitude values (Greaves, 2003).

Despite rapid improvements in the quality and affordability of GIS software, the success of geocoding continues to depend on the quality of input data used, and the actual method adopted for matching reported addresses with address information contained in a GIS database. Address matching is the actual process of matching street address information recorded in travel surveys (known as a target database) with an address gazetteer (reference database) using some predetermined rules which are usually built into the GIS package (Drummond, 1995). GIS layers containing street information consist of line features (links) that contain street names, and number ranges. Address data recorded on trip ends are matched to names on links, and a point is interpolated based on the number range shown on the street (Greaves, 2003). In principle at least, it is possible to geocode 100 percent of all origins and destinations in a travel survey using this approach; however, the process is still far from perfect and it is unlikely geocoding will ever be an error free exercise. The quality of reference databases, target databases, and the

method used to deal with partial address matches all impact on the overall success of geocoding and need to be given careful consideration before undertaking a household travel survey.

The most commonly used reference database is the Topographically Integrated Geographic Encoding and Referencing (TIGER/Line) files developed by the U.S. Bureau of the Census. These files are freely available on a county by county basis, and include data on address ranges, political and statistical boundaries, and zip codes. Despite the wide availability of these data, there are a number of problems with the files, notably, non-residential and non-urban locations are poorly documented, and there are often missing or erroneous records (Greaves, 2003). There are now many commercial databases available which are generally derived from TIGER/Line files, but have been updated and improved with supplementary data from the U.S. Postal Service, or other sources, such as land parcel information held by governments, or 911 databases (Greaves, 1998, 2003). In addition to this, many MPOs themselves have developed or refined reference databases (Greaves, 1998).

Collecting good quality address information in travel surveys has always been challenging because survey respondents generally find it difficult to provide precise information for most locations outside of home and work. The methods used to recruit respondents and to collect information on their travel activities will obviously have a significant bearing on the quality of target databases. In most survey settings, accurate home and work addresses can be collected relatively easily (i.e., at recruitment); however, it can be more of a challenge to collect good data on non-home and non-work addresses, particularly in the context of self administered surveys. Non-home and non-work trips are, to some extent, under-reported by respondents and because of this, geocoding can actually increase biases that may already be present in survey data.

There is evidence to suggest that high quality address information can be obtained if geocoding is done on-line or in real time during the data collection process. Greaves (2003) reviewed a number of recent household travel surveys that used CATI systems with in-built features allowing reported addresses to be instantaneously validated and cross checked with other data during retrieval. These systems give interviewers access to supplementary data on schools, landmarks, nearest cross streets, major shopping centers, etc. which can be used to locate exact addresses. While such systems can be expensive to develop, the additional costs can, to some extent, be offset by savings in data editing and post-processing (Greaves, 2003). A number of systems have also been developed to improve reporting of addresses in computer aided personal interviews (CAPIs) and computer assisted self interviews (CASIs) (Greaves, 2003). The general preference for CATI based surveys over other methods means these systems have not progressed beyond experimental stages.

For the immediate future, it appears that face-to-face methods and other non-computer aided methods will continue to rely on interviewer knowledge and post interview data editing and cleaning to maximize the accuracy of reported addresses. It is worth noting that some innovative methods have been developed to improve geocoding in more conventional survey settings. In the OKI household travel survey, for example, geocoding was performed a day after travel data retrieval to allow interviewers to re-contact respondents and clarify addresses that could not be located (Market Opinion Research, 1995). Internet based surveys, although still in their infancy, hold considerable promise for improving address information because they could incorporate supplementary data and allow cross checks to be performed on reported locations like those CATI systems discussed earlier. Methods involving Global Positioning System (GPS) technology have the ability to provide highly precise information on the location of trip ends (Greaves, 2003), but are not discussed further, because the intention here is to examine geocoding in more conventional survey settings.

Aside from the quality of reference and target databases, geocoding match rates also depend on the actual technique used to match addresses. Drummond (1995) provides a comprehensive review of address matching procedures. Irrespective of the actual method that might be used, there are essentially three possible outcomes in address matching procedures: addresses may be matched correctly, partially matched, or not matched in any circumstances. Partial matches can be assigned latitude-longitude values if the rules used for matching records are relaxed in some way (i.e., by accepting differences in spelling, street abbreviations and zip codes). Criteria relaxation can take several forms. Scoring systems compare

the 'sounds' (known as soundex functions) between addresses listed in target and reference databases and provide scores to indicate the closeness of potential matches (the user decides on the scores they will accept for matches). There are also more advanced techniques using probabilities and weights (Drummond, 1995). Criteria relaxation methods vary between different GIS packages. MapInfo uses criteria relaxation while Arcview and TransCAD use rating and scoring-based procedures (Greaves, 2003). At this point in time, more advanced techniques are generally not available within standard GIS software packages. While little testing has been done to evaluate the merits of each approach, anecdotal evidence suggests that scoring methods are probably the best because they are easy to learn and provide slightly more flexibility than criteria relaxation methods (Drummond, 1995).

Section 2.5.1 of the Final Report lays out recommendations for standardized procedures and guidelines for geocoding.

8.2 C-2: LEVEL OF GEOCODING TO BE PERFORMED

8.2.1 Description

It is theoretically possible to geocode 100 percent of all trip ends in a survey, but in practice this is difficult, if not impossible. Most travel surveys will encounter some difficulties in geocoding and so there is a need to determine a reasonable minimum match rate that could be achieved in most survey settings. This item is concerned with determining minimum percentages of trip ends that should be geocoded in household travel surveys.

8.2.2 Discussion and Analysis

The success of geocoding depends on the quality of reference and target databases and the technique used to match addresses. Thus, a problem in one of these areas will result in a less than perfect match rate. Although the quality of TIGER/Line files and commercially available address databases appears to be improving, these sources of information will never be completely free of errors. In addition to this, it will probably never be possible to have all addresses reported accurately by respondents. In any survey, there will always be a certain number of addresses reported incorrectly, either because respondents genuinely do not know the right address, or because they may deliberately choose not to report it.

In a survey of GIS practices by MPOs, Greaves (1998) found that most agencies reported a geocoding match rate of between 85 and 95 percent. Many of the difficulties in achieving high match rates stem from the fact that certain types of addresses are much more difficult to geocode than others. Most people are able to report their home and work addresses with considerable accuracy. While the majority of people would not be able to recall an exact street address for a school, this information can be obtained relatively easily after an interview (if the name of the school is reported). Addresses outside home, work and school tend to be reported much less accurately however (Stopher and Bullock, 2001). A review of trip files from household travel surveys conducted in New York, Phoenix, and South East Florida appears to support this. Unfortunately, it was not possible to examine more of the files made available for this project, because geocoding data in these files were either incomplete or unusable.

Table 76 shows a comparison of geocoding match rates by trip purpose for New York, Phoenix, and South East Florida. In each survey, geocoding was performed to latitude and longitude, but higher spatial units (TAZ, etc.) were also derived from these points. For each survey and trip purpose, four geocoding outcomes are shown: matched, unmatched, imputed and out of region. In the New York City survey, all trip ends were geocoded; however, geocodes were imputed in situations where unacceptably

high speeds were calculated between trip ends (speed violations). The actual method used for imputation is not detailed in the survey documentation; however, for the purposes of this exercise these records can be considered unmatched. The New York City and Phoenix files contained "geocoding status" variables to show the final outcomes of the matching procedures used, while the South East Florida file only contained latitude and longitude values for those records successfully geocoded, and did not provide any additional information.

Table 76: Geocoding Match Rates for New York City, Phoenix and South East Florida Trip Files

Survey	*Purpose of Trip*	*Geocoding Outcome*			
		Matched	**Unmatched**	**Imputed**	**Out of region**
New York City	H-B Work	96.7%	-	3.0%	0.4%
	H-B School	97.5%	-	2.2%	0.2%
	H-B Shop	96.1%	-	3.6%	0.3%
	H-B Other	94.8%	-	4.6%	0.6%
	N-H-B Work	90.2%	-	8.2%	1.6%
	N-H-B Other	90.9%	-	7.4%	1.7%
	Total	94.4%	-	4.8%	0.8%
Phoenix	H-B Work	92.6%	7.1%	-	0.3%
	H-B School	96.5%	3.5%	-	0.0%
	H-B Shop	98.7%	1.3%	-	0.0%
	H-B Other	96.3%	3.3%	-	0.4%
	N-H-B Work	92.4%	6.0%	-	1.6%
	N-H-B Other	93.8%	4.1%	-	2.1%
	Total	95.0%	4.3%	-	0.7%
South East Florida	H-B Work	94.9%	5.1%	-	-
	H-B School	95.4%	4.6%	-	-
	H-B Shop	95.1%	4.9%	-	-
	H-B Other	94.2%	5.8%	-	-
	N-H-B Work	96.6%	3.4%	-	-
	N-H-B Other	94.2%	5.8%	-	-
	Total	94.8%	5.2%	-	-

In each of the surveys, 94-95 percent of all trip ends were successfully matched. For New York City, 96-97 percent of home based work, school and shopping trips were matched. Match rates for home based other trips and non-home based trips were noticeably lower, with 91 percent of addresses being matched for the latter. According to reports from the survey, most respondents had little difficulty in reporting their home addresses and habitual addresses (work and school), but were less accurate in reporting "other trip locations" (Nustats International, 2000).

Match rates for Phoenix were roughly similar to those found for New York City, although the match rate for home-based work trips for this survey appeared relatively low at 93 percent. Analysis of the original location file for the survey revealed that 17 percent of work locations were not geocoded, which in most surveys would be unacceptably high. No documentation was available to explain the cause of this. Match rates for South East Florida were consistently between 94 and 97 percent for all trip purposes. The higher percentage of non-home trip matches for South East Florida is probably attributable to the fact that geocoding was undertaken in real time, during the CATI interview, with special geocoding software (Carr Smith Corradino, 2000a), while address locations were post processed in the case of New York City and Phoenix.

It is generally very difficult to geocode out of region locations, not just because respondents have difficulty reporting accurate addresses, but because reference data may not even be held for such areas. For the majority of trip types for New York City and Phoenix, less than 1 percent of trips were not

geocoded because they were made outside the study region. For South East Florida, trip ends outside the study region were matched with a "representative point north or south of the region."

Recommended standardized procedures for the level of geocoding to be performed are provided in section 2.5.2 of the Final Report.

8.3 C-4: MISSING VALUES, USE OF ZERO, ETC.

8.3.1 Introduction

There is considerable variability in how missing data are recorded in transport surveys, and even variability within the same survey. The issues in this item relate to standardizing the ways in which missing data are flagged, and how zeroes and blanks are to be used in coding.

8.3.2 Coding Issues

There is no agreement among recent household surveys on what to use for flagging missing values, and other aspects of setting coded values for non-numeric data. It is not uncommon to find that codes are left blank if the response is missing. This is unfortunate when zero is a legitimate response, because it becomes impossible in most computer analyses to distinguish between a blank and a zero in a numeric field. In statistical packages, missing values can be declared and are replaced in internal data sets with the missing data code of the package. However, in ASCII data files that are usually the ones stored for archives and provided to other agencies and individuals, these missing data codes may vary from variable to variable within one survey.

The first issue, then, is to address the appropriate use of blanks in data fields. The second issue is to specify standard codes that should be used to indicate missing data. These codes need to distinguish between a respondent refusal, a lack of knowledge by the respondent, and non-applicability or legitimate skips.

The third issue is to specify as a standard that there should be correspondence between the numeric values of a categorical variable and the codes. For example, if there are 0 workers, this should be coded as 0, one worker as 1, two workers, as 2, etc. Similarly, zero cars would be coded as zero, one car as 1, etc. This is a problem, for example, in U.S. Bureau of the Census codes, where zero indicates missing, 1 indicates zero, 2 indicates 1, etc. Such coding should be avoided, because of the confusion it creates and the potential it offers for misinterpretation of results.

A fourth issue here is the inclusion in diary data sets of a variable to indicate the number of trips reported in the diary. This is seen as necessary, where it is otherwise difficult to determine if a respondent refused to return a travel diary, returned a blank travel diary, or indicated that no travel was performed on the diary day.

The fifth issue is to establish standard codes for binary variables, such as questions to which the answer is either "yes" or "no," or "male" or "female," etc. Again, this is a standard that would improve comparability of surveys and would also remove potential ambiguities.

Recommendations for standardized procedures on these coding issues are provided in section 2.5.3 of the Final Report.

8.4 C-5: CODING COMPLEX VARIABLES

8.4.1 Introduction

This item is concerned with how to code the responses to certain types of questions that involve categories that may vary from survey to survey, depending on the level of detail required for a specific survey. Among the questions that fit within this item are income and activity.

8.4.2 Discussion and Analysis

There are a number of complex variables, where it would be useful to adopt consistent codes for the values used to report the data. This would enhance comparability of surveys and remove potential ambiguities. It is also contingent on standardizing response categories to certain questions, as discussed in the section on the Standardization of Categories. These proposed consistent codes should be developed not only for any appropriate questions in the minimum question specifications, but also for additional questions that may be used in many travel surveys.

Standardized categories have been proposed for the following: relationship, race, disability, employment status, education level, type of dwelling, housing tenure, obtained vehicle, fuel type, vehicle ownership, body type, internet and cell phone use, and means of travel.

Along with this should be the specification of consistent numeric codes to be used with the standardized categories. This is particularly important to allow comparability among surveys. It is also helpful in reporting out results of any given survey. Because the specification of standardized categories may result in specifying a minimum set of categories, it is important to consider the impacts of this on coding. For example, suppose that it is agreed that income should be coded at least in $10,000 steps up to $150,000, some agencies may elect to code income at a more detailed level. A possible way to handle this variable and its coding would be to set up the coding as shown in Table 77. Similar flexible codes could be devised for other cases. The value of this scheme is that aggregation of the detailed codes to the minimum coding is possible by just dropping the last digit of the code. In most statistical programs, this could be achieved by dividing the code by 10 and truncating the result to an integer. This appears to be a desirable way to handle agreement on the minimum detail in categories and consistent coding of the categories into numeric codes.

In the seven data sets examined, income categories differed and the base category also differed. In some cases, increments of $10,000 were used while the base category was less than $10,000, whereas in other cases, increments of $15,000 were used and the base category was less than $15,000. The overlapping of the categories used and the different base categories made it difficult to standardize the variable for income across the data sets. Table 77 explains how income should be categorized in order to overcome the problem of incomparability.

Table 77: Possible Coding for Varying Income Detail

Minimum Detail for Income Categories	*Minimum Coding*	*More Detailed Categories*	*More Detailed Coding*
Under $10,000	00	Under $5,000	000
		$5,000-$9,999	005
$10,000-$19,999	01	$10,000 -$14,999	010
		$15,000-$19,999	015
$20,000-$29,999	02	$20,000-$24,999	020
		$25,000-$29,999	025
$30,000-$39,999	03	$30,000-$34,999	030
		$35,000-$39,999	035

$40,000-$49,999	04	$40,000-$44,999	040
		$45,000-$49,999	045
$50,000-$59,999	05	$50,000-$54,999	050
		$55,000-$59,999	055
$60,000-$69,999	06	$60,000-$64,999	060
		$65,000-$69,999	065
$70,000-$79,999	07	$70,000-$74,999	070
		$75,000-$79,999	075
$80,000-$89,999	08	$80,000-$84,999	080
		$85,000-$89,999	085
$90,000-$99,999	09	$90,000-$94,999	090
		$95,000-$99,999	095
$100,000-$109,999	10	$100,000-$104,999	100
		$105,000-$109,999	105
$110,000-$119,999	11	$110,000-$114,999	110
		$115,000-$119,999	115
$120,000-$129,999	12	$120,000-$124,999	120
		$125,000-$129,999	125
$130,000-$139,999	13	$130,000-$134,999	130
		$135,000-$139,999	135
$140,000-$149,999	14	$140,000-$144,999	140
		$145,000-$149,999	145
$150,000 and over	15	$150,000 and over	150
Legitimate skip	-997	Legitimate skip	-997
Don't Know	-998	Don't Know	-998
Refused	-999	Refused	-999

Codes should be set up in such a way as to allow varying levels of aggregation, depending on the needs of any particular survey, as shown in Table 77. In general, this can be done by setting up multi-digit codes, where appropriate, in which the first one or two digits represent the coarsest level of aggregation that would be used, the next digit provides greater disaggregation, and a further digit (if applicable) could provide even greater disaggregation. This would follow along the lines that were used for many years for Standard Industrial Codes (SICs) (now the North American Industrial Classification System – NAICS (NTIS, 1997)). In all probability, establishing such codes would also accommodate more easily the probable need, from time to time, to add new categories, which could be done most often at the lower levels of aggregation. As shown in Table 77, it would also be possible, over time, to add further categories at the high end, indicating incomes in further $10,000 increments. This would also help accommodate inflationary effects on income. Further, an additional digit can be used to provide disaggregation to as fine a level of detail as every $1,000.

An appealing aspect of the codes shown in Table 77 is that the code relates numerically to the income group, indicating the low point on the range. Furthermore, the codes require use of no more digits than in virtually every income coding regime to be found in transportation surveys. At the same time, by using a relatively fine division of income levels, various aggregations are easy to accomplish.

As previously noted, activity is another complex variable item. Until now, most travel surveys did not adequately account for activities undertaken by the respondent. However, with the increasing use of activity-based and time-use surveys (and it is possible that time-use diaries will become the primary data collection instrument in the context of travel and travel behavior), activity has become a very important item. It is widely acknowledged that the demand for travel is derived, hence collecting data on the types of activities undertaken gives insight into the types of trips the respondent makes. It should be noted that the National Household Travel Survey conducted in 2001 used a multi-digit coding scheme for activities.

The seven data sets that were analyzed comprised data from travel and activity-based travel surveys. This made it difficult to suggest standardized activities, because in some data sets activity

categories were defined to a relatively fine level of detail, whereas in others, activity categories were more coarsely defined. However, because of the importance of travel and travel-related activities, these elements have been separated into different categories and sub-categories. This is dissimilar to how travel is accounted for in the two documents consulted. Table 78 shows a set of recommended categories for coding activity that aggregate back to commonly accepted coding of trip purpose, and match the trip purpose categories of section 2.1.2 of the Final Report.

Table 78: Guidelines for Trip Purpose/Activity Categories

Primary Category	Code	Secondary Categories	Code	Tertiary Categories	Code
Home	01	Sleeping/napping	011	Sleeping	0110
		Preparing/eating meals/snack/drinks	012	Preparing a meal/snack	0121
				Eating a meal/snack	0122
				Other specified food related activities	0129
		Home maintenance/cleaning	013	Indoor cleaning	0131
				Outdoor cleaning	0132
				Gardening/ tending plants	0134
				Care of textiles and footwear	0138
				Other specified home maintenance and cleaning	0139
		Household management	014	Paying household bills	0141
				Budgeting, organizing, planning	0142
				Selling, disposing of household assets	0143
				Other specified household management	0149
		Personal care activities	015	Showering, bathing, personal grooming	0151
				Health/medical care to oneself	0152
				Receiving personal care from others	0153
				Other specified personal care activities	0159
		Using computer/telephone	016	Using telephone (fixed line) (not incl. telephone shopping)	0161
				Using cell phone (not incl. telephone shopping)	0162
				Sending/reading/receiving email	0163
				Internet browsing (not incl. on-line shopping)	0164
				Shopping for goods and services using telephone (fixed line)	0165
				Shopping for goods and services using cell phone	0166
				Shopping for goods and services using internet	0167
				Other specified use of computer/telephone	0169
		Caring for others	017	Caring for children	0171
				Teaching, training, helping children	0172
				Caring for adults	0173
				Other specified caring for others	0179
		Paid work	018	Paid work – main job	0181
				Paid work – other job	0182
				Other specified at home paid work	0189
		Other specified at home activities	019	Not further defined (n.f.d.)	0190
Work	02	Main job	021	Regular hours	0211
				Overtime hours	0212
				Extra hours (not paid as overtime)	0213
				Other specified main job activities	0219
		Other job	022	Regular hours	0221
				Overtime hours	0222
				Extra hours (not paid as overtime)	0223
				Other specified other job activities	0229

Primary Category	Code	Secondary Categories	Code	Tertiary Categories	Code
		Work in internship, apprenticeship etc.	023	Regular hours	0231
				Overtime hours	0232
				Extra hours (not paid as overtime)	0233
				Other specified internship/apprenticeship activities	0239
		Unpaid work in family business	024	n.f.d.	0240
		Breaks and interruptions from work	025	n.f.d.	0250
		Training and studies in relation to work	026	n.f.d.	0260
		Volunteer work and community services	027	n.f.d.	0270
		Looking for work/setting up business	028	Looking for work	0281
				Looking for/setting up business	0282
		Other specified work related activities	029	n.f.d.	0290
Education / Childcare Activities	03	Attendance at childcare	031	n.f.d.	0310
		Attendance at school	032	n.f.d.	0320
		Attendance at college	033	n.f.d.	0330
		Breaks/waiting at place of general education	034	n.f.d.	0340
		Self study for distance education course work	035	n.f.d.	0350
		Homework, study, research	036	n.f.d.	0360
		Career/professional development training and studies	037	n.f.d.	0370
		Other specified activities relating to education/childcare	039	n.f.d.	0390
Eating Out	04	Restaurant/Café	041	Restaurant	0411
				Café/Snack Bar/Cafeteria	0412
		Fast food	042	Take out	0421
				Eat in	0422
		At friends' home	043	n.f.d.	0430
		Picnicking	044	n.f.d.	0440
		Other specified eating out	049	n.f.d.	0490
Personal Business	05	Availing of/shopping for administrative services	051	Post Office	0511
				Other specified administrative service	0519
		Availing of/shopping for educational services	052	n.f.d.	0520
		Availing of/shopping for professional services	053	Banking/Credit Union	0531
				Insurance	0532
				Real Estate	0533
				Tax or Accountant	0534
				Legal services	0535
				Other specified professional services	0539

Primary Category	Code	Secondary Categories	Code	Tertiary Categories	Code
		Availing of/shopping for government/public services	054	n.f.d.	0540
		Availing of/shopping for personal services	055	Hairdresser/barber/beautician	0551
				Other specified personal service	0559
		Availing of/shopping for medical and health care services	056	Medical	0561
				Dental	0562
				Eye care	0563
				Physiotherapy	0564
				Other specified healthcare service	0569
		Availing of/shopping for rental services	057	n.f.d.	0570
		Availing of/shopping for repair and maintenance services	058	n.f.d.	0580
		Other specified activities relating to personal business	059	n.f.d.	0590
Shopping	06	Purchasing food and household supplies (groceries)	061	n.f.d.	0610
		Purchasing clothes, shoes, personal items	062	n.f.d.	0620
		Purchasing school supplies	063	n.f.d.	0630
		Purchasing medical supplies	064	n.f.d.	0640
		Purchasing household appliances, articles, equipment	065	n.f.d.	0650
		Purchasing capital goods (cars, houses etc.)	066	n.f.d.	0660
		Comparison shopping	067	n.f.d.	0670
		Window shopping	068	n.f.d.	0680
		Purchasing other specified goods.	069	n.f.d.	0690
Social and Recreational Activities	07	Communication/ correspondence	071	n.f.d.	0710
		Socializing activities	072	Doing activities/going to places and events together	0721
				Receiving visitors	0722
				Visiting friends and relatives	0723
				Other specified socializing activities	0729
		Participating in religious/community/cultural events/activities	073	Participating in community celebration of historical/cultural events	0731
				Participation in non-religious community rites of weddings, funerals, births etc	0732
				Participating in community social functions	0733
				Participating in religious activities	0734
				Participating in other specified religious/community/cultural activities.	0739
		Visiting entertainment and cultural venues	074	Attendance at movies/cinema	0741
				Attendance at concerts	0742
				Attendance at sporting events	0743

Primary Category	Code	Secondary Categories	Code	Tertiary Categories	Code
				Attendance at library	0744
				Attendance at amusement park	0745
				Attendance at museum/exhibition/art gallery	0746
				Attendance at zoo/animal park	0747
				Attendance at other specified entertainment and cultural venues	0749
		Indoor and outdoor sporting activities	075	Organized sport	0751
				Informal sport	0752
				Exercise (excludes walking)	0753
				Walking, hiking, bushwalking	0754
				Fishing, hunting	0755
				Driving for pleasure	0756
				Participation in other specified indoor and outdoor sporting activities	0759
		Games/hobbies/arts/ crafts	076	Card, paper, board games, crosswords	0761
				Gambling	0762
				Arcade games	0763
				Home computer games	0764
				Hobbies, handwork, crafts	0765
				Other specified activities relating to games/hobbies/arts/crafts	0769
		Print/audio/visual media	077	Reading	0771
				Watching/listening to television/video programs/radio	0774
				Other specified activities using print, audio or visual media	0779
		Other specified social and recreational activities	079	n.f.d.	0790
Accompanying/helping others and travel related	08	Accompanying children to places	081	Accompanying children to receive personal services	0811
				Accompanying children to receive medical/health services	0812
				Accompanying children to school, daycare centers	0813
				Accompanying children to sports lessons etc.	0814
				Accompanying children to other specified places	0819
		Accompanying adults to places	082	Accompanying adults to receive personal services	0821
				Accompanying adults to receive medical/health services	0822
				Accompanying adults for shopping	0823
				Accompanying adults for social activities	0824
				Accompanying adults to cultural, sports and entertainment venues	0825
				Accompanying adults to other specified places	0829
		Pick up or drop off other people/get picked up or dropped off (private car, car/van pool, shuttle/limousine)	083	Pick up someone or get picked up	0831
				Drop off someone or get dropped off	0832
		Activities related to bus,	084	Wait for/get on vehicle	0841

Primary Category	Code	Secondary Categories	Code	Tertiary Categories	Code
		public transit and group rides (except car/van pool and shuttle/limousine)		Leave/get off vehicle	0842
		Change travel mode	085	n.f.d.	0850
		Other specified activity related to accompanying others or travel related	089	n.f.d.	0890
No activity	09	No activity	091	n.f.d.	0910
		No recorded activity	092	n.f.d.	0920
		No further activity recorded	093	n.f.d.	0930
Other	99	n.f.d.	990	n.f.d.	9900

There is also a more extensive listing of activity codes provided in Table 79. The time use categories shown in Table 79 have been adopted and modified from the International Classification of Activities for Time Use Statistics (United Nations Secretariat, 2000b), and Time Use Survey: Confidentialised Unit Record File, 1997 (Trewin, 1999). Other variables that may be required in the future should be coded in a similar manner.

Table 79: Guidelines for Potential Detailed Categories for Activities

Primary Category	Code	Secondary Categories	Code	Tertiary and Quaternary Categories			Code
Home	01	Sleeping/napping	011	Sleeping			0111
				Taking a nap/incidental sleep			0112
				Sleeplessness			0113
				Other specified sleeping/napping activity			0119
		Preparing/eating meals/snack/drinks	012	Preparing a meal/snack			0121
				Eating a meal/snack			0122
				Cleaning up after food preparation/meals/snacks			0123
				Drinking other than with meal/snack			0124
				Other specified food related activities			0129
		Home maintenance/cleaning	013	Indoor cleaning			0131
				Outdoor cleaning			0132
				Recycling/disposal of garbage			0133
				Gardening/ tending plants	0134	Care of houseplants and tending indoor flowers	01341
						Care of outdoor garden/maintenance	01342
				Maintenance of heating/water supply			0135
				Do-it-yourself improvement maintenance and repair of dwelling			0136
				Installation, servicing and repair of personal and household goods			0137
				Care of textiles and footwear	0138	Hand washing; loading and unloading washing machine	01381
						Drying; hanging out, bringing in wash	01382
						Ironing/pressing	01383
						Sorting/folding/storing	01384

							Mending/repairing/making and care of clothes; cleaning and polishing shoes	01385
							Other specified care of textiles and footwear	01389
				Other specified home maintenance and cleaning				0139
		Household management	014	Paying household bills				0141
				Budgeting, organizing, planning				0142
				Selling, disposing of household assets				0143
				Other specified household management				0149
		Personal care activities	015	Showering, bathing, personal grooming				0151
				Health/medical care to oneself				0152
				Receiving personal care from others				0153
				Resting/relaxing				0154
				Thinking/planning				0155
				Private prayer/meditation				0156
				Other specified private reflection				0159
		Using computer/telephone	016	Using telephone (fixed line) (not incl. telephone shopping)				0161
				Using cell phone (not incl. telephone shopping)				0162
				Sending/reading/receiving email				0163
				Internet browsing (not incl. on-line shopping)				0164
				Shopping for goods and services using telephone (fixed line)	0165		Shopping for groceries	01651
							Shopping for clothes	01652
							Shopping for capital goods	01653
							Shopping for services	01654
							Banking	01655
				Shopping for goods and services using cell phone	0166		Shopping for groceries	01661
							Shopping for clothes	01662
							Shopping for capital goods	01663
							Shopping for services	01664
							Banking	01665
				Shopping for goods and services using internet	0167		Shopping for groceries	01671
							Shopping for clothes	01672
							Shopping for capital goods	01673
							Shopping for services	01674
							Banking	01675
				Other specified use of computer/telephone				0169
		Caring for others	017	Caring for children	0171		General childcare	01711
							Putting children to bed	01712
							Getting children ready for school	01713
							Giving personal care to children	01714
							Giving medical/health care to children	01715
							Minding children (passive care)	01716
							Other specified caring for children	01719
				Teaching, training, helping children	0172		Teaching children	01721
							Reading, playing and talking with children	01722
							Giving emotional support to children	01723

						Other specified teaching, training and helping activities with children	01729
				Caring for adults	0173	Giving personal care to adults	01731
						Giving medical/health care to adults	01732
						Giving emotional support to adults	01733
						Other specified care for adults	01739
				Other specified caring for others			0179
		Paid work	018	Paid work – main job			0181
				Paid work – other job			0182
				Other specified at home paid work			0189
		Other specified at home activities	019	n.f.d.			0190
Work	02	Main job	021	Regular hours			0211
				Overtime hours			0212
				Extra hours (not paid as overtime)			0213
				Other specified main job activities			0219
		Other job	022	Regular hours			0221
				Overtime hours			0222
				Extra hours (not paid as overtime)			0223
				Other specified other job activities			0229
		Work in internship, apprenticeship etc.	023	Regular hours			0231
				Overtime hours			0232
				Extra hours (not paid as overtime)			0233
				Other specified internship/apprenticeship activities			0239
		Unpaid work in family business	024	n.f.d.			0240
		Breaks and interruptions from work	025	Short breaks/coffee breaks			0251
				Waiting due to delays at work			0252
				Lunch break from work			0253
				Idle time before/after work			0254
				Other specified breaks and interruptions from work			0259
		Training and studies in relation to work	026	Attending in-house training			0261
				Attending training courses, conferences, seminars, and studies on official time			0262
				Attending classes, part-time on official time			0263
				Attending training in own time			0264
				Attending teleconferences			0265
				Attending other specified training and studies in relation to work			0269
		Volunteer work and community services	027	Household maintenance and management as help to other households	0271	Preparing and serving meals as help to other households	02711
						Cleaning and upkeep as help to other households	02712
						Care of textiles as help	02713
						Household management as help	02714
						Pet care as help to other households	02715
						Construction, renovation and repairs of dwellings and other structures as help to other households	02716

						Repairs of consumer and household goods as help to other households	02717
						Other specified help to other households	02719
				Shopping for/purchasing of goods and services as help to other households	0272	Shopping for/purchasing of goods as help	02721
						Shopping for/purchasing of services as help	02722
						Other specified shopping/purchasing as help	02729
				Unpaid help in business/farm employment as help to other households	0273	Unpaid help in business as help to other households	02731
						Unpaid help in farm employment as help to other households	02732
				Care to other households	0274	Child care to other households	02741
						Adult care to other households	02742
				Community organized services	0275	Community organized work: cooking for collective celebrations	02751
						Work on clearing and preparing community land	02752
						Organizing and work on community based assistance to other sub locations as well as families and individuals	02753
						Attendance in meetings	02754
						Involvement in civic responsibilities	02755
				Volunteer work for/ through organizations	0276	Volunteer work for organizations	02761
						Volunteer work through organizations	02762
				Other specified volunteer work and community services			0279
		Looking for work/setting up business	028	Looking for work			0281
				Looking for/setting up business			0282
		Other specified work related activities	029	n.f.d.			0290
Education / Childcare Activities	03	Attendance at childcare	031	n.f.d.			0310
		Attendance at school	032	Attending classes/lectures including taking examinations			0321
				Engaging in co-curricular activities			0322
				Other specified activities relating to school attendance			0329
		Attendance at college	033	Attending classes/lectures including taking examinations			0331
				Engaging in co-curricular activities			0332
				Other specified activities relating to college attendance			0339
		Breaks/waiting at place of general education	034	n.f.d.			0340
		Self study for distance education course work	035	n.f.d.			0350
		Homework, study, research	036	n.f.d.			0360

		Career/professional development training and studies	037	n.f.d.	0370
		Other specified activities relating to education/childcare	039	n.f.d.	0390
Eating Out	04	Restaurant/Café	041	Restaurant	0411
				Café/Snack Bar/Cafeteria	0412
		Fast food	042	Take out	0421
				Eat in	0422
		At friends' home	043	n.f.d.	0430
		Picnicking	044	n.f.d.	0440
		Other specified eating out	049	n.f.d.	0490
Personal Business	05	Availing of/shopping for administrative services	051	Post Office	0511
				Other specified administrative service	0519
		Availing of/shopping for educational services	052	n.f.d.	0520
		Availing of/shopping for professional services	053	Banking/Credit Union	0531
				Insurance	0532
				Real Estate	0533
				Tax or Accountant	0534
				Legal services	0535
				Other specified professional services	0539
		Availing of/shopping for government/public services	054	n.f.d.	0540
		Availing of/shopping for personal services	055	Hairdresser/barber/beautician	0551
				Other specified personal service	0559
		Availing of/shopping for medical and health care services	056	Medical	0561
				Dental	0562
				Eye care	0563
				Physiotherapy	0564
				Other specified healthcare service	0569
		Availing of/shopping for rental services	057	n.f.d.	0570
		Availing of/shopping for repair and maintenance services	058	n.f.d.	0580
		Other specified activities relating to personal business	059	n.f.d.	0590
Shopping	06	Purchasing food and household supplies (groceries)	061	n.f.d.	0610
		Purchasing clothes, shoes, personal items	062	n.f.d.	0620
		Purchasing school supplies	063	n.f.d.	0630
		Purchasing medical supplies	064	n.f.d.	0640
		Purchasing household appliances, articles, equipment	065	n.f.d.	0650
		Purchasing capital goods (cars, houses etc.)	066	n.f.d.	0660
		Comparison shopping	067	n.f.d.	0670
		Window shopping	068	n.f.d.	0680
		Purchasing other specified goods.	069	n.f.d.	0690
Social and Recreational Activities	07	Communication/ correspondence	071	Talking/conversing face-to-face	0711
				Talking/conversing by telephone (fixed line)	0712
				Talking/conversing by cell phone	0713
				Reading and writing mail - work related	0714
				Reading and writing mail - not work related	0715
				Cyber chatting, including instant messaging, discussion groups etc	0716
				Reading and writing email -work related	0717
				Reading and writing email - not work related	0718

				Other specified activities relating to communication/correspondence	0719
		Socializing activities	072	Doing activities/going to places and events together	0721
				Receiving visitors	0722
				Visiting friends and relatives	0723
				Hosting parties, receptions, similar gatherings	0724
				Attending parties, receptions, similar gatherings	0725
				Socializing at bars/clubs	0726
				Anti social activities	0727
				Other specified socializing activities	0729
		Participating in religious/community/cultural events/activities	073	Participating in community celebration of historical/cultural events	0731
				Participation in non-religious community rites of weddings, funerals, births etc	0732
				Participating in community social functions	0733
				Participating in religious activities	0734
				Participating in other specified religious/community/cultural activities.	0739
		Visiting entertainment and cultural venues	074	Attendance at movies/cinema	0741
				Attendance at concerts	0742
				Attendance at sporting events	0743
				Attendance at library	0744
				Attendance at amusement park	0745
				Attendance at museum/exhibition/art gallery	0746
				Attendance at zoo/animal park	0747
				Attendance at other specified entertainment and cultural venues	0749
		Indoor and outdoor sporting activities	075	Organized sport	0751
				Informal sport	0752
				Exercise (excludes walking)	0753
				Walking, hiking, bushwalking	0754
				Fishing, hunting	0755
				Driving for pleasure	0756
				Participation in other specified indoor and outdoor sporting activities	0759
		Games/hobbies/arts/ crafts	076	Card, paper, board games, crosswords	0761
				Gambling	0762
				Arcade games	0763
				Home computer games	0764
				Hobbies, handwork, crafts	0765
				Arts (music composition, literature, art etc.)	0766
				Performing, composing music	0767
				Other specified activities relating to games/hobbies/arts/crafts	0769
		Print/audio/visual media	077	Reading books	0771
				Reading newspapers	0772
				Reading magazines, newsletters, bulletins	0773
				Watching/listening to television/video programs	0774
				Listening to radio programs	0775
				Using computer technology for reading	0776
				Using computer technology for video/audio	0777
				Surfing the internet; downloading, uploading	0778
				Other specified activities using print, audio or visual media	0779
		Other specified social and recreational activities	079	n.f.d.	0790
Accompanying/helping	08	Accompanying children to places	081	Accompanying children to receive personal services	0811
				Accompanying children to receive medical/health services	0812
				Accompanying children to school, daycare centers	0813

				Accompanying children to sports lessons etc.	0814
				Taking children on excursions: school and non- school	0815
				Accompanying children to other specified places	0819
		Accompanying adults to places	082	Accompanying adults to receive personal services	0821
				Accompanying adults to receive medical/health services	0822
				Accompanying adults for shopping	0823
				Accompanying adults for social activities	0824
				Accompanying adults to cultural, sports and entertainment venues	0825
				Accompanying adults to other specified places	0829
		Pick up or drop off other people/get picked up or dropped off (private car, car/van pool, shuttle/limousine)	083	Pick up someone or get picked up	0831
				Drop off someone or get dropped off	0832
		Activities related to bus, public transit and group rides (except car/van pool and shuttle/limousine)	084	Wait for/get on vehicle	0841
				Leave/get off vehicle	0842
		Change travel mode	085	n.f.d.	0850
		Other specified activity related to accompanying others or travel related	089	n.f.d.	0890
No activity	09	No activity	091	n.f.d.	0910
		No recorded activity	092	n.f.d.	0920
		No further activity recorded	093	n.f.d.	0930
Other	99	n.f.d.	990	n.f.d.	9900

1. ABS 1997 Time Use Survey
2. UNSTATS International Classification for Time Use Activities (2000)
3. From the Standardization of Categories (Section V)
4. Adopted from the seven metropolitan data sets examined

Two other variables that may be asked for in some surveys also merit provision of codes under this topic, namely internet and cell phone use and vehicle manufacturer. These are provided in Table 80 and Table 81. Recommended standardized coding procedures are provided in section 2.5.4 of the Final Report.

Table 80: Proposed Primary and Secondary Category Standards for the Variable "Internet and Cell Phone Use"

Primary Category	Code	Secondary Categories	Code
No	1		10
Yes (both)	2	Internet shopping	21
		Internet banking	22
		Internet- work related	23
		Internet-research	24
		Internet- general surfing	25
		Internet chat room/communication	26
		Cell phone work related	27
		Cell phone non work related	28
Yes, internet only	3	Shopping	31
		Banking	32
		Work related	33
		Research	34
		General surfing	35
		Chat room/communication	36
Yes, cell phone only	4	Work related	41
		Non work related	42

Table 81: Proposed Primary and Secondary Category Standards for the Variable "Vehicle Manufacturer"

Primary Category	Code	Secondary Category	Code
Ford Motor Company	01	Ford	010
		Lincoln	011
General Motors	02	Chevrolet	021
		Pontiac	022
		Opel	023
		Cadillac	024
		GMC	025
		Buick	026
		Hummer	027
		Isuzu	028
		Saturn	029
Chrysler	03	Chrysler	030
		Plymouth	031
		Dodge	032
		Jeep	033
Toyota	04	Toyota	040
		Lexus	041
Mercedes Benz	05	Mercedes Benz	050
Audi	06	Audi	060
BMW	07	BMW	070
		Mini Cooper	071
Daewoo	08	Daewoo	080
Honda	09	Honda	090
		Acura	091
Hyundai	10	Hyundai	100
Nissan	11	Nissan	110
		Infiniti	111
Jaguar	12	Jaguar	120
Kia	13	Kia	130
Land Rover	15	Land Rover	150
Mazda	16	Mazda	160
Mitsubishi Motors	17	Mitsubishi Motors	170
Suburu	18	Suburu	180
Saab	19	Saab	190
Porsche	20	Porsche	200
Suzuki	21	Suzuki	210
Volkswagen	22	Volkswagen	220
Volvo	23	Volvo	230
Other	24	Other	240

CHAPTER 9

9. Data Analysis and Expansion

9.1 A-1: ASSESSING SAMPLE BIAS

9.1.1 Definition

Sample bias is a systematic error in survey sample data. It reflects a consistent deviation of sample values from true values in the population. Bias can occur within individual observations when, for example, a faulty measurement device is used and a consistent error is introduced into each observation. Of course, bias in individual observations is carried through to aggregate values of the sample such as means and proportions. However, even if individual observations are not biased, if the sample is not representative of the population, assumptions that it is produces biased estimates of the population. This is a condition that can occur quite readily, because drawing a truly random sample from the population is complicated by factors such as the practical difficulty of establishing a perfect sampling frame, having an equal likelihood of contacting each sampling unit, and obtaining full response from each sampling unit.

9.1.2 Review and Analysis

The establishment of standardized procedures in the assessment of bias in travel surveys would be useful because it would permit the identification, measurement, and interpretation of bias in a uniform manner. This would allow bias in individual data sets to be used as a measure of data quality and the extent of bias to be compared among data sets.

The extent to which bias has been identified in past studies reveals the diversity with which this subject is regarded. A review of nine travel surveys conducted in the previous decade (1991 California Statewide Survey, 1993 Wasatch Home Interview Travel Survey, 1995 Origin-Destination Survey for Northwestern Indiana, 1996 Bay Area Survey, 1996 Broward Travel Characteristics Survey, 1996-97 Corpus Christi Study Area Travel Survey, 1997-98 Regional (New Jersey, New York, Connecticut) Travel Household Interview Survey, 1998-99 Greenville Travel Study, and the 2000 Southeast Florida Regional Travel Characteristics Survey), revealed that only five tested for bias in their sample by comparing sample values to independent external sources. Of these five, only three reported making adjustments to the sample data to compensate for the error introduced. The four surveys that did not investigate the presence of bias did, however, in three of the four surveys, anticipate bias in their sample due to the survey procedure used and adjusted for it. In two of these surveys, adjustments were made for missing households and trip under-reporting. In another, adjustments were made to compensate for the disproportional sampling procedure used.

The factors used to identify bias among the nine surveys we reviewed were very similar. Household size, vehicle availability, and household income were common household characteristics used to detect bias in the survey sample. Personal characteristics of respondents, such as age, gender, employment status, and driver license status were also used often. However, it was found that the classification of age and employment status varied considerably from survey to survey. Standardizing the variables on which bias is measured, and the categories into which these variables are classified, is necessary if comparisons among studies are to be made or norms established that will distinguish acceptable and unacceptable levels of bias.

Common causes of survey bias are coverage error, non-response, instrument error, and temporal and/or geographic bias. Coverage error is caused primarily by an inadequate sample frame resulting in omission of valid cases, inclusion of invalid cases, or duplication of valid cases within the frame. A related source of bias originating in the sample frame occurs when the unit of investigation is different from the sampling unit and the relationship between the two units is not constant. An example of this is when the unit of investigation is the individual but the sampling unit is the household or dwelling unit. Because the number of individuals in a household or dwelling unit varies, a random sampling strategy employed at the household or dwelling unit level will not lead to a random sample of individuals. Most sample frames are imperfect because they are an incomplete or inaccurate representation of the population. For example, mailing addresses are generally an incomplete sampling frame because households in group quarters, hotels, hospitals, or prisons are not included in the frame. They may also be inaccurate because they usually do not have information on which dwellings are vacant at the time of the survey, which dwellings have recently been added to the list of occupied dwellings, and which dwellings are occupied by multiple households. The same situation occurs when telephones are used as the sampling frame where some households are without telephones – 2.4 percent of all households in 2000 as estimated by the U.S. Bureau of the Census (2000b) – some use cell phones only, and others have multiple lines within a single household thereby increasing their likelihood of being sampled.

Non-response is a major potential source of bias in travel surveys. As mentioned in an earlier section, non-response causes the sample to be a biased representation of the population when respondent behavior or characteristics are different to those of non-respondents. Thus, non-response as a cause of bias is not directly related to response rate but to the degree to which the sample is representative of the population. There is considerable evidence that non-respondents are often different to respondents in terms of socio-demographic and travel characteristics (Richardson *et al.*, 1995). Typically, non-respondents are more likely to be elderly, physically or mentally challenged, non-English speaking, limited literacy, minority, less mobile persons (Kim *et al.,* 1993; Ettema *et al.*, 1996; Zimowski *et al.,* 1997a). It has also been observed that one-person and more than four-person households are more likely to be among the non-respondents than households of other sizes (Armoogum and Madre, 1997). Another observation is that highly mobile persons are more likely to be among the non-respondents in interview-type surveys, because they are less likely to be found at home at the time of recruitment and are thus less likely to be in the final sample (Ettema *et al.*, 1996). While exactly the opposite is true of the less mobile, they tend to be underrepresented in the sample because they erroneously believe that their lack of travel makes them less relevant to a travel survey and are thus less likely to respond. Proxy reporting can improve non-response among individuals in the household but it is known to underreport trips, particularly those of a discretionary nature. Thus, proxy reporting can be a source of bias in trip reporting but forbidding proxy reporting may lead to bias as well if greater non-response at individual level results from such action.

Instrument bias is generally caused by poor instrument design. Respondents either misunderstand the question and therefore answer the question they think is being asked, or they are influenced to give an inaccurate answer by the circumstances surrounding the posing of the question. For example, in obtaining household income, respondents may interpret income as being solely salary or wages and omit income in the form of pension payments, rent, interest, dividends, etc. In addition, some respondents may feel embarrassed to give an accurate answer and overstate their income if it is low and understate it if it is high. Instrument bias often goes unnoticed unless it is specifically tested for (Richardson *et al.*, 1995).

Temporal and geographic bias occurs when the time during which the survey is conducted or the area in which it is conducted is not representative of the entire period or area which the survey is meant to represent. Travel surveys are typically conducted over a few months of the year and yet it is known that travel patterns vary throughout the year. For this reason, travel surveys are typically conducted in the Fall or Spring of each year, because travel patterns are more typical during these seasons. However, travel patterns during a weekday are different to those during the weekend. With the growing importance of weekend travel, those designing travel surveys must decide whether they are going to include weekend travel within the survey or not.

Geographic bias occurs because the location of economic activities that prompt travel are constantly changing. The location and intensity of economic activity in an urban area change and expand into areas that were unoccupied at the time of the survey, resulting in different travel patterns to those observed in the travel survey. Alternatively, a travel survey may be restricted to certain areas of an urban area, or the sampling rate may, for political reasons, vary by area within the total urban metropolitan area. In each case, care must be taken to ensure that the sample is representative of the population it is intended to represent, otherwise geographic bias can result.

The most common means of identifying and measuring bias in travel surveys in the past has been comparison of sample values with those of the census. Other sources of reliable external information can also be used such as the Current Population Survey, surveys from the Bureau of Economic Analysis, or the American Community Survey. The Current Population Survey is a monthly household survey conducted by the Bureau of the Census for the Bureau of Labor Statistics collecting information on employment. The Bureau of Economic Analysis of the Department of Commerce produces both historical and forecast values of population, employment, and income at the regional level. The American Community Survey (ACS) is a continuous survey providing the same information previously obtained in the census 'long form' and disseminated as the Public Use Microdata Samples (PUMS). The ACS will randomly sample a new set of approximately three million households across the United States annually. The demographic, social, housing, and economic characteristics of geographical areas with populations in excess of 65,000 will be updated on an annual basis. Smaller areas such as census tracts will operate on accumulated totals over three to five years, depending on the population, but will be updated on an annual basis using the average of the most recent years needed to provide the necessary sample size. The ACS is administered by the Bureau of the Census and was implemented on a test basis for the first time in the 2000 census.

In the past, bias has been measured by comparing sample values with those of a reliable external source. However, in reality this measures the combination of sampling and bias error, because both these errors work together to produce the final sample values. Sampling error can be estimated from the sample size and the variance of the variable and, therefore, could be subtracted from the observed total error to obtain an estimate of the bias error. However, if the measurement of bias is only used to infer data quality, total error (the combination of sampling and bias error) is a better statistic on which to base that assessment. Therefore, it would appear preferable to use the traditional measure of bias – the difference between sample and reference values – even though it is not a true measure of bias.

When measuring the difference between sample and reference values and using this measurement to infer data quality, two issues arise. First, the question arises as to how the values are to be measured. Are they measured in terms of means or proportions? Are the means or proportions study-area wide, or are they by smaller geographic area? For example, if the deviation in household size is being measured, is it measured in terms of the difference in mean value between the survey sample and the reference value, or is it measured in terms of the difference in proportion in each category of household size? In addition, is the measurement over the entire study area or is it by spatial, demographic, or other subdivision of the population? Second, how are the multiple comparisons that result from measurement on multiple variables, and multiple categories within those variables, to be combined into a single measure that expresses the relative deviation of the sample from the true values? We suggest that the answer to the first question is that the procedure by which each variable is measured will depend on the variable in question; some may effectively be measured by the mean while others may need to be measured by proportions in each category. For example, household size may be effectively measured in terms of average household size but household income may be more effectively measured by the proportion in each income category. With respect to the second question, the method of combining the measurement of deviation in each variable or category into a single measure, a root-mean-square-error (RMSE) statistic with equal weight accorded to each variable could provide such a measure. The RMSE expression that would satisfy this condition would be:

$$Percent\ RMSE = \sqrt{\frac{1}{n_i}\sum_{i}^{n_i}\frac{1}{n_{ji}}\sum_{j}^{n_{ji}}\left(\frac{r_{ij}-s_{ij}}{r_{ij}}\right)^2}\ x\,100 \quad \text{..... (1)}$$

where:
n_i = number of variables i;
n_{ji} = number of categories j in variable i;
r_{ji} = reference value of variable i in category j;
s_{ji} = sample value of variable i in category j.

Kish (1965) suggested that the accuracy of a survey can be expressed as "the inverse of total error." Thus, it would seem appropriate to use a measure of average total error such as RMSE as a statistic of data quality. Percentage RMSE is a unitless measure which must be interpreted subjectively although it has a clear intuitive meaning that is generally well understood. Participants in a workshop at the Travel Surveys Conference in Eibsee in 1997 suggested, however, that "..it is not currently possible to define acceptable levels for these errors" (TRB, 2002). Recommendations for standardizing the assessment of sample bias are provided in section 2.6.1 of the Final Report.

9.2 A-2: WEIGHTING AND EXPANSION OF DATA

9.2.1 Definition

Weighting is the process of assigning weights to observations in a sample so that the weighted sample accurately represents the population. Expansion is the multiplication applied to each observation in a sample so that the expanded sample is an estimate of the population. Weighting is determined by comparing values of variables within the sample to values of corresponding variables from a reliable external source such as the census. Expansion factors are the inverse of the sampling rate.

Weighting and expansion are often combined into a single factor, or weight, which reflects both the relative representativeness of each observation in the sample, and the number of similar cases each observation in the sample represents in the population. Separate weights are usually assigned to households, persons, and trips. These weights sum to the number of households, persons, and trips in the population, respectively.

9.2.2 Review and Analysis of Weighting Procedures

Several authors have called for standardizing the weighting process in travel surveys (Purvis, 1990, Stopher and Metcalf, 1996). This has been motivated by the need to improve the comparability of values among surveys and reduce variability in the process followed in estimating weights. Weighting reduces bias in survey values and, therefore, provides more accurate estimates of the true underlying values obtained in a survey. Requiring that future travel surveys incorporate a weighting process that complies with certain standards would improve consistency among surveys and remove uncertainty among users as to whether or not weighting has been performed on the data.

A review of past studies shows that approximately one-half to two-thirds of the travel surveys conducted in the past have employed weighting. For example, Kim *et al*. (1993) report that in a study of 23 of the larger MPOs in the country, 11 used some form of factoring. In a review of nine travel surveys conducted between 1991 and 2000, we found that six of the nine conducted some form of weighting. Of these, four used the traditional method of estimating factors from comparison of survey sample values to

those from external sources, while the remaining two only used internal estimates of missing households and trip under-reporting to factor their data. Of the three that did not perform weighting, one did account for the disproportional sampling incorporated in the design of the study, another estimated bias but did not report any adjustment to the data to compensate for the bias, and the third made no mention of identifying bias or estimating weights at all.

The variables used to compare sample and population values in past travel surveys have varied. The most common variables have been household size and number of vehicles per household (Kim *et al.,* 1993), but household income, number of workers, gender, race, and age have also been used. The comparison between the sample and population values has been conducted at varying geographic levels, ranging from the entire study area down to county and smaller statistical areas, depending on the availability of external data and the complexity of analysis required. The variables on which the comparison is made should, ideally, capture the greatest difference between sample and population values because these reveal where bias is the greatest. However, the incidence of bias depends on survey design, survey execution, and characteristics of the survey population, and these vary from survey to survey, so it is not feasible to establish a fixed set of variables to measure bias in surveys.

Several methods have been used to identify weights in travel surveys in the past (Ollmann *et al.,* 1979, Kim *et al.,* 1993, Stopher and Stecher, 1993, NHTS, 2001g). All identify weights by comparing sample values with those from an external source, but the manner in which the information is used tends to vary among the studies. The more sophisticated procedures establish weighting factors in a two-stage process. In the first stage, all adjustments that can be attributed to individual observations, or to groups of observations in the sample data set, are applied. This includes expansion, adjustments due to differential response rates among groups in the sample, and adjustments for changes in selection probability due to, for example, multiple telephone lines in the home. The adjustments in stage 1 generally use information from within the survey and do not rely on information from external sources. The details of how this stage should be conducted are provided in section 9.2.3.

The second stage involves adjusting the weights established in stage 1 to match the population information. Typically, information on population values is available on a univariate basis. That is, the distribution of individual variables is known but their joint distribution is not. With two variables, this is equivalent to knowing the row and column totals in a cross-classification table without knowing the cell values in the table. This can be extended to any number of variables where the marginals (cell totals on each dimension) are known but the individual cell values are not. Because this is an underspecified problem where the number of unknowns exceeds the knowns, multiple solutions (cell values) that satisfy the conditions (marginals) are possible. The idea is to establish a solution that satisfies the conditions, while matching the sample cell values as closely as possible.

Deming and Stephan (1940) first suggested using least squares to achieve an “optimal” or “good” solution to this problem. They demonstrated that the least squares solution with one set of marginals is the sample value in each cell multiplied by the corresponding population marginal over the sample marginal. That is, proportionally scaling up sample values, so that they total population values, is the least squares solution, when one marginal is being satisfied. However, when two or more marginals are satisfied, the least squares solution no longer coincides with the proportional scaling of the sample values, although the difference between the least squares solution and the proportional solution is small (Deming and Stephan, 1940). The procedure of proportionally scaling sample values to match given marginals on two or more variables, and establishing a solution by iteratively cycling through the proportional fitting process on each variable until all marginals are simultaneously satisfied, was proposed by Deming and Stephan (1940) as a practical, effort-saving alternative to the least squares procedure. The use of this process in balancing origin-destination tables in transportation modeling came to be known as the Furness, iterative proportional fitting (IPF), or row-and-column balancing procedure. However, the iterative proportional fitting procedure proposed by Deming and Stephan is applicable to any number of variables and Evans and Kirby (1974) used it to establish a tri-proportional Furness procedure. They also proved that the procedure produces a unique solution. Ollmann *et al.* (1979) compared the performance of the least squares solution with that of the row-and-column balancing method and found they produced very similar

results except when the distribution of the marginals is skewed, in which case the row-and-column balancing method produced more plausible results. They also noted that the least squares procedure which requires solution through the use of LaGrange multipliers, is considerably more labor-intensive than the row-and-column balancing method.

The solution emerging from the iterative proportional fitting procedure is sensitive to the seed matrix from which it is initiated. Thus, the final weightings which emerge at the end of the second stage are sensitive to the weights established in the first stage. This is as it should be, because this provides the greatest use of the information available to modify the sample values to become representative of the population.

Household weights are established using household variables in stage 2, while person weights are established by using variables related to individuals in stage 2. Both start off with the same weights established in stage 1. Trip weights are usually assumed to be directly related to person weights because the lack of information on total trips in an area makes it difficult to establish trip weights independently.

Calculating Weights

STAGE 1. To establish household weights, stage 1 of the weighting and expansion process must include the following steps:

1. Estimate an initial weight equal to the inverse of the design sampling rate. If disproportional sampling is used then weights must be estimated for each stratum separately. The initial weight of household *i* in stratum *h* is:

$$w_{i,exp} = \frac{1}{s_{h,i \in h}}$$

where:

$w_{i,\text{exp}}$ = initial weight (or expansion factor) for household *i*.

$s_{h,i \in h}$ = design sampling rate in stratum *h* of which *i* is an element.

8. If knowledge is available on levels of non-response in the survey at geographic or demographic subdivision level, establish a weight to account for differential non-response. If non-response is not known at a level which subdivides the sample, assume the weight for this step is 1 and proceed to the next step. If the response rate is known at a level that subdivides the sample, the response weight for household *i* in subdivision *j* is:

$$w_{i,resp} = \frac{1}{r_{j,i \in j}}$$

where:

$w_{i,resp}$ = response weight for household *i*.

$r_{j,i \in j}$ = response rate in subdivision *j* of which *i* is an element.

9. Weight for difference in selection probabilities. This is necessary when the sample frame and the sampling unit do not coincide as, for example, when the sample frame is residential telephone numbers and the sampling unit is households. Households with more telephone lines are more

likely to be selected under this system than households with fewer lines. The same applies if the sample frame is dwelling units and multiple households occupy some dwelling units. To account for these differential selection probabilities, the following weight should be applied to the households, where a one-to-one relationship between the sample frame and the households does not exist:

$$w_{i,sel} = \frac{1}{u_i}$$

where:

$w_{i,sel}$ = selection weight for observation i.

u_i = number of times household *i* is represented in the sample frame.

Note that u_i can range from a fraction for those households who share a dwelling or telephone line (or are episodic telephone owners) to values in excess of 1 when a household owns multiple telephone lines or inhabits more than one dwelling in the study area.

10. Obtain a composite weight for each household by multiplying the weights from the equations in steps 1, 2, and 3 together:

$$w_i = w_{i,exp} \times w_{i,resp} \times w_{i,sel}$$

The weights identified for households in stage 1 are also assigned to the persons and trips in the household.

STAGE 2. Separate weighting is conducted for households and persons. While the procedure used is similar, different variables are used in each weighting process. Final weights for households are identified by conducting the following steps:

1. Identify household variables for which population values are available (from external sources) and which also occur within the sample. The choice of variables should be dictated by the purpose of the survey, where bias is most expected, and the reliability of population values.
2. Each variable must be broken into a manageable number of categories. The categories must be selected so as to ensure that the multidimensional "cells" that are produced by simultaneously cross-classifying all variables, all contain at least some sample values, because empty cells cannot be adjusted by weights and are, therefore, redundant. Individual cells can be collapsed into single larger cells to eliminate empty cells.
3. Households weights, established in stage 1, must be summed in each cell.
4. Iterative proportional fitting should be applied to the cell weights identified above. The order in which the variables are considered in each iterative cycle is irrelevant since a unique solution is guaranteed irrespective of the order of the variables. A closing error of no more than one percent on any marginal value is recommended.
5. Final weights are identified by dividing the final cell weights above by the sum of the households in each cell. This is effectively dividing the weighted sum of households in each cell by the unweighted sum to produce a common weight for all households that belong in each cell. Note that while individual households had different weights at the end of stage 1, households in the same cell now have the same weight. However, the effect of those individual weights did have an impact in structuring the seed n-dimensional matrix used in the iterative proportional fitting

process employed here. The adjustments in stage 2 represent a further improvement in stage 1 weights, but, because cell totals are used in the process, individual weights are lost.

6. Transfer the final household weights to the data and include a description of the expansion and weighting process in the metadata.
7. Person weights are established in the same manner as was accomplished with household weights with the exception that person variables are used in the process and person weights from stage 1 are used in the initial (seed) n-dimensional matrix. Final person weights are established by dividing the final cell values by the number of persons in each cell.
11. Trip weights are established by applying person weights to each trip. The sum of all trip weights in the sample will then represent the total number of trips made in the study area during the survey period although trip underreporting will tend to result in this estimate being lower than the true number of trips conducted. Separate trip weights cannot be established because the true number of trips made in an area is unknown.

Recommendations on the standardization of the weighting procedure are provided in section 2.6.2 of the Final Report.

9.3 A-3: MISSING DATA IMPUTATION

9.3.1 Introduction and Background

Imputation is the substitution of values for missing data items, or for values of data items that are known to be faulty. Data values are known to be faulty if they are infeasible (e.g., a five-year old with a drivers license) or are inconsistent with other information known of an individual or their household.

There are two mechanisms for substituting values for missing or faulty data items – deductive imputation (or inference) and regular imputation. Inference involves deriving the value of a missing or faulty data item from the information known of a respondent or their household, when such a derivation can be made with relative certainty. For example, the gender of a person can often be inferred from their first name, and a person 16 years of age or older who reports making multiple trips alone by car, probably has a drivers license. Imputation, on the other hand, is the generation of a likely value for missing data with no assurance that the imputed value is correct on a case-by-case basis. For example, if the number of vehicles owned by a household is missing, a likely number could be imputed by considering the household income, number of licensed drivers, and age of the members of the household. Imputation is expected to produce the correct distribution of values for each variable even though individual imputed values are not necessarily correct.

Imputation is the last resort in replacing missing or faulty data items with valid values. Every effort is first made to limit missing or faulty data through good survey design, well-managed survey execution, and aggressive editing and call-back to respondents. However, when the best efforts to obtain accurate reported information on each item fails, inference, followed by imputation, should be applied. Inference should always precede imputation because inferred values are more accurate than imputed values.

9.3.2 Discussion of Imputation Procedures

For imputation to work most effectively, collected data must be subjected to editing. Editing involves reviewing data values for reasonableness, consistency, and completeness. The reasonableness of values is determined by establishing permissible or feasible ranges of values and testing whether the

collected data falls within those ranges. Where possible, cases in which variable values fall outside the feasible range of values are identified, and the persons re-contacted to establish the correct value. Where the correct value cannot be obtained, the value should be identified as a candidate for inference or imputation. Consistency checks are verification that information on an individual or household is consistent among variables. For example, a consistency check could include verification that a walk-access transit trip does not include a parking cost, that persons under 15 are not recorded as having a drivers license, or that persons traveling between two locations, make the trip in a realistic period of time.

Data editing is usually conducted very soon after data are collected so that unreasonable, inconsistent, or missing data can be recovered by re-contacting the respondent as soon as possible. Editing is common practice in travel surveys as evidenced in *NCHRP Synthesis 236* where a review of more than 50 travel surveys conducted in the late 1980s and early 1990s, showed that more than 80 percent of those surveys conducted some form of data editing (Stopher and Metcalf, 1996). The form of editing used in the past has depended entirely on the agency conducting the survey. Editing is largely dependent on the survey instrument used, response rates, and the quality of data required. Because of the diversity of travel surveys it is difficult to establish standards that would apply to all surveys. However, a comprehensive list of editing questions that can be used to guide the development of an editing protocol have been suggested by Richardson, Ampt, and Meyburg (1995, pp. 299-304).

While data editing is fairly commonplace in travel surveys, inference or imputation in travel surveys is relatively rare. In the Canadian Travel Survey, computer-assisted interviewing (CAI) has been used since 1996, and procedures are built into the interview process to check the reported data for reasonableness and consistency. These procedures permit editing to occur online during the interview process. However, of the missing or incorrect data items that remain in the data after editing, imputation is applied to expenditure data only and all other data items are changed to a "not stated" code (Statistics Canada, 2002b). In a review of 11 recent surveys in the U.S. (2000 Southeast Florida Regional Travel Characteristics Survey, 1998-99 Greenville Travel Study, 1993 Wasatch Home Interview Travel Survey, 1997-98 New York and New Jersey Regional Travel Household Interview Survey, 1996-97 Corpus Christi Study Area Travel Survey, 1996 Bay Area Travel Survey, 1996 Broward Travel Characteristics Survey, 1996 Dallas Fort Worth Survey, 1995 Origin Destination Survey For Northwestern Indiana, 1991 California Statewide Survey, 1990 Ohio, Kentucky, Indiana Survey,), only two were found to have used imputation, and they employed it on household income only. One survey reported on the imputation method used, the other did not.

Several imputation procedures are available for use in travel surveys. Among those available are the following (NCES, 2002).

Historical Imputation

Historical imputation is used when values of variables remain stable over time. This procedure is most applicable to panel survey values or aggregate variables from repeated cross section surveys.

Mean imputation

Use of the mean of observed values to replace missing or incorrect data values. With overall mean imputation, the mean is taken from the entire distribution of observed values; with within-class mean imputation, the mean from each class is used to impute values within each class.

Ratio imputation

Ratio imputation uses an auxiliary variable that is closely associated with the variable to be imputed and which has values for all, or nearly all, of the observations. Ratios can be established for all

observations combined, or separate ratios can be established for individual classes of variables. Imputed values are derived as follows:

$$y_{i,k} = \frac{\bar{y}_k}{\bar{x}_k} \cdot x_{i,k}$$

where:

$y_{i,k}$ = imputed value of the i^{th} observation of variable y in class k.

$\bar{y}_k$ = average value of variable y in class k (among observations with valid values).

$\bar{x}_k$ = average value of variable x in class k.

$x_{i,k}$ = value of the i^{th} observation of variable x in class k.

Regression imputation

Regression imputation is closely related to ratio imputation in that auxiliary variables are used to predict imputed values. However, in place of a single variable, several variables are used. Regression imputation can be used to predict fixed (deterministic) values or, with the addition of a random error term, can be used to predict stochastic values.

Hot-deck and Cold-deck imputation

Hot-deck and cold-deck imputation both involve establishing imputation classes of observations in the data set, and then replacing missing values with an available value from a similar respondent in the same class. The difference between hot- and cold-deck imputation is that hot-deck draws its imputation values from variables within the same data set, while cold-deck relies on another data set. The terms "hot" and "cold" can be understood from the fact that one data set gets used more than once (and thus is "hot") and the other not (NCES, 2002).

Several forms of hot-deck imputation are employed. Sequential hot-deck imputation involves sequentially stepping through the observations in each class on each variable and assigning values to missing items in the following manner. Each variable in each class is assigned a starter value. If the first observation has a missing value, it is assigned the starter value, but if not, the starter value is assigned the observed value. The process proceeds through all observations sequentially, with missing values attaining the value of the last observed value. One of the features of this process is that a sequence of missing values will attain the same value and many similar values will be generated if the number of missing values is large compared to the number of observed values.

Another form of hot-deck imputation is to assign imputed values randomly within each imputation class. If this is done with replacement, it is possible to assign the same donor more than once. If there are a relatively large number of missing values in relation to observed values, the possibility of repeat values may become a problem. Sampling without replacement avoids this problem.

Another hot-deck method is hierarchical hot-deck imputation. In this procedure, observations are broken down into a detailed set of classes so that there are relatively few observations in each class. Starting with the smallest class, if one or more non-respondents are present, they are matched with respondents in that class. The method of matching can be random or it may use further variables to identify the case that is the most similar to the non-respondent case in a "nearest-neighbor" type approach. If the class contains no missing values, it is collapsed to the next higher tier in the hierarchical classification approach. Tree classification procedures such as those in Answertree® can be used to establishing such hierarchical classification systems.

Expectation Maximization

Expectation Maximization is a general method of obtaining maximum likelihood estimates when missing data are present (McLachlan and Krishnan, 1997). It consists of two steps that are applied iteratively; an expectation step where imputed values are estimated and a maximization step in which maximum likelihood is used to estimate parameters of the model used to estimate the imputation values. That is, imputed values are assigned an initial value, these are then used together with observed values in the data to estimate the parameters of a model which is used, in turn, to estimate the imputed values. The new imputed values are used to re-estimate the model, and the process is repeated until stability in the imputed values and the parameter values are obtained.

Multiple Imputation

Multiple Imputation involves imputing multiple values for each missing observation so that a distribution of values is obtained, rather than a single value as in all other imputation procedures (Rubin, 1987). Multiple Imputation has the advantage that it explicitly reflects the uncertainty of the imputed value and allows the mean and variance of each imputed value to be estimated.

Conclusions

Assessments have been conducted on the relative accuracy of alternative imputation procedures. The general consensus is that overall mean imputation is an inferior procedure in all applications, because it concentrates variable values at the mean, thereby distorting the distribution of the variable. This leads to an underestimate of the variance of the variable, which is further exacerbated by assuming a larger sample size with the added imputed values. Within-class mean imputation reduces the problem in that it moves the concentration of values to several class means. Overall, however, the best results have been obtained with Expectation Maximization, with hot-deck also producing good results (NCES, 2002). Multiple Imputation is generally recognized as producing imputation results that are at least as good as any other imputation procedure, although greater effort is usually involved in conducting the process (Allison, 2002).

Imputation is typically used to impute individual data values. This is particularly true in travel surveys where its use beyond the estimation of individual data items has been limited (Dudala and Stopher, 2001). However, it has been used to impute entire non-responding households in the Decennial Census on a regular basis in the past (Farber, 1996). In the Census, the typical procedure has been to use a complete nearby household to impute a missing household. Similar procedures could be used in travel surveys to impute missing travel, missing persons, or even missing households but further research is needed before this could become standard practice.

Implicit in all imputation procedures is that sufficient information is available from responding households to permit reasonable estimates of missing or erroneous values. Some researchers suggest, intuitively, that no more than 20 percent of the values in a data set should be imputed. However, analysis of both empirical and simulated data in areas outside transportation, suggest that this may be too conservative and that missing value percentages of 40 percent or more may still result in reliable imputation (Strauss *et al.*, 2003). Sample size was observed to have an effect on the results, with smaller sample sizes generating larger errors, although the effect was only a few percent.

Recent research on hot-deck imputation (Dudala and Stopher, 2001) found that there were not adequate sociodemographic variables available to categorize households into homogeneous groups for income imputation. Instead, a wide diversity of incomes was found to remain within the groups that could be achieved. Rather than address this issue by requiring that more household variables be collected in a household travel survey, a more cost-effective means of establishing a larger set of household characteristics may be to use person data to create additional household variables. For example, the age of

the head of the household, the occupation of the head of the household, and the presence of children may be used to further distinguish households. Other variables such as levels of mobility of the household, household structure, transit use, could also be used to distinguish households from each other. Recommendations on data inference and imputation are provided in section 2.6.3 of the Final Report.

9.4 A-4: DATA ARCHIVING

9.4.1 Definition of Archiving

Archiving data preserves the data for future use; it is considered a method for maintaining the value of data and allows space to be freed on expensive data storage mediums (Norwegian Social Science Data Services, 1999; McKemmish *et al.,* 2001). As usage of particular data sets decreases, it becomes obvious to place these files on less expensive forms of storage (Moore, 2000). However, these important files need to be stored on a medium that is safe, and in a form that enables easy access to the data. In other words, data archiving is about the careful storage of data as well as the incorporation of relevant documentation of the data (data documentation is addressed in Section 5.20 of this report).

Archiving was not conducted in the past because transport agencies did not feel this was part of their responsibility, agencies were reluctant to make their data readily available to the public, and archiving was not accounted for in initial budgets of projects. A key to effective data archiving is the assignment of responsibility and adequate funding in the initial stages of project design (Axhausen, 2000; Dahlgreen *et al.,* 2002; ICPSR, 2002; CODATA, 2003; Sharp, 2003).

However, a relatively new development in the U.S. is the Archived Data User Services (ADUS) for ITS generated data (U.S. Department of Transportation, 2004). This enables transportation agencies to preserve ITS generated data, as well as make these available for analyses. Important, however, is the acknowledgement that only data sets, from different transportation agencies with compatible structures, can be combined, compared, and shared. In addition, ADUS and associated standards are not enforced standards; therefore, transportation agencies do not have to follow these standards. The standard is a tool to provide background and guidance to transportation agencies in relation to the archiving of ITS generated data (U.S. Department of Transportation, 2004).

9.4.2 Potential Standardized Procedures for Archiving

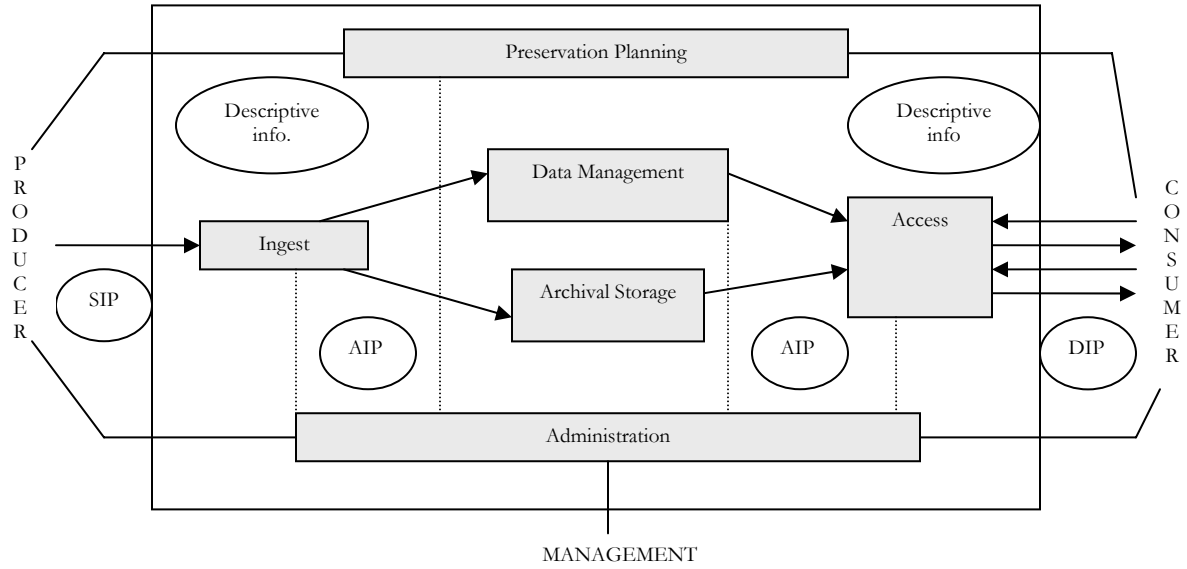
In the past, storage of expensive travel data has been far from adequate. For example, in the United States, some data sets housing important travel information have been misplaced or irretrievably lost. The cost of travel data is exacerbated by the fact that in today's research climate, it is even harder to collect travel data due to tighter research budgets, less participant cooperation, and stricter modeling requirements; therefore, higher respondent burden (this often leads to a reduction in data quality and further adds to data collection costs). In addition, freedom of information acts legally enable the public to access information previously labeled as "confidential". This has resulted in the public's stronger feelings about the public ownership and acquisition of data (Axhausen, 2000). For example, data users in the United States, in terms of access to Census data, said they wanted the U.S. Bureau of the Census's Data Access and Dissemination Systems to allow them to define their own data products online, access data documentation online via hypertext links, retrieve, display, order, fax, and download pre-packaged products, and be user friendly and print on demand (Sprehe, 1997).

The benefits of access to any data, whether this is transport data or social science data, include additional secondary analysis and the application of new statistical methodologies which may lead to

better analysis, hence, more information derived from the data (Axhausen, 2000; ICPSR, 2002). Archiving not only preserves the data for future use, but also increases the value of the preserved data by:

1. Checking and cleaning the data to ensure data integrity;
2. Eliminating software or system dependency to ensure that the data can be read any time in the future;
3. Avoiding duplication of data collections, hence reducing costs;
4. Developing comprehensive metadata (component of the required documentation);
5. Developing methods to improve data collection efforts;
6. Allowing for the integration of data from various sources to produce user friendly information products such as CD-ROMs and on-line databases;
7. Enabling students to access the information for research training purposes; and
8. Cataloging the data so that the data can be accessed through electronic search and retrieval systems (Norwegian Social Science Data Services, 1999).

Figure 24 shows an archival system developed for the preservation of digital data, by the University of Leeds, United Kingdom.



Note: SIP= submitted information package; DIP= disseminated information package; AIP= archived information package

Figure 24: Open Archival Information System Model

Source: The Cedars Project, 2002.

A basic assumption of the model, shown in Figure 24 is that all information projects are composed of data objects. The model has four main information objects:

1. Content information – the information that requires preservation (data and documentation);
2. Preservation Description Information (PDI) – any information that will allow the understanding of the content of information over an indefinite period of time (the documentation; in essence, this is part of the content information);
3. Packaging information – the information that binds all other components into a specific medium (the data archive format and structure); and

4. Descriptive information – information that helps users locate and access information of potential interest; this is distinct from PDI. This is the preservation metadata: documentation that describes the contents of the archive (The Cedars Project, 2002).

Despite the relative straight forwardness of the model shown in Figure 24, there are a few problematic issues that arise especially when archiving transportation data. Transportation archives may also include spatial data. The model shown in Figure 24 specifically deals with social science data. Therefore, the complexities associated with archiving spatial data are not addressed. Also, the model assumes that data archiving is conducted by a central agency and not the agency that collected the data. At present, most transportation data are archived by the data collecting agency.

Problems

A more recent acknowledgement is that data archiving is now a more dynamic system of multiple interrelationships, making it even more complex to initiate; hence, the reluctance of agencies to implement data archiving strategies (McKemmish *et al.,* 2001). Another obstacle, especially in relation to transportation data, is the complexity of the data itself. For example, many types of transportation data are incorporated in transportation data files, such as network data (Axhausen, 2000). This adds to the difficulty in standardizing archived transportation data because many different software tools are used to store these data initially. To implement a successful transportation data archive, a specialized archive that can support a multitude of software products needs to be developed (Axhausen, 2000).

An important aspect, in terms of transport surveys, is the type of data base the data are held in (i.e., relational data base). According to the data base structure (i.e., relational), the data may require careful interpretation because results need to be obtained from a well formed structural query language; the data base is not normalized. In this situation, direct access by users is therefore problematic (Axhausen and Wigan, 2003). Normalizing the data base will further add to the archiving cost and if agencies did not include this cost in their initial project costs, the agency may be reluctant to archive the data in a sufficient manner until funds become available. Until this arises, the data may be irretrievably lost. Therefore, the lesson is that agencies really need to consider data archiving during the project proposal stage, so that adequate funding is allocated to this exercise (ICPSR, 2002).

Despite the complexity of travel data, tools should be developed that allow for the better use of these data. This will also enable the public to understand the data (Axhausen, 2000). In addition, this issue will be of increasing importance as public awareness of and involvement in data collection practices increases in the future.

There is little information available as to how best to preserve transportation data. This makes it very difficult to propose a list of standardized procedures, but, importantly, highlights the need for more work to be done in this area. However, the following is a list of things to consider when archiving data:

- How to describe the system;
- How to describe the property;
- Description of text – how data were generated, analyzed, variables created and why;
- Descriptions of changes over time;
- How to save and store data base management systems (size, version, propriety software, etc.);
- Make sure that all relevant documentation is incorporated in the archive;
- How should changes to databases be saved; should data be saved at every point in time or just archive the important results?
- How to preserve operating systems, hardware, and storage media; and
- Who pays for data preservation and storage (CODATA, 2003).

The Inter-university Consortium of Political and Social Research (ICPSR) proposed the following guidelines for the deposition of any social science database into an archive:

1. Databases to be in ASCII format; as portable SPSS or SAS files. However, privacy of respondents must be maintained, therefore, it is recommended that any personal information be removed from the data base before it is deposited.
2. If the archive contains two or more related files, such as the case for travel data bases, variables that link the files together should be included in each file.
3. Despite having a different definition of a codebook to that used by transport professionals, the documentation to be included in the archive is almost identical to that suggested by Sharp (2003). However, an important inclusion in this archive is the archiving of the call history documentation part of the process involved in CATI surveys. The documentation should be in the DDI format - extended markup language.
4. The ICPSR also has a data deposit form that must be completed by the data producer. This form is equivalent, although not as detailed, as the preservation metadata requirements described in section 5.20.

Given the guidelines proposed by the ICPSR (2002) and literature consulted, recommendations on archiving of transportation survey data are provided in section 2.6.4 of the Final Report.

9.5 A-6: DOCUMENTATION

9.5.1 Introduction

This section deals with how to document a household travel survey. Currently, very little has been written about documentation of travel data. The term “metadata” in European literature is what is generally referred to in U.S. transportation literature as “data documentation” (Axhausen and Wigan, 2003). There has been some writing on metadata in recent literature, but there are still no standards that have been suggested for documentation of household travel surveys.

9.5.2 Review and Discussion of Standardizing Documentation

A brief review of household travel survey reports reveals that there is considerable variability in what is included and what is omitted in these reports. Some documentation will include response rates, while others do not. Some will specify how the sample was drawn, others will not. Recent European literature on metadata has indicated some of the content that should be included in the documentation. For example, below is a recommended list of metadata elements, developed by the United Nations, to be included in sample survey reports. The first list relates to the contents of a general report while the second list refers to the contents of a technical report.

- General Report:
  - Statement of purposes of the survey;
  - Description of the coverage;
  - Collection of information;
  - Repetition;
  - Numerical Results;
  - Date and duration;

  - Accuracy;
  - Cost;
  - Assessment;
  - Responsibility; and
  - References.
- Technical Report:
  - Specification of the sampling frame;
  - Design of the survey;
  - Personnel and equipment;
  - Statistical analysis and computational procedure;
  - Accuracy of the survey;
  - Accuracy, completeness and adequacy of the sampling frame;
  - Results and comparison of findings with findings from other sources;
  - Cost of project;
  - Efficiency; and
  - Conclusions drawn (Mayo, 2000).

In this section, data documentation is about how best to document the survey process and methodologies associated with the collection of travel data. *Preservation Metadata* is also defined.

Definition

Data documentation is descriptive information or documentation about statistical data that describes specific information about data sets and allows for the understanding of the elements and structure of a given dataset (Gillman *et al.,* 1996; Sprehe, 1997; National Archives of Australia, 1999; McKemmish *et al.,* 2001; Wigan *et al.,* 2002; Sharp, 2003).

Data documentation has four main aspects in survey research:

1. Provides a description of the survey and methodology employed;
2. Lists supplementary and secondary source data used and materials – data used for weighting, networks, validation, and other purposes;
3. Provides a description of the responsibilities for the survey; and
4. Includes a critical assessment of the processes used to generate data (Axhausen and Wigan, 2003).

PRESERVATION METADATA is the documentation of elements included in a data archive. This is important information because it informs the user about the type of data contained within the database, the agency(ies) responsible for data collection, terms and conditions for the use of the data contained within the archive, and the time and date when the database was created.

Due to the varying time horizons for the use of transport and travel data, it is essential that data collected, and all relevant documentation, are not lost (Wigan *et al.,* 2002). Any loss of information will result in a loss of knowledge. This reinforces the need for standards on data archiving and documentation. Another reason for developing standards relates to public access to data. Nowadays, the public are more involved in decision making processes, especially in terms of new transportation infrastructure. Hence, the public requests transportation data from specific agencies. Prior to this, data collection agencies were reluctant to provide the public with access to their data and their reports. However, it has become a legal obligation to do so. With this in mind, secure archives and adequate documentation of the data must be established.

Data Documentation

Personnel working on certain projects usually are the only individuals who possess the critical information about the data. When these people leave the organization(s), this knowledge also leaves the agency(ies), unless thorough documentation of the entire project has taken place (Axhausen, 2000; Wigan *et al.,* 2002). Documentation of data is, therefore, essential because it explains methodologies, ideas, and other data used. Incorrect documentation as well as the exclusion of major elements of the survey process from the documentation, has often resulted in the loss of significant information.

Also, it must be noted that in the social science literature, "codebooks" are also called metadata. In transportation, "codebooks" house only variable names and codes, category codes and labels, and missing value codes and labels. In social science literature, in contrast to this, a codebook may house all of the information included in transportation survey codebooks, as well as survey questions asked, skips patterns employed and response rates (Leighton, 2002; ICPSR, 2003). This is another reason why standards should be developed.

Preservation Metadata

Preservation Metadata is the documentation for archived databases. Standardizing preservation metadata will complement, and is a requirement for, data archiving standards. It will benefit users of the archived data by enabling better data organization and discovery, and by facilitating data management (Gillman *et al.,* 1996; Sprehe, 1997; Wigan *et al.,* 2002). It also provides a succinct description of the contents of the archive. This saves time for all users.

Preservation metadata standards have been established in Europe and Australia, such as the Metadata Encoding and Transmission Standard Initiative (The Cedars Project, 2002), The Dublin Core Metadata Initiative (Dublin Core, 2004), and the Commonwealth Recordkeeping Metadata Standard (National Archives of Australia, 1999). Contents of these standards are very similar. However, the former standard is more difficult to comprehend at first glance. In essence, if agencies are to archive data properly, metadata documentation of these archives should incorporate the elements described in Table 82. This will enable users of archived data to be familiar with how the archive was established which, in turn, will minimize data retrieval costs, especially when collating data from different sources (McKemmish *et al.,* 2001). A broader description of each element is provided in Table 83. This is a recommended guideline.

Table 82: 20 Elements of the Commonwealth Recordkeeping Metadata Standard

Layers Element	*Content*
Registration	Record identifier
	Date
	Location
Terms and conditions	Rights management
	Disposal
Structural	Type
	Aggregation level
	Format
	Preservation history
Contextual	Agent
	Relation
	Function
	Mandate
Content	Title
	Subject
	Description
	Language

	Coverage
History of use	Management history
	Use history

Source: National Archives of Australia, 1999.

Table 83: Preservation Metadata Elements and Description

Layers	***No.***	***Element***	***Repeatable***	***Description, Example***
Registration	14	Record identifier	Yes	Primary key for the metadata record, would be assigned by the computer, e.g., 20011005_MD1
	10	Date/Time Created	No	Date/time when database was created
	18	Location	Yes	E.g., //server2/datawarehouse/file.csv
Terms and conditions	2	Rights Management		
	2.1	Security Classification	No	E.g., unrestricted, restricted
	2.2	Usage Condition	No	E.g., "must be a member of Workgroup" or "usage upon payment of $74.50" or "ITS staff only"
	19	Disposal		
	19.1	Disposal Authorization	No	Person authorizing or able to authorize disposal of record
	19.2	Disposal Status	No	E.g., not disposed, removed from system, archived in…
	19.3	Reason for Disposal	No	E.g., "replaced through different data set"
Structural	11	Type	No	E.g., Data base, map
	12	Aggregation Level	No	E.g., tables, series, set
	13	Format		
	13.1	Media Format	No	E.g., Electronic, Printed
	13.2	Data Format	No	E.g., Access, Database, SPSS, csv
	13.3	Medium	No	E.g., Hard Drive. CD-ROM, DVD
	13.4	Size	No	E.g., 100MB, 300 pages
Contextual	1	Agent		
	1.1	Agent Type	Yes	E.g., Publisher, administrator, user
	1.2	Jurisdiction	Yes	The jurisdiction within which the Agent operates
	1.3	Corporate ID	Yes	Identifier assigned to the agent department or agency, e.g., 1234ID
	1.4	Corporate Name	Yes	E.g., University of Sydney
	1.5	Person ID	Yes	Identifier assigned to an individual who performs some action 1234ID-123
	1.6	Personal Name	Yes	E.g., John Doe
	1.7	Section Name	Yes	E.g., "ITS"
	1.8	Position Name	Yes	E.g., "Research Analyst"
	1.9	Contact Details	Yes	E.g., "12 Brown Street, Newtown NSW 2042, Australia"
	1.10	Emails	Yes	E.g., johnd@its.usyd.edu.au
	7	Relation		
	7.1	Related Item ID	Yes	Unique identifier for the related record or information source, e.g., Filename or metadata record
	7.2	Relation Type	Yes	Category of relationship, e.g., subset of…

Layers	*No.*	*Element*	*Repeatable*	*Description, Example*
	7.3	Relation Description	Yes	Additional description if 7.1 and 7.2 do not provide enough information
Content	3	Title		The name given to the record, e.g., "National Household Travel Survey 1995"
	3.1	Scheme Type	No	Naming convention used to title the records
	3.2	Scheme Name	No	Naming of standard used for naming
	3.3	Title Words	No	The Title
	3.4	Alternative	Yes	Alternative name by which the record is known
	4	Subject		Subject of topic that concisely or accurately describes the record's content
	4.1	Keyword	No	Highest level of a subject weighted title
	4.2	Second Level Keyword	Yes	Intermediate Level of a Subject Based Title
	4.3	Third Level Keyword	Yes	Third level of a subject based title
	5	Description	No	Free text description of the content and purpose of the dataset or record
	6	Language	No	The language of the content or the record
	8	Coverage		The jurisdictional, spatial and/or temporal characteristics of the content of the record
	8.1	Place Name	Yes	Locations, regions or geographical areas covered by/discussed in the content of the record
	8.2	Period Name	Yes	Time period covered by and/or discussed in the record
History of Use	15	Management History		
	15.1	Event Date/Time	Yes	E.g., date edited
	15.2	Event Type	Yes	E.g., update records, add entries
	15.3	Event Description	Yes	E.g., replacing outliers with data from another source…
	16	Use History		
	16.1	Use Date/Time	Yes	E.g., access date
	16.2	Use Type	Yes	E.g., extraction
	16.3	Use Description	Yes	E.g., extraction of data for paper on…
	21	Links to other documentation files	Yes	E.g., server2//data_documentation.doc
For Databases	22	General Dataset Characteristics		
	22.1	Number of Records	No	E.g., 23455
	22.2	Dataset Classification	No	E.g., random sample
	22.3	Dataset Classification Description	No	E.g., random sample of 5% of the population
	23	Field Identifiers		
	23.1	Table Name	Yes	E.g., survey.xls
	23.2	Field Name	Yes	E.g., workers
	23.3	Field Size	Yes	E.g., single, double
	23.4	Field Format	Yes	E.g., integer, real, Boolean
	23.5	Decimal Places	Yes	E.g., 3
	23.6	Field Description	Yes	E.g., 3
	23.7	Primary Key	Yes	E.g., Yes/No

Source: National Archives of Australia, 1999

Spatial Data

Another type of database resulting from transportation research is the spatial database. Standards for documentation of spatial databases have been developed by the Federal Geographic Data Committee (FGDC), and these are recommended as a standard. The seven major components are:

- Identification information which contains basic characteristics of the data set e.g., description of its content, its spatial domain and its time period of content;
- Data Quality information that assesses the data set's quality and in turn, its suitability for use;
- Spatial Data Organization information that describes the mechanism used to represent the information within the spatial data set;
- Spatial Reference information that describes the reference frame used to encode spatial information;
- Entity and attribute information that outlines the characteristics of each attribute including its definition, domain and unit of measure;
- Distribution information that identifies the data distributor and the options of obtaining the data; and
- Metadata reference information that describes the date, time, and the person(s) responsible for maintaining the database (Cromley and McGlamery, 2002).

Recommendations for the structure of documentation from transportation surveys is provided in section 2.6.5 of the Final Report.

CHAPTER 10

10. Assessment of Quality

10.1 Q-1: COMPUTING RESPONSE RATES

10.1.1 Background

Proper calculation of response rates is important because response rates are used by analysts to assess survey quality. Higher response rates are usually desired to reduce the likely incidence of non-response bias. For example, in household travel surveys, it has been found that non-respondents have different travel and demographic characteristics to those of respondents. Hence, the resulting data set is biased – not representative of the general population. This has been widely documented (DeHeer and Moritz, 1997; Kam and Morris, 1999; Richardson, 2000). However, in transportation surveys, no standard has been established and many surveys compute quite different rates.

10.1.2 Methods of Computing Response Rates

Until recently, the Council of American Survey Research Organizations, CASRO, was the only organization with its own method for calculating response rates. However, some years after the development of the CASRO method, the American Association of Public Opinion Research (AAPOR) developed another method for calculating response rates. Both the CASRO and AAPOR formulas are commonly used by survey practitioners. For example, the Advertising Research Council (ARC), Council of Marketing Opinion Research (CMOR) and Marketing Research Association (MRA) use a modified version of the AAPOR method for calculating response rates (CMOR, 1999). The World Association of Opinion and Marketing Research Professionals (ESOMAR) does not have its own method for calculating response rates.

Estimating Response Rates

The response rate is simply defined as the ratio of the number of completed interviews divided by the number of eligible sample units, where eligible sample units are the sample units that have met certain eligibility criteria (CASRO, 1982; CMOR, 1999; Ezzati-Rice *et al.,* 1999; Richardson and Meyburg, 2003; AAPOR, 2004). The main difference between the CASRO and AAPOR methods lies in the estimation of the eligibility rate for sample units of unknown eligibility. In addition, despite the fact that the response rate formulas are rather simplistic, a complex issue arises when trying to determine the number of eligible sample units from the eligibility unknown sample units, especially when using the AAPOR method, given that the CASRO method assumes that the eligibility rate of the unknown sample units is equal to the eligibility rate of the known sample units. Furthermore, the number of non-contacts (eligibility unknown sample units) is increasing in sample surveys and this accentuates the need to appropriately estimate the eligibility rate for the sample units of unknown eligibility.

Before describing the formulae used to calculate response rates in more detail, broad classifications regarding eligibility status are discussed. This provides a better understanding of the problems encountered during the analyses of call history files and subsequently, the calculation of response rates.

In the literature on response rate calculations, a sample is divided first into two groups. The first group is called the "eligibility known" group, and the second group is called the "eligibility unknown" group. The eligibility known group divides into two further subgroups: the eligible and ineligible. In the first group and subgroup, there is a further sub-grouping into respondents and non-respondents. This is shown diagrammatically in Figure 25. The second group, of eligibility unknown, comprises all sample units whose eligibility for the travel survey is never established.

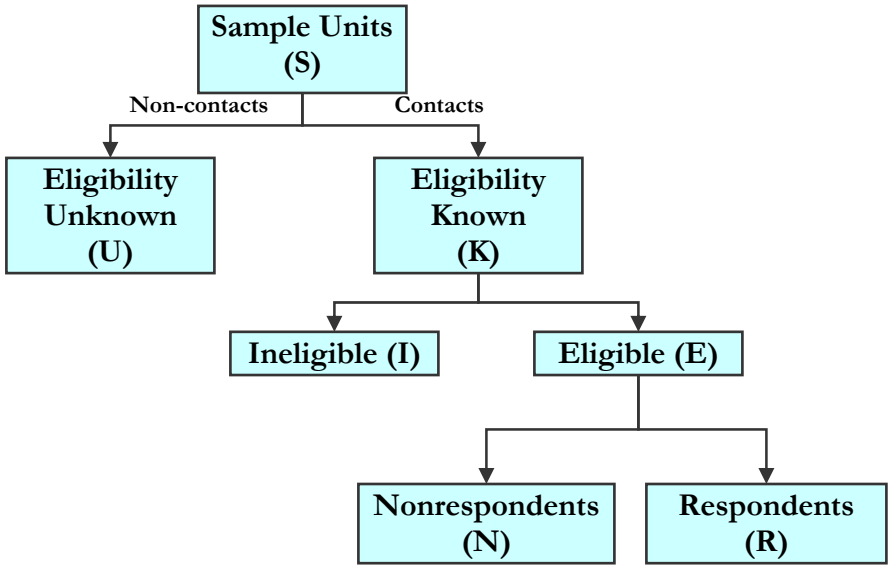


Figure 25: Sample Grouping By Eligibility

In many cases, in transportation surveys, the response rate is presented as the respondents divided by the eligible sample units (i.e., R/E). This is actually the cooperation rate, defined by the AAPOR (2004) and is similar to the response rate formula (RR5), also devised by the AAPOR (2004), except that the RR5 formula includes non-contacts in the denominator. The removal of these would in fact give the cooperation rate (COOP1). By definition, the COOP1 rate ignores the portion of the sample that have not been contacted successfully, and within which there is presumably a number of eligible sample units. However, this is also the case for RR5. Thus, the response rate (RR5) formula is not useful in relation to travel surveys and other surveys of the general population, because it assumes that the eligibility rate of the unknown cases is actually zero. In addition, the response rate formula (RR5) is likely to overestimate the response rate of surveys of the general population.

Other possible definitions of response rate might include the number of respondents divided by the total sample units (R/S), which would provide a response rate that is generally considered too low. Many of the eligibility unknown units may prove to be ineligible, so that including them as though they are eligible produces an incorrect estimate of response rate. Another, also generally erroneous calculation would be the respondents divided by the eligibility known units (R/K). In one paper consulted, this formula for the calculation of response rates was used (Singer *et al.,* 2000). The result was an under estimation of response rates because all known ineligible sample units were included in the calculation (denominator). The problem is accentuated if many of the attempted contacts are ineligible sample units.

Response rates are calculated by analysts to observe the overall quality of the completed survey (Beerten *et al.,* 2000; Lynn *et al.,* 2001). However, the response rate to a survey is only one survey quality indicator, therefore, one cannot assume that a high response rate relates to good quality data. Although

response rates are not the only indicators of survey quality, they are important indicators that are readily quoted by survey practitioners, reinforcing the need for this item to be standardized.

Response rates have become more of an issue because response rates have been falling over recent years (Ezzati-Rice *et al.,* 1999; Dillman and Carley-Baxter, 2000; Dillman *et al.,* 2001; Kalfs and van Evert, 2003). In relation to travel surveys, it has also been widely documented that the differences in terms of key statistics, between respondents and non-respondents is significant (DeHeer and Moritz, 1997; Kam and Morris, 1999; Richardson, 2000). This highlights the desire by most travel survey practitioners to obtain higher response rates to travel surveys. However, due to the inconsistency of the definition of response rates often quoted in travel surveys, it is difficult to state explicitly that declining response rates are the result of less people willing to participate in surveys or are attributable to the calculation of response rates. It is most likely to be a combination of the two. This then leads to the problem of incomparability: hence, the need for a standard for the calculation of response rates.

The widely used CASRO method is:

$$RR = \frac{SR}{E + e_C * U}$$

where:

RR = response rate
SR = complete interviews
E = eligible sample units
e_C = CASRO eligibility rate (eligible units divided by the sum of the eligible and ineligible units)
U = unknown sample units refers to the sample units with unknown eligibility (unresolved).

The CASRO formula assumes that the proportion of eligible units amongst the eligibility unknown sample units is equal to the proportion of eligible units amongst the eligibility known sample units. For example, if a Random-Digit-Dialing survey was conducted and 20,000 telephone numbers are called, there may only be 4,800 people successfully recruited to participate in the survey, of which only 1,579 complete the survey. The rest of the sample is characterized by refusals (1,200), ineligible respondents (2,400) and 11,600 cases where eligibility is unknown. The eligibility rate for this survey is:

(4,800+1,200)/(4,800+1,200+2,400) = 71 percent.

Applying the CASRO formula for response rates, the result is 11.1 percent, a very low response rate for the entire survey procedure, because CASRO requires that 71 percent of the unknown eligibility cases are assumed actually to be eligible.

The formula for response rates (RR3) devised by the AAPOR, is shown below:

$$RR3 = \frac{SR}{(SR + PI) + (RB + NC + O) + e_A(UH + UO)} \quad \text{.....(2)}$$

where:

SR = complete interview/ questionnaire
PI = partial interview/questionnaire
RB = refusal and break-off
NC = non-contact
O = other
UH = unknown if household occupied
UO = unknown other

e_A = estimated proportion of cases of unknown eligibility that are eligible (AAPOR eligibility rate: the same formula for calculating the eligibility rate is used).

Sample units labeled as non-contacts, according to the AAPOR formula, are allocated an eligibility known status. The AAPOR reasoning for this is that prior knowledge of the household has determined the household as an eligible sample unit.

Interestingly, another paper also categorized non-contacted sample units as eligible sample units (Lynn *et al.,* 2001). A diagram shown on page 7 of Lynn *et al.* labels a sampling unit as eligible before contact takes place: this does not seem correct. Furthermore, if eligibility criteria have to be met, than this is certainly incorrect and this does not seem relevant to surveys of the general population. However, it may be relevant to panel surveys, in relation to subsequent waves. With this in mind, the above response rate is re-written as:

$$RR3A = \frac{SR}{(SR + PI) + (RB + O) + e_A(UH + UO + NC)} \quad \text{.....(3)}$$

where the symbols have the same meanings as in equation 2.

Apart from the different labeling in relation to the non-contacts, the AAPOR formula (RR3) is only slightly different from the CASRO formula, and this difference is in relation to the specification of e_A. The two methods are similar because the sum of SR, PI, RB, and O is simply the total of eligible units in the sample (E), and the sum of the UH, UO and NC is the total of the unknown eligibility units (U).

Despite the modification of the AAPOR RR3 formula in this analysis (referred to as RR3A), the AAPOR breakdown of disposition codes enables the research agency to understand better the possible contact outcomes and therefore label correctly the disposition codes, in terms of eligibility status. In addition, the AAPOR formula more or less requires the agency to distinguish between the responses that are complete and those that are partial. Even though this should be determined by the agency before fieldwork commences, the AAPOR formula reinforces the distinction and hence, does not allow for the over estimation of response rates.

The real question, in relation to the calculation of response rates, is the determination of the eligibility rate for the unknown sample units (Ezzati-Rice *et al.,* 1999; Brick *et al.,* 2002; AAPOR, 2004). The AAPOR definition of response rates (RR3) states that the estimation of the eligibility rate is left to the discretion of the organization(s) and individual(s) undertaking the research, that the estimate for eligibility from unknown cases should be based on the best available scientific information, and that the basis of the estimate must be explicitly stated and explained. A relatively recent study used the AAPOR (RR3) formula to calculate response rates (Keeter *et al.,* 2000). In this study the eligibility rate for the unknown sample units was estimated to be around 20 percent due to investigations that indicated that around 20 percent of eligible units were among the unknown sample units.

Two or More Stage Surveys

There is a further complication in a survey that involves two or more steps. For example, most household travel surveys involve an initial recruitment contact, followed by a data retrieval procedure that may take place some days later, as shown in Figure 26. This process often leads to incorrect estimates of response rates. Some surveys ignore the response rate from the recruitment, and report only the response rate of the retrieval process (SR/R). Others may calculate the response rate from the recruitment incorrectly using one of the methods discussed above, and then correctly multiply the resulting response rate from the retrieval. Agencies calculating response rates for two or more stage surveys should not

encounter difficulties as long as disposition codes are correctly labeled in terms of known and unknown eligibility. This would allow for the overall response rate to be calculated directly as demonstrated in equation 4:

$$RR = \left(\frac{RH}{E + e * U}\right) * \left(\frac{SR}{RH}\right) \quad \text{.....(4)}$$

where:

RR= response rate,
SR =successful retrievals,
RH= recruited households (respondents in the recruitment phase),
E= eligible sample units,
e= eligibility rate, and
U= unknown sample units.

Actually, this equation is very similar to standard 1-3-3 developed by the National Center for Education Statistics (NCES, 2002).

The first part of the formula gives the recruitment response rate and the second part calculates the retrieval response rate. Equation 4 reduces to equation 5, the formula for response rates (CASRO, 1982; Groves and Couper, 1998; AAPOR, 2004).

$$\boldsymbol{RR = \frac{SR}{E + e * U}} \quad \text{.....(5)}$$

However, calculating the response rate for each stage of the survey may be useful for agencies to identify problematic areas encountered during any phase of the survey process. For example, the recruitment response rate is calculated by using equation 6.

$$\boldsymbol{RR = \frac{RH}{E + e * U}} \quad \text{.....(6)}$$

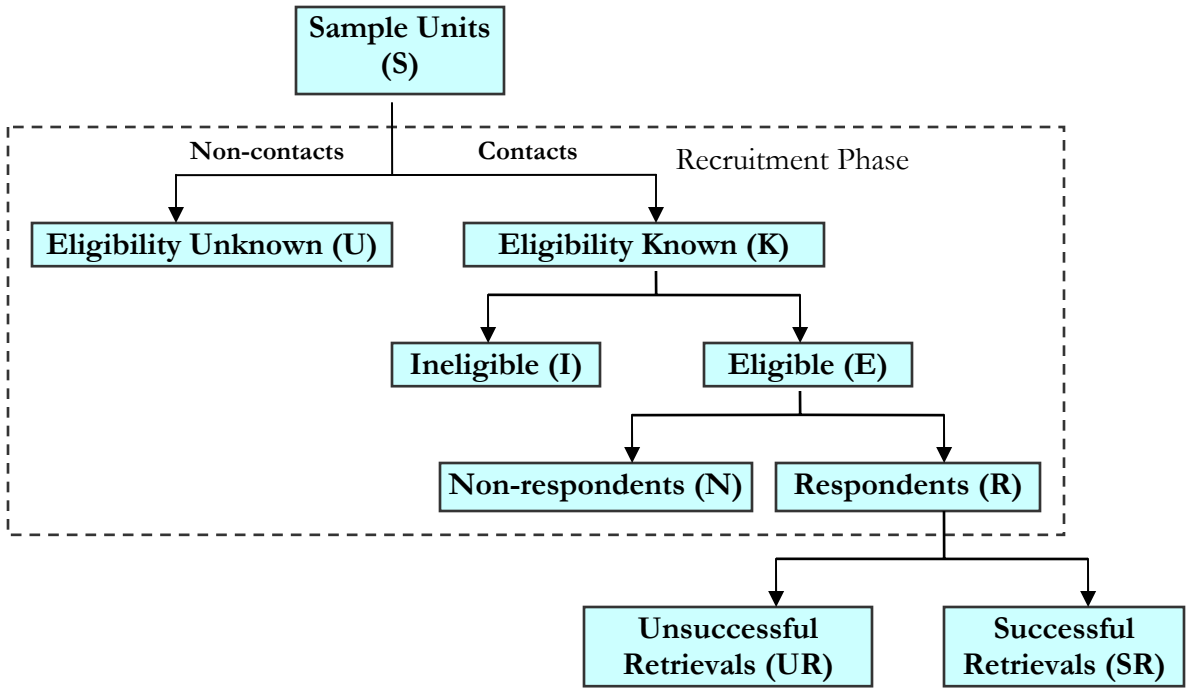


Figure 26: Two-Stage Survey Process: Recruitment and Retrieval

Equation 6 may make agencies aware that recruiting methods and materials used were not suitable, if the response rate calculated for this stage of the survey is poor. This exercise is even more beneficial to agencies wishing to undertake follow-up studies to surveys that yielded very poor overall response rates.

Through analyses of two call history files for the recruitment phase for two recent household travel surveys, an attempt to propose standards or guidelines for the estimation of the eligibility rate across sample units of unknown eligibility was made. This is described in the following section.

Estimating the Eligibility Rate

Given that many agencies use either the AAPOR or CASRO methods for calculating response rates, we examined call history files to determine the eligibility status of the unknown sample units after ten call attempts. We selected ten, because this was the number of calls made to the same sample unit to try to resolve the sample unit in relation to its eligibility status (eligible or ineligible), although not every sample unit that had not been resolved was called ten times, because time may have run out before some units could be called that many times. The status of some sample units will never be known, because either time did not permit ten attempts to be made, or because they were still never contacted after ten attempts. These are the sample units that remain as units of unknown eligibility after the ten call attempts have been made, in this analysis. In addition, an analysis of five call attempts was used to show the difference in the response rate.

By looking at each call attempt, the rates at which previously unknown sample units become resolved are determined for each call attempt. This is important because the rates at which the unknown units become resolved are not fixed across the ten call attempts, and this information is vital when trying to establish a suitable eligibility rate to use in the AAPOR method for calculating response rates. In addition, this is important when comparing this method to the CASRO method for calculating response rates.

CALL HISTORY FILES. The prime purpose for undertaking the analyses of call history files is to determine eligibility rates of the eligibility unknown sample units. However, call history files are not commonly referred to and, therefore, it is useful to provide a definition of such a file. A call history file is the file that houses disposition codes (labels) for each call attempt for each sample unit, during the recruitment phase of the survey process. It therefore contains temporary and final disposition codes for each call attempt for each sample unit (AAPOR, 2004). It also contains other information such as the type of recruitment, (for example whether a cold call is made or the intercept recruitment method is adopted), records the time, day, and date when each call was made, and importantly, the telephone number. Eligibility status is not explicitly shown in a call history file. However, if the number is re-called, this does not necessarily mean eligibility status of the number has not been determined. This depends on how the survey agency decides to categorize certain disposition codes. For example, some call history files categorize call backs as calls of known eligibility whereas other call history files categorize these as calls of unknown eligibility. This is so because a screener interview, if conducted, may have been able to establish the eligibility of the number called, in relation to the bounds of the study undertaken. Thus, it is important to examine the call history file, in terms of the disposition codes used, and any relevant documentation before undertaking any analysis. Disposition codes for the two files are shown in Table 84 and Table 85.

Table 84: Disposition Codes, Call History File 1

Disposition (Labels)	*Code*	*Eligibility Status*
No answer	2	U
Busy	3	U
Disconnected/changed	4	I
Answering machine	5	U
Wrong number/ business number	6	I
Language barrier/deaf	7	I
Party not available	8	E
Party terminated (refused)	10	E
Scheduled for call-back	11	U
Terminated by quota	13	I
Party terminated mid-survey	16	E
New number	17	I
Completed interview	20	E

In Table 84 and **Error! Reference source not found.**, a few differences should be noted in terms of the disposition codes categorized as eligible sample units. The first call history file categorized requests for call backs as units of unknown eligibility whereas the second call history file categorized these as units of known eligibility. This was because, for the second call history file, a screener question determined the eligibility status of the household before a request for call back was made.

For the first household travel survey (relating to the first call history file), no attempt was made to convert households that refused to participate, and contacted households in which respondents did not speak English were not called back (this was a function of the bounds of the study, as well as budget). The different temporary and final disposition codes, used in these two call history files, demonstrate the complexity of this analysis as well as highlighting the need for agencies to use the AAPOR standards for temporary and final call disposition codes.

Table 85: Disposition Codes, File 2

Disposition (Labels)	*Code*	*Eligibility Status*	*Disposition (Labels)*	*Code*	*Eligibility Status*
Complete	1	E	Over quota cell	59	I

Hard refusals	2	E	Over quota county	60	I
Second refusals	3	E	No answer	101	U
Disconnected number	4	I	Busy	102	U
System default	6	I	1/2 Busy	103	U
Business number	8	I	Call back specific	104	E
Second language barrier not Spanish	13	I	Call back non-specific	105	E
Second fax machine/ modem	14	I	System default (live number)	110	U
Terminated interview/ Q BR	18	E	First fax machine/modem	127	U
Terminated Q1	50	E	All other reasons	128	U
Terminate out of area	51	I	First refusals	140	E
Bad zip code	52	I	Answering machine	141	U
Terminate Q20	53	E	First language barrier not Spanish	143	U
Terminate Q21 – household count	54	E	Wrong number but second attempt chain – live	144	U
Refused to participate at invite	55	E	Language barrier Spanish	191	U
Refused address component(s)	56	E	Eligible	212	E
Unable/Refuse to reassign date	58	E	Ineligible	213	I

The second call history file had a more detailed breakdown of call dispositions. The research agency was able to provide Spanish speaking interviewers; hence, "language barrier Spanish" was not given an ineligibility status, but rather a status of unknown eligibility after first contact. These households were re-called by Spanish speaking interviewers to determine whether the households were eligible or ineligible. In the report by the AAPOR (2004), it is indicated that language barriers can be allocated an unknown eligibility status if the survey can account for non-English speaking respondents.

Also in the second call history file, a distinction was made between hard and soft refusals:

1. Hard refusals refer to respondents who made it clear that they did not want to participate in the survey and who may have also specifically stated they should not be called back; and
2. Soft refusals (first refusals) were called again. If respondents refused a second time, the disposition was labeled as a second refusal and the household was not called again. These sample units were eligible, which is why they were referred to as "eligible households."

Hard refusals were not re-called; hence, the call disposition is the final call disposition. Fax machines were allocated a separate disposition code. This should be adopted in call history files given that many households may have more than one phone line; however, first contact should be allocated a status of unknown eligibility. If the second call attempt confirmed that the line is dedicated to a fax machine or modem, then the number is given a status of ineligibility because telephone contact with an individual will never take place. The last two disposition codes listed in Table 85 were created to allow for the analysis of the call history file. Once eligibility is established, subsequent call dispositions cannot be categorized as unknown. This too has been suggested in the report by the AAPOR (2004). Therefore, the disposition codes for these households have to be recoded to temporary disposition codes that still represent eligibility. For example, if the request for call back is made after eligibility has been established, the call should be allocated a different disposition code to signify that the household has requested to be called back and that the eligibility status was known and determined as eligible. This clearly demonstrates the need to look across the disposition codes for all call attempts made for each specific number. In addition, it would not make any sense to call back a household determined as ineligible, because such a number has been resolved.

After consulting the documentation and examining the call history files, it was obvious that some disposition codes were incorrectly categorized in the second call history file, in terms of eligibility status.

For example, in the documentation for the second call history file, call dispositions "All other reasons", "Wrong number but second attempt chain – live", and "System default (live number)" were considered as ineligible sample units, which in turn, indicated that these numbers should not have been called again; the numbers were resolved. However, these numbers were called again meaning that these disposition codes should be grouped with the units of unknown eligibility. Correctly re-classifying these numbers was vital for the call history file analyses to yield meaningful results.

ANALYSIS. An important step required was to devise a program that corrected for cases where eligibility was established but on later calls was labeled as unknown (as described above). A temporary or intermediate call disposition code was created. These are shown in Table 85. To create this program, first the data were examined and the disposition codes for calls one to ten were either categorized as eligibility known (eligible and ineligible) or eligibility unknown. For example, the disposition code labeled "refused" was categorized as eligible, the disposition code labeled "over quota" was categorized as ineligible, and the disposition code labeled "machine answering device" was categorized as unknown. These three categories need to be determined to calculate the eligibility rates, where the eligibility rate is defined as the number of eligible units divided by the sum of the eligible units and the ineligible units, which reduces to the number of eligible units divided by the total number of eligibility known units.

Second, for cases when a call back has been determined as an eligible sample unit and is given the disposition of no answer, busy, answering machine, or any other disposition code of unknown eligibility after subsequent call attempts, the program recoded all cases coded "unknown" to eligible. A number cannot be labeled as a known unit and on later calls be given a status of unknown eligibility. For cases that were initially coded as call backs and later determined as ineligible sample units, the program also recoded these cases to ineligible and created a new variable. In addition, running a frequency count, in terms of call disposition codes for call one, enabled the calculation of the eligibility rate for the known units after call one.

Third, another new variable was created to group the eligibility known units (eligible and ineligible). The eligibility known units were allocated the code "0", and the code "1" was allocated to the eligibility unknown units. Finally, a cross tabulation was performed: call one from step three was cross tabulated against call two in step two. By looking at the eligibility unknown column for the variable created in step 3 (coded as 1) and looking at the disposition codes for the variable created in step 2, the eligibility rates for the unknown units (call 2 to call 10,) in the variables created in step 3, were determined by applying the eligibility rate formula.

RESULTS. The results from the analyses of the two call history files are displayed graphically in Figure 27 to Figure 31. In call history file one, no units of known eligibility were called on subsequent calls. Thus, the eligibility rate of the known units is the eligibility rate of the known units determined after the first call; units of unknown eligibility after call one are the sample units called in call two. Given this, the eligibility rate of the unknown units in call one can be determined from call two onwards. For example, the eligibility rate of the unknown units in call one equals the eligibility rate of the known units in call two. This pattern repeats itself for the remainder of the call attempts.

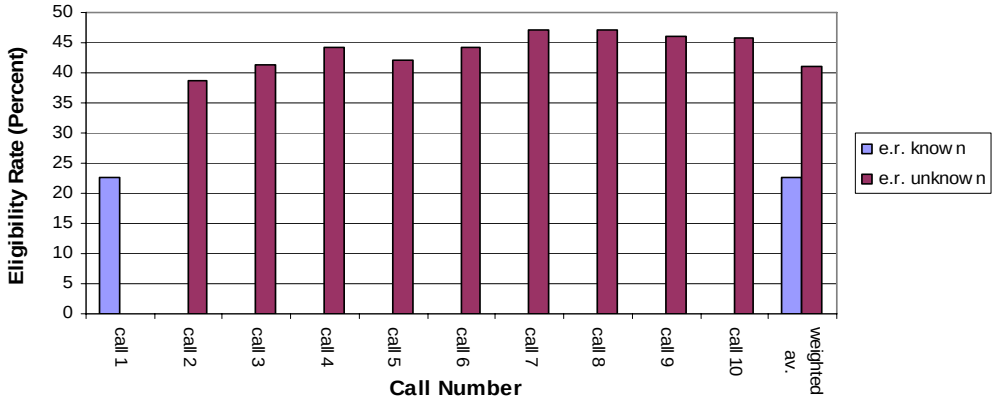


Figure 27: Eligibility Rates for Known and Unknown Sample Units, File 1

Figure 27 shows that there is a substantial difference between the eligibility rate of the known units and the eligibility rate of the unknown units (weighted average) for call history file 1; the eligibility rate of the unknown units is higher than the eligibility rate for the known units. This is surprising and disputes what the CASRO formula states; the eligibility rate of the known units equals the eligibility rate of the unknown units. Despite the eligibility rate of the unknown units in call 1 equaling the eligibility rate of the known units in call 2, the weighted average should be used for the eligibility rate of the entire recruitment process, and not just the eligibility rate of an individual call attempt. If one was assessing the eligibility rate for every call attempt, then the CASRO definition of the eligibility rate would be correct (eligibility rate of the unknown units in call 1 equals the eligibility rate of the known units in call 2).

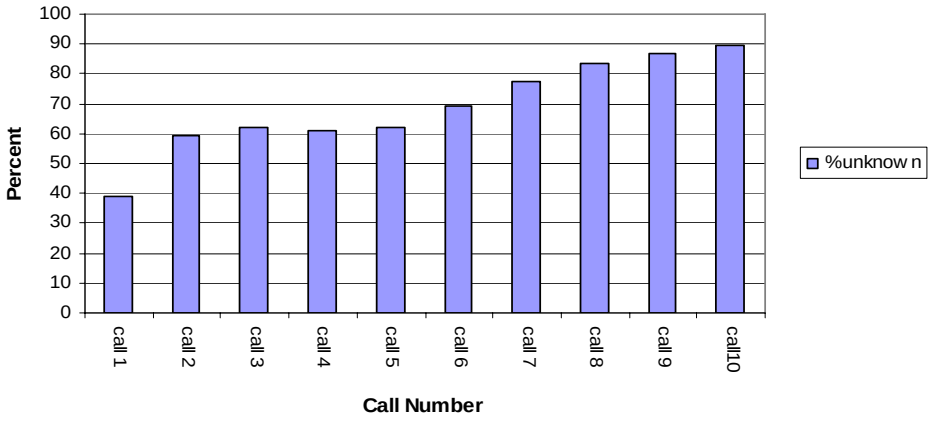


Figure 28: Percentage of Calls that Remain Unresolved After Each Call, File 1

In addition, the percentage of calls for which eligibility status could not be determined (the total number of units of unknown eligibility divided by the total number of calls made on each call attempt), increased as the number of call attempts increased. This is because a high number of the units of unknown eligibility were non-contacts.

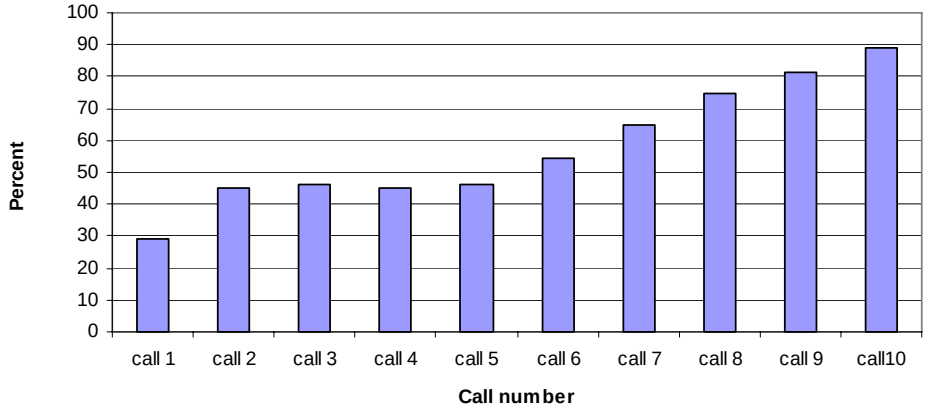


Figure 29: Percent of the Total Calls Made on Each Call Attempt that Were Non-Contacts

For the first call history file examined, the percentage of calls that remain unknown (unresolved in this case because no calls determined as having an eligible status were called back) increased across the ten call attempts. Called numbers whereby contact with an individual did not arise (non-contacts), hence eligibility status is unknown, include call dispositions busy, no answer, and answering machine. Looking at Figure 29, the number of unresolved numbers for call history file one consisted mainly of non-contacted sample units.

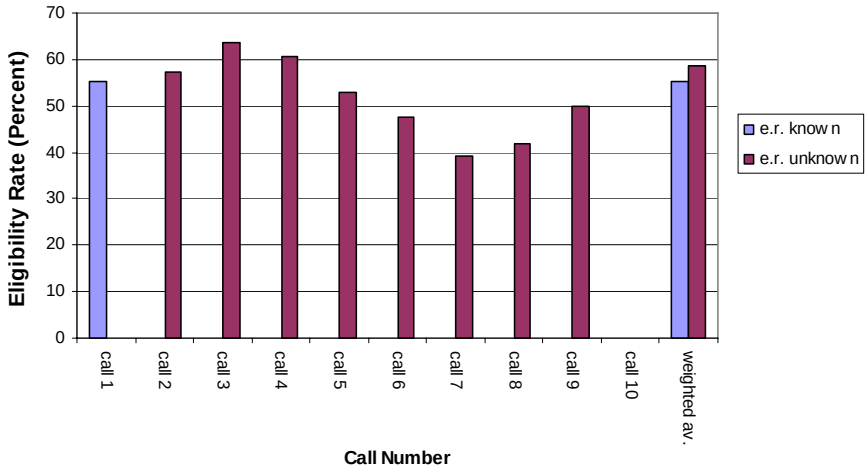


Figure 30: Eligibility Rates for Known and Unknown Sample Units, File 2

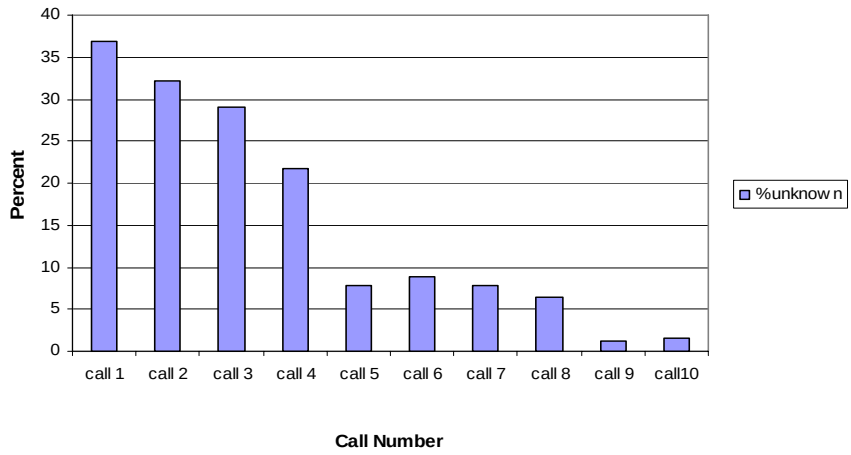


Figure 31: Percentage of Calls that Remain Unresolved after Each Call, File 2

Table 86 shows the response rate for the first household travel survey, using the CASRO and AAPOR formulas. In this case, the CASRO formula yielded a higher response rate. This was expected given that the eligibility rate for the known units was lower than that for the unknown units.

Table 86: AAPOR and CASRO Response Rates, File 1

Statistic	*CASRO*	*Statistic*	*AAPOR*
SR	15064	**SR**	15064
E	117291	**E**	117291
E	e.r. unknown = e.r. of known units = 22.6%	**E**	e.r. unknown = average weighted for ten calls = 41.1 %
U	total unknowns= 174979	**U**	total unknowns= 174979
RR	15064/ 117291+(0.226*174979) = 9.6 %	$RR3_A$	15064/ 117291+(0.411*174979) = 7.9%
*RR	9.3% (-0.3%)	$*RR3_A$	7.6% (-0.3%)

* Response rate if five call limit set

The known and unknown eligibility rates determined for the second call history file are shown in Figure 30. There is only a slight difference between the eligibility rate of the known units and the eligibility rate of the unknown units (weighted average); 55.1 percent and 58.5 percent respectively. It is also important to note that these eligibility rates are in fact weighted averages for nine call attempts because it was not possible to determine the eligibility rate of the unknown units for the tenth call attempt.

As mentioned earlier in this section, this call history file involved calling numbers with an eligible status, on subsequent call attempts. When a cross tabulation was performed, the eligible cases depicted in the known column were the units where eligibility was pre-determined. Hence, performing the cross tabulation enabled the avoidance of double counting of eligible cases. This was not an issue for the first call history file because cases determined as eligible were not called on subsequent call attempts.

Comparing the eligibility rates of the two call history files, the eligibility rates for the second file are much higher than for the first. According to Ellis (2000), the national estimate of residential working numbers is around 41.8 percent. Given that both call history files involve the recruitment phase of the household travel survey, where the eligible unit is a household, the eligibility rates calculated conform to the national estimate.

The eligibility rates for the second file examined are higher. This may be the result of the survey being able to interview households that speak Spanish only; therefore, the eligibility status of these households could be determined. In addition, these sample units were not all pooled with the ineligible sample units, which is part of the denominator in the eligibility rate formula. Importantly, the eligibility criteria will affect the eligibility rates observed, and this will vary across surveys.

Figure 31 shows that the number of calls resolved increased across the ten call attempts. This is also very different to the situation in the first call history file. Figure 32 is very similar to Figure 31, because the number of call-backs and first refusals called in subsequent calls diminished as the number of call attempts increased. These two call dispositions are not non-contacts and are, therefore, not included in Figure 32, hence the similarity between Figure 31 and Figure 32.

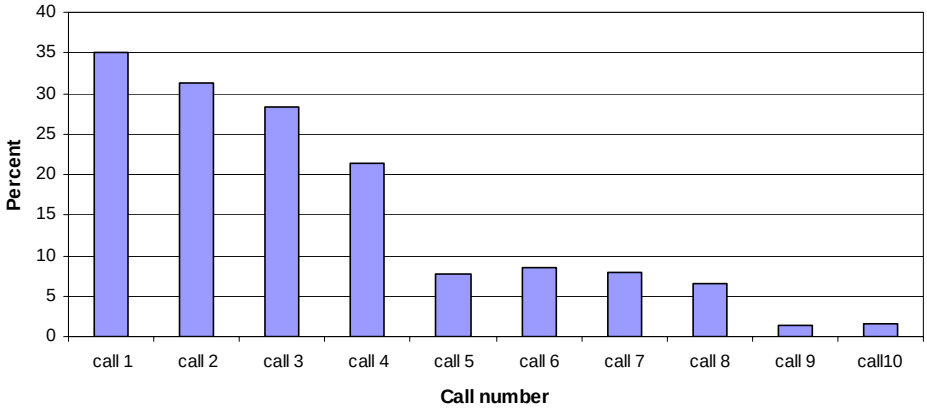


Figure 32: Percentage of Calls Made on Each Call Attempt that Were Non-Contacts

Table 87 shows that eligibility rates estimated using the CASRO and AAPOR methods gave almost identical response rates. This occurred because the difference between the eligibility rate for the known cases and unknown cases was very small.

Table 87: AAPOR and CASRO Response Rates, File 2

Statistic	*CASRO*	*Statistic*	*AAPOR*
SR	3996	**SR**	3996
E	19197	**E**	19197
E	e.r. of unknown = e.r. of known = 55.1%	**E**	e.r. of unknown = average weighted for nine calls = 58.5 %
U	total unknowns= 13029	**U**	total unknowns= 13029
RR	3996/ 19197+(0.551*13029) = 15.2%	$\boldsymbol{RR3_A}$	3996/ 19197+(0.585*13029) = 14.9%
*RR	14.5% (-0.7%)	$\boldsymbol{*RR3_A}$	14.3% (-0/6%)

* Response rate if five call limit set

Another important issue is how to set an appropriate call limit and how this may affect the overall response rate. For example, it has been proposed that non-contact and refusal conversions (that may also involve the temporary dispositions codes non-contacts and requests for call backs), as well as call back requests, should incur a five call limit. After this, the number will remain unresolved. From this research, the change in the conversion of non-contacts, call backs and first refusals, to complete household interviews, as a result of a five call limit instead of a ten call limit, was either non-existent or negligible. Given these results, the effect on the overall response rates is shown in the last rows in Table 86 and Table 87.

The changes in overall response rates, as a result of a five call limit, range from a 0.3 percent reduction to a 0.7 percent reduction. It appears as though the CASRO method is slightly more sensitive to the five call limit than the AAPOR method; the reduction in the response rate for the CASRO method after a five call limit is greater than the reduction in response rate after a five call limit for the AAPOR method. Obviously, for file 2, the decrease in the response rate due to a five call limit is more pronounced than for file 1. This is because many of the unknown units in file 2 were actually resolved by the tenth call. Therefore, setting a call limit to five will decrease the response rate because many of these units are still of unknown eligibility after the fifth call (denominator in response rate calculation).

Section 2.7.1 of the Final Report provides recommendations on the method to use to calculate response rates, while section 2.2.1 provides recommendations on number of contacts.

10.1.3 Standardizing Disposition Codes

Disposition Codes

The analysis in the preceding section also demonstrated that there need to be consistent disposition codes adopted, so that response rates can be calculated correctly. AAPOR has recommended disposition codes for each of the three main types of survey – telephone, face-to-face, and mail. The AAPOR recommended codes are shown in Table 88 to Table 90, respectively. Specifically for transportation surveys, a set of recommended consistent disposition codes have been proposed and are provided in section 2.7.1 of the Final Report.

Table 88: Final Disposition Codes for RDD Telephone Surveys

Primary Disposition	Code	Secondary Disposition			Code
Interview	1.0	Complete			1.1
		Partial			1.2
Eligible, Non-Interview	2.0	Refusal and break off			2.10
		Refusal	2.11	Household level refusal	2.111
				Known respondent refusal	2.112
		Break off			2.12
		Non-contact			2.20
		Respondent never available			2.21
		Telephone answering device (message confirms residential household)	2.22	No message left	2.221
				Message left	2.222
		Other			2.30
		Dead			2.31
		Physically or mentally unable/incompetent			2.32
		Language	2.33	Household-level language problem	2.331
				Respondent language problem	2.332
				No interviewer available for needed language	2.333
		Miscellaneous			2.35
Unknown Eligibility, Non Interview	3.0	Unknown if housing unit			3.10
		Not attempted or worked			3.11
		Always busy			3.12
		No answer			3.13
		Telephone answering device (don't know if housing unit)			3.14
		Telecommunication technological barriers, e.g., call-blocking			3.15
		Technical phone problems			3.16
		Housing unit, unknown if eligible respondent			3.20
		No screener completed			3.21
		Other			3.90

Primary Disposition	Code	Secondary Disposition			Code
Not Eligible	4.0	Out of sample			4.10
		Fax/data line			4.20
		Non-working/disconnected number			4.30
		Non-working number			4.31
		Disconnected number			4.32
		Temporarily out of service			4.33
		Special technological circumstances			4.40
		Number changed			4.41
		Cell phone			4.42
		Call forwarding	4.43	Residence to residence	4.431
				Nonresidence to residence	4.432
		Pagers			4.44
		Nonresidence			4.50
		Business, government office, other organization			4.51
		Institution			4.52
		Group quarters			4.53
		No eligible respondent			4.70

Table 89: Final Disposition Codes for In-Person, Household Surveys

Primary Disposition	Code	Secondary and Tertiary Disposition			Code
Interview	1.0	Complete			1.1
		Partial			1.2
Eligible, Non-Interview	2.0	Refusal and break off			2.10
		Refusal	2.11	Household level refusal	2.111
				Known respondent refusal	2.112
		Break off			2.12
		Non-contact			2.20
		Unable to enter building/reach housing unit			2.23
		No one at residence			2.24
		Respondent away/unavailable			2.25
		Other			2.30
		Dead			2.31
		Physically or mentally unable/incompetent			2.32
		Language	2.33	Household-level language problem	2.331
				Respondent language problem	2.332
				No interviewer available for needed language	2.333
		Miscellaneous			2.35
Unknown Eligibility, Non Interview	3.0	Unknown if housing unit			3.10
		Not attempted or worked			3.11
		Unable to reach/unsafe area			3.17
		Unable to locate address			3.18
		Housing unit, unknown if eligible respondent			3.20
		No screener completed			3.21
		Other			3.90
Not Eligible	4.0	Out of sample			4.10
		Not a housing unit			4.50
		Business, government office, other organization			4.51
		Institution			4.52
		Group quarters			4.53
		Vacant housing unit			4.60
		Regular, vacant residences			4.61
		Seasonal/Vacation/Temporary residence			4.62
		Other			4.63

Primary Disposition	Code	Secondary and Tertiary Disposition	Code
		No eligible respondent	4.70
		Quota filled	4.80

Table 90: Final Disposition Codes for Mail Surveys of Specifically Named Person

Primary Disposition	Code	Secondary Disposition				Code
Returned Questionnaire	1.0	Complete				1.1
		Partial				1.2
Eligible, "Non-Interview"	2.0	Refusal and break off				2.10
		Refusal	2.11	Other person refusal		2.111
				Known respondent refusal		2.112
		Blank questionnaire mailed back, "implicit refusal"				2.113
		Break off questionnaire, too incomplete to process				2.12
		Non-contact				2.20
		Other notification that respondent was unavailable during field period				2.26
		Completed questionnaire but not returned during field period				2.27
		Other				2.30
		Death (including USPS category: deceased)				2.31
		Physically or mentally unable/incompetent				2.32
		Language	2.33	Respondent language problem		2.332
				Wrong language questionnaire sent for needed language		2.333
		Literacy problems				2.34
		Miscellaneous				2.35
Unknown Eligibility, "Non Interview"	3.0	Nothing known about respondent or address				3.10
		Not mailed				3.11
		Nothing ever returned				3.19
		Unknown if eligible respondent in unit				3.20
		No screener completed				3.21
		USPS category: refused by addresses	3.23	Refused to accept		3.231
				Refused to pay postage		3.232
		USPS category: returned to sender due to various USPS violations by addressee				3.24
		USPS category: cannot be delivered	3.25	USPS category: illegible address		3.251
				USPS category: insufficient address on mail from one Post Office to another Post Office		3.252
				USPS category: no mail receptacle		3.253
				USPS category: delivery suspended to commercial mailing agency		3.254
		Unknown whereabouts, mailing returned undelivered				3.30
		Cannot be delivered as addressed	3.31	USPS category: attempted – addressee not known		3.311
				USPS category: postal box closed		3.312
				No such address	3.313	USPS category: no such number	3.3131
						USPS category: no such office in state	3.3132
						USPS category: no such street	3.3133
						USPS category: vacant	3.3134
				Not delivered as addressed	3.314	USPS category: unable to forward	3.3141
						USPS category: outside delivery limits	3.3142
						USPS category: returned for better address	3.3143
				Not delivered as addressed	3.314	USPS category: unable to forward	3.3141
						USPS category: outside delivery limits	3.3142
						USPS category: returned for better address	3.3143
		USPS category: moved, left no address				3.32
		USPS category: returned for postage				3.33

Primary Disposition	Code	Secondary Disposition	Code
		USPS category: temporarily away, holding period expired, unclaimed	3.34
		USPS category: unclaimed – failure to call for held mail	3.35
		USPS category: no one signed	3.36
		Returned with forwarding information	3.40
		Returned unopened – address correction provided	3.41
		Returned opened – address correction provided	3.42
		Other	3.90
Not Eligible	4.0	Selected respondent screened out of sample	4.10

10.2 Q-2: TRANSPORTATION MEASURES OF QUALITY

10.2.1 Definition

A variety of data quality measures have been proposed in this study but, in this section, we consider variables that have not been used elsewhere. The type of variables considered are specific to personal travel surveys and are those that are temporally and spatially stable and, therefore, should acquire similar values among surveys. Special circumstances may cause values to deviate from the norm but, generally, deviations from standard values are an indication of a breach in the quality of the data.

10.2.2 Potential Measures and Their Attributes

For the variables considered in this section, it is necessary to agree on which variables should feature as transportation measures of data quality, what their expected values are, and what deviation from these values should be considered tolerable. It is common practice to compare values from new surveys with those from surveys that are considered reliable. Data sets that are generally considered to produce reliable results include the national census, national household surveys such as the Nationwide Personal Transportation Survey (NPTS) and the National Household Travel Survey (NHTS), or carefully designed and executed local household travel surveys. The Institute of Transportation Engineers published average values of socio-economic, travel, vehicle usage, time-of-day behavior, and network characteristics from 12 urban areas in the U.S. specifically for the purpose of providing such a reference for new surveys (ITE, 1995). Average values from numerous past surveys have also been published in *NCHRP Synthesis 236* (Stopher and Metcalf, 1996) and *NCHRP Report 365* (Martin and McGuckin, 1998).

It is intuitively expected that variables that relate to the characteristics of a traveler rather than the environment in which travel occurs, are more likely to be stable among surveys. For example, it is known that trip lengths are affected by metropolitan size, and mode choice is affected by the level of transit service and road congestion existing in an area. On the other hand, the number of trips made by an individual are primarily determined by the characteristics of the individual. With this in mind, candidate variables investigated for stability in this study were those that characterize the traveler. Variables investigated included:

- The proportion of non-mobile households;
- The proportion of non-mobile persons;
- The average activity rate per household;
- The average activity rate per person;
- The average trip rate (overall) per household;

- The average trip rate (overall) per person; and
- The average trip rates per household and per person for specific trip purposes.

The number of households or persons making no trips during a travel survey are seldom reported in survey documentation. However, the statistic can easily be calculated from the raw data. Values of non-mobile rates from several past studies are shown in Table 91. The values in the table are the percentage of persons or households who reported no travel activity during an observation period of one day.

Table 91: Percentage of Non-Mobiles Observed in Past Travel Surveys

Data	*Percentage Non-Mobile*	
	Persons	Households
NPTS, 1990	21	-
San Francisco, 1981&1990	18	-
Sydney, 1981	22	-
Adelaide, 1977	13	-
Salt Lake City, 1993	18	0.9
Ohio, Kentucky, Indiana Survey, 1990	17	1.6
Dallas Fort Worth, 1996	-	0.8
Southeast Florida Regional Characteristics Study, 2000	-	1.3

The use of non-mobility as a measure of data quality has been suggested in the past (Kitamura, 1995). The premise is that beyond the actual immobility of some respondents, failure to report trip-making reflects a shortcoming in the survey. The reason for respondents failing to report trips actually made are varied. Some do not want to go to the time and effort of reporting them. Others may believe that the travel they made was too insignificant to be of interest to those conducting the survey. Some merely forget the travel they did make or forget to record it. However, in all cases the incidence can be reduced by good survey design and execution.

The portion of recorded immobility that is true inactivity is difficult to estimate because at least some immobility on any given day is elective. For example, older people in particular may often choose to stay home all day. However, statistics are not available on elective immobility as a whole. On the other hand, there are those that are permanently or temporarily incapacitated and unable to travel, and some statistics are available for these cases. In the U.S., approximately 12 percent of the U.S. population is characterized as “severely disabled” and approximately one-third of these people require “assistance with activities of daily living” (U.S. Bureau of the Census, 1997). Individuals are classified as severely disabled if they use a wheelchair, cane, crutches, or a walker, if they have mental or emotional conditions that seriously interfere with everyday activities, if they receive federal benefits based on an inability to work, have Alzheimer’s disease, mental retardation, or another developmental disability, or are unable to work or perform every-day activities such as walk, speak, hear, grasp objects, etc. Those needing assistance with “activities of daily living” are individuals requiring assistance in moving inside or outside the home, getting in or out of bed, bathing, dressing, eating, taking medicine responsibly, using the telephone, preparing meals, etc. Thus, while some of the severely disabled persons may indeed make a trip on any given day, virtually none of those requiring assistance with activities of daily living are expected to make a trip. Therefore, it appears that between four and ten percent of the population is either unable or unwilling to travel due to a disability.

Illness that prevents an individual from traveling is another possible reason why individuals may not travel on any given day. Statistics from the U.S. Bureau of Labor Statistics and from Canadian Statistics suggest that, on average, the number of days lost per worker due to injury or illness is seven days per annum (Bureau of Labor Statistics, 2003, Statistics Canada, 2002a). Thus, on any given day a worker would have approximately a two percent (7/365) chance of missing work due to injury or illness.

What proportion of these workers would make no trips is not known but the statistic does show that the source of immobility due to illness is small relative to that due to disability.

Activity rates, like non-mobility rates, are statistics that are seldom reported. Because activity levels are intuitively expected to be more a function of the characteristics of an individual or household rather than their location, activity levels could be expected to remain relatively stable among surveys. The activity rates of a few activity-based surveys are shown in Table 92.

Table 92: Activity Rates from Selected Travel Surveys

Data	*Number of Activities Per Day*	
	Per Household	Per Person
Salt Lake City, 1993	13.3	4.2
Ohio, Kentucky, Indiana Survey, 1990	13.5	5.3
Dallas-Fort Worth, 1996	9.1	-

The activity rates between the Salt Lake City and Ohio, Kentucky, Indiana Survey are relatively similar, but different to the household activity rate in Dallas-Fort Worth. One of the major obstacles in obtaining similar activity rates is the difference in the classification of activities among surveys. The issue of standardized time use activities has been the subject of several endeavors in the past decade. The United Nations Statistical Office has developed a Trial International Classification of Activities for Time Use Statistics (ICATUS) that is "… an international classification of activities for time use statistics that is sensitive to the differences between women and men in remunerated and unremunerated work" (UNSD, 1997a and UNSD, 1997b). In Europe, an alternative time use classification scheme was developed for the Harmonized Time-Use Study Project (Eurostat, 1996). However, there has not been widespread acceptance of these proposed standards and alternative classification schemes have been developed by several agencies in the United States, Canada, and Australia (Hoffmann and Mata, 1997; UNSD, 1997c; UNSD, 1998; Harvey, 2001).

Activity classification schemes require specification of both **what** is done and the **context** in which it is conducted (Hoffmann and Mata, 1997). This is because an activity is qualified by its setting. For example, cooking (as an activity) for one's own family is quite different to cooking as a commercial activity, and caring for a family member is different to providing care to a stranger in a hospice. The classification schemes that are currently under development take these factors into account. However, they are different from each other, and until a single, standardized activity classification system for transportation is established, it will not be possible to identify standard activity rates.

Reviewing past experience on the stability of trip rates among surveys suggests that there is indeed a degree of stability among the values. A review of more than 50 recent urban travel surveys in *NCHRP Synthesis 236* (Stopher and Metcalf, 1996) show that the number of trips per person per day can be expected to range between 3.5 and 4.5, and trips per household per day between 8 and 11 (Stopher and Metcalf, 1996). This is also supported by the research which led to publication of NCHRP 365 – the update of standard trip-making characteristics first established in NCHRP 187 in 1978 – that household trip rates vary between 8.5 and 9.2 trips per household per day (Martin and McGuckin, 1998). Household trip rates from a number of studies, including those from NCHRP 187 (Sosslau et. al, 1978), 236, and 365, are shown in Table 93. The data in Table 93 appear to support the contention that the average household trip rate falls within the range of 8-11 person trips per day.

Table 93: Average All-Purpose Household Trip Rate from Recent Travel Surveys

Data	*Survey Date*	*Source*	*Person trips/hh/day*
San Francisco	1981	ITE, 1995	8.71
Albany, NY (Capital District)	1983	ITE, 1995	8.25
Houston-Galveston	1984	ITE, 1995	9.32
Denver, CO	1988	ITE, 1995	7.89
Philadelphia, PA – Southern N.J.	1989	ITE, 1995	7.81

51urban travel surveys	1990-1995	NCHRP 236	8.91
Home interview surveys	1956-1976	NCHRP 187	7.6-14.1
12 urban travel surveys & NPTS 90	1985-1990	NCHRP 365	8.5-9.2
Ohio, Kentucky, Indiana Survey	1990	-	10.03
Salt Lake City	1993	-	13.8
NPTS 95	1995	NPTS 95	9.73
Baton Rouge Personal Tr. Survey	1997	LTRC/LSU	9.69
Dallas/Fort Worth	1996	NCTCOG	9.47
Nashville, Memphis, Knoxville, TN	1998-2003	Everett, 2003	8.04 - 8.44
South East Florida	2000	-	7.19
Florida	-	Schiffer, 2003	7.31 - 9.80
Twin Cities (urban)	2001	Filipi, 2003	10.3
Twin Cities (rural)	2001	Filipi, 2003	9.5
Oregon	1996	Ayash, 2003	7.8
Atlanta (SMARTRAQ) (day 1)	2001-2002	Rousseau, 2003	8.31
Atlanta (SMARTRAQ) (day 2)	2001-2002	Rousseau, 2003	7.95

As pointed out by Stopher and Metcalf (1996) in *NCHRP Synthesis of Highway Practice 236*, measuring trip rates is not without ambiguity. First, there is seldom a clear specification of whether the trip reported is a linked or unlinked trip. A single linked trip between an origin and destination consists of two or more unlinked trips (or, synonymously, segmented trips) if the traveler changes mode, or if the trip is interrupted to drop off or pick up a passenger (Stopher and Metcalf, 1996; RTI, 1997). In transportation planning, linked trips are typically used, and unlinked trips are combined to form linked trips before analysis begins. Reported trip rates are typically linked trip rates but care must be taken to ensure that this is the case since unlinked trip rates will inevitably be higher. Second, the definition of a trip has not been standardized and this can affect the observed rates. Specifically, the inclusion of all non-motorized travel and the inclusion of very short trips can alter the number of trips recorded. Third, the issue of weighting, employed to adjust the sample for bias, can affect trip rates. Weighting is conducted in a variety of ways during the processing of travel survey data, and the procedure used can affect the weighted trip rate. More importantly though, is knowing whether the reported trip rate is of weighted or unweighted trips. Weighted and unweighted trip rates can be quite different, as demonstrated in the NPTS 95 data where the weighted household trip rate is 10.5 compared to 9.7 for the unweighted trips. In most studies, if not specified, unweighted trip rates are reported. Fourth, care must be taken to ensure that the trips reported are person trips and not vehicle trips, since both are often reported in travel survey results.

Household trip rates by purpose are shown in Table 94. The values average 1.7, 4.7, and 2.8 person trips per day for home-based work, home-based other, and non home-based trip purposes, respectively. This implies an average all-purpose household trip rate of 9.2 person trips per day, which is consistent with the rates shown in Table 93.

Table 94: Average Household Trip Rate by Purpose from Recent Travel Surveys

Data	***Survey date***	***Source***	***Person trips/hh/day***		
			HBW	HBO	NHB
San Francisco	1981	ITE, 1995	1.89	-	-
Houston-Galveston	1984	ITE, 1995	1.72	4.65	2.95
Philadelphia, PA – Southern N.J.	1989	ITE, 1995	2.14	4.03	1.64
Ohio, Kentucky, Indiana Survey	1990		1.72	-	-
Salt Lake City	1993		1.66	4.93	-
NPTS 95	1995	NPTS 95	1.56	4.99	3.03
Baton Rouge Personal Tr. Survey	1997	LTRC/LSU	1.57	4.94	3.18
Dallas/Fort Worth	1996	NCTCOG	1.63	4.68	3.16

A problem with measuring trip rates at the household level is the impact household size has on the results. The effect of household size can be eliminated by observing trip rates per person. However, this will not necessarily reduce the variation in trip rate values because of the different levels of aggregation at which the two trip rates are measured. The Coefficient of Variation (COV) of the trip rates per person in Table 95 is 0.20 while the COV for the household trip rates shown as single values in Table 93 is 0.17. The average all purpose trip rate in Table 95 is 3.38 trips per person per day.

A review of the trip rates per person by purpose revealed considerable variation among the data sets considered in this study. Subsequently, we were unable to identify representative values that could function as useful reference values.

Recommendations on mobility rate per person and per household, and on trip rates per household as transportation measures of quality are provided in section 2.7.2 of the Final Report, together with reference values for each measure.

Table 95: Average All-Purpose Person Trip Rate from Recent Travel Surveys

Data	*Survey Date*	*Source*	*Person trips/person/day*
San Francisco	1981	ITE, 1995	3.40
Albany, NY (Capital District)	1983	ITE, 1995	2.05
Houston-Galveston	1984	ITE, 1995	3.48
Denver, CO	1988	ITE, 1995	2.54
51urban travel surveys	1990-1995	NCHRP 236	3.50
Ohio, Kentucky, Indiana Survey	1990	-	3.87
Salt Lake City	1993	-	4.23
NPTS 95	1995	NPTS 95	3.76
Baton Rouge Personal Tr. Survey	1997	LTRC/LSU	3.70
South East Florida	2000	-	2.30
Atlanta (SMARTRAQ) (day 1)	2001-2002	Rousseau	3.90
Atlanta (SMARTRAQ) (day 2)	2001-2002	Rousseau	3.80

10.3 Q-3: COVERAGE ERROR

10.3.1 Definition

Coverage error in surveys is the error incurred by having a sampling frame that deviates from the survey population. It has been described as the "failure to include some units, or entire sections, of the defined survey population in the actual operational sampling frame" (Kish, 1965), or the error that "results from every unit in the survey population not having a known, non-zero chance of being selected" (Dillman, 2000). However, in addition to the "under-coverage" which results from exclusion of valid units in the sampling frame, it is also the unintentional inclusion of units in the survey sample (including duplication of units) that do not belong there (Kish, 1965 p. 529; Statistics Canada, 1998, p. 16). This "over-coverage" can occur, for example, when telephone numbers are used as a sampling frame in a random digit dialing (RDD) sampling process, and households with multiple telephone lines are, subsequently, sampled at a higher rate than those with a single line. Similarly, "under-coverage" can occur in the same type of survey because some households do not own a telephone or have interrupted telephone service.

Coverage error is distinct from non-response error although both result from not obtaining information from units in the survey population. Coverage error results from not having some units in the

sampling frame, or from having units in the sampling frame that do not belong there. Non-response is failing to obtain a response from units that are within the sampling frame.

Coverage error does not include *intentional* deviation of the sampling frame from a complete and accurate listing of the population (Kish, 1965). In travel surveys, certain portions of the population are often intentionally excluded from the sample frame, either because they do not contribute in any meaningful way to travel in the area, or they are too difficult to survey. For instance, household travel surveys exclude those in hospital and in prison from the sampling frame, and usually exclude households living in group quarters such as military barracks or university residence halls. Even children under the age of 5 have typically been excluded from the sampling frame because they were considered to generate virtually no trips of their own. This may change as more children under the age of five are placed in day-care centers, nursery schools, and pre-Kindergarten classes and they begin to generate significant travel of their own. However, the intentional omission of these sections of the population from the sampling frame are considered a redefining of the survey population and not a contribution to coverage error.

10.3.2 Potential as a Measure of Survey Quality

Coverage error is seldom estimated and rarely reported in travel surveys. Among the eleven data sources reviewed and analyzed for various purposes in this study (the Research Triangle survey is not included, because of lack of documentation), none were found to have estimated and reported coverage error. However, coverage error can be significant and, therefore, it is important that it be measured and reported as a means of assessing the quality of data. Establishing a standardized method of measuring coverage error, and recommending that it be estimated and reported in all future surveys will provide a useful additional measure of the quality of survey data in the future.

Two alternative procedures are typically used to estimate coverage error (Kish, 1965). The first involves a second survey with improved procedures and good sampling frame where coverage error is supposedly absent or, at least, substantially diminished. With this method, comparison between the original survey and the results from the improved procedure provide an estimate of coverage error. The method is expensive and is generally not appropriate in all but large surveys with big budgets. The second alternative is to estimate the population of the study area using the sample, and compare it with an estimate of the population from an external source. The estimate of the population using the sample is obtained by multiplying the sample population by the inverse of the sampling rate to produce an estimate of the total population. External estimates of the population are obtained from sources with low coverage error, such as the decennial Census or the Current Population Survey (CPS) (Zimowski *et al.,* 1997a). The CPS is a sample survey conducted monthly by the U.S. Bureau of the Census for the Bureau of Labor Statistics to produce a variety of statistics on employment and related items. The sample frame used in the CPS is an updated version of that used in the last census. Coverage error in the CPS is currently estimated at 7.4 percent (U.S. Bureau of the Census, 2000). Interestingly, coverage error in the CPS has increased in the last two or three decades, because it was 3.7 percent in the mid 1970s (U.S. Bureau of the Census, 2000).

Coverage error is traditionally measured by the extent to which the population is accurately measured by the sample frame (U.S. Bureau of the Census, 2000). A statistic which achieves this is the following formulation which measures the percentage error in population estimation resulting from deviation of the sampling frame from the true population (Kish, 1965):

$$CE = (1 - \frac{F_x}{\tilde{X}})100$$

where:

CE = coverage error in percent

F_x = sample population multiplied by the inverse of the sampling rate
$\tilde{X}$ = population from an external source.

If the sample consists of a disproportionate stratified sample, the population estimated from the sample (F_x) is the sum of the individual products of the sample population and inverse of the sampling rate over the strata. The sampling rate used in this expression is the planned sampling rate and not the sampling rate ultimately obtained in the survey. That is, it is the sampling rate designed for the survey and, subsequently, is not affected by refusals, non-contacts, non-response, or incomplete responses.

It should be noted that the measure of coverage error in this equation provides an estimate of the net effect of over-coverage and under-coverage. For example, in a telephone interview using RDD, the sampling frame would be all residential telephone numbers in a study area, and an accurate estimate of the population of telephone-owning households would be obtained if each household had one telephone and the sample size divided by the sampling rate were multiplied by the average household size. However, those households with multiple telephone lines have a higher chance of selection and, if the average household size is different among these households to that among the remainder of the telephone-owning households, an incorrect estimate of the population will be obtained. Similarly, if the average household size among those with interrupted telephone service is different to those with full service, an incorrect estimate of the population would be obtained. The presence of households without telephone service reduces the estimate of the population to an estimate of the population in telephone-owning households only. In the presence of all of these conditions, as is typically the case, only the net effect of these over-, under-, and zero-cover conditions would be observed because one condition plays off against the other.

Generally, over-coverage in RDD surveys can be eliminated by weighting households with multiple lines so that they reflect the same chance of selection as a household with a single telephone line. This can be achieved because information on the number of voice lines used by the household can be gathered during the interview. If over-coverage due to multiple telephone lines is eliminated through weighting, the remaining coverage error in a RDD survey will be reduced to reflect under-coverage only. This would make measurement of coverage error more useful as a measure of data quality. Consequently, it is recommended that over-coverage caused by multiple telephone lines be eliminated by weighting whenever possible, to allow the coverage error measure to reflect more accurately the level of under-coverage present in the sample.

The level of under-coverage can be quite high in certain types of surveys. For instance, the number of households without telephone service was estimated at 2.4 percent by the U.S. Bureau of Census in 1997 (U.S. Bureau of the Census, 2000). From the Nationwide Personal Transportation Survey (NPTS) of 1995, a further 2.2 percent of households in the U.S. are estimated to have interrupted telephone service. Those with interrupted or no telephone service are not a random selection from the population. Analysis of the Public-Use Microdata Sample (PUMS) data has shown that low phone ownership is more common among low income groups, persons below 25 years of age, and African Americans (Federal Highway Administration, 1998). Research conducted by Banks *et al.* (2001) compared the demographic and travel characteristics of people with a history of interrupted telephone service with those with no telephone service and found that there are significant differences between the two groups. People in households with interrupted telephone service were more likely to own their home, have more workers in the household, and have more vehicles available than people in households without telephone service. Thus, while both groups are poor, any weighting that may be applied to try to adjust for this under-coverage would need to take these differences into account.

Coverage error can be reduced by weighting, if it is known how to weight respondents in the sample so that they represent the entire population. Sometimes, as in the case of multiple-line households, the appropriate weighting can be determined easily. However, when the characteristics of those omitted from the sample frame are not well understood, it is difficult to determine appropriate weights. In this case, it would probably be more appropriate not to attempt to effect any change to the sample and merely

estimate the coverage error on the sample as is. However, for coverage error that can be reliably corrected with weighting, these corrections should be made to the sample before the estimation of coverage error using the equation above.

Interpretation of what constitutes acceptable levels of coverage error will remain subjective. One suggestion is that good surveys should produce CE values of less than ten percent (Kish, 1965). Considering the level of telephone ownership quoted above, surveys using the RDD sampling process may be able to achieve such values. However, if "do not call" lists are commonly perceived to include research surveys, if more households make exclusive use of cell phones, if cell phone numbers are not included in the sample frame, and if devices such as caller ID effectively eliminate certain numbers from the design sample, then much higher coverage errors will be produced. Recommendations on coverage error are provided in section 2.7.3 of the Final Report.

10.4 Q-5: PROXY REPORTING AS A QUALITY INDICATOR

10.4.1 Introduction

As discussed in section 5.2 of this Technical Appendix, proxy reporting in a travel survey is the reporting of one person on behalf of another. Sometimes it is necessary to perform proxy reporting, because some persons in the household are too young to answer the questions themselves, individuals are temporarily incapacitated due to illness or injury, or they are permanently incapable of answering questions due to language difficulties or mental incapacity. However, beyond these cases, proxy reporting also occurs when participants feel little commitment to the survey or the survey is conducted in such a manner as to make individual participation less of a requirement than is desirable. This latter condition occurs, for example, when data are retrieved by telephone and the person answering the telephone is encouraged by other members of the household, or is forced by their absence or refusal to talk on the telephone, to provide the information required. Thus, while proxy reporting is unavoidable in some cases, it is also susceptible to survey design and the method of survey execution.

Because proxy reporting affects the accuracy of the data, it is reasonable to suggest that more proxy reporting is likely to lead to less accuracy in the data. Accuracy is an important component of data quality and, therefore, it is suggested that the incidence of proxy reporting can be used as a measure of data quality of the data set. This section addresses that issue.

10.4.2 Proxy Reporting as a Quality Measure

Proxy reporting is known to bias reported data (Richardson *et al.*, 1995, p. 49; Greaves, 2000). Analyzing data from the 1995 Nationwide Personal Transportation Survey (NPTS), Greaves (2000) found that among persons over the age of 13 (children were not permitted to report their own travel in the survey), those that completed a diary and reported their own trips had, on average, trip rates that were 21 percent higher than those who completed a diary but had someone else report the data. Among those who did not complete a diary, self-reported trip rates were 63 percent higher than those using proxy reporting. However, of even greater significance was the fact that these differences were not consistent among the different trip purposes; in some cases proxy reporting produced higher trip rates than self reporting. For trip purposes involving regular trip activity such as work and school trips, proxy reporting tended to overestimate the trip rate while the more spontaneous or discretionary trips such as non-home-based trips were severely underestimated. Thus, while proxy reporting displays a clear impact at the aggregate level, its impact is even larger at the disaggregate (i.e., individual or household) level.

To use the incidence of proxy reporting as a measure of data quality, the definition, measurement, and interpretation of proxy reporting must be standardized. That is, a common understanding of what proxy reporting is, how it is measured, and how the results are interpreted, must be formulated so that a consistent expression of this measure can be generated in each data set. Each of these aspects is discussed more fully below.

First, there is currently no definition or common agreement among survey practitioners of what constitutes proxy reporting. The general concept of proxy reporting is easily understood, but its application in practice is often more difficult. For example, if a person filled in a travel diary but does not personally report the information in a CATI retrieval, is that proxy reporting? That is, is proxy reporting linked to the reporting or recording activity? Similarly, how much information must be supplied by another person for a response to be qualified as a proxy response? For example, if a person recorded their own personal information but someone else furnished their travel information, would this qualify as a proxy response or not? The complexity of the possible forms of proxy reporting are demonstrated by an analysis of the 1995 Nationwide Personal Transportation Survey (NPTS) in which the questions "Is this a proxy interview?" and "Who completed the diary?" were both asked.

Table 96 shows the joint answers to these questions from all persons over the age of 13. The 1995 NPTS survey involved telephone recruitment, a mail-out travel diary in which household members were to record their travel on the travel day, and a CATI retrieval of all the information after the travel day. Table 96 shows that while approximately 22 percent of total sample provided information by proxy (17,608/81,252), almost half of those (8,497/17,608) filled in their own diary. Another quarter (4,022/17,608) had someone else complete their diary, while most of the remainder had no completed diary at all. Thus, among the reports that were classified by the respondents themselves as proxy reporting, considerable variation in the level of involvement of both the proxy reporter and the subject is evident. Review of the self reported cases is equally interesting. Approximately two-thirds of the self reporters completed their own diaries (41,154/63,644), but some (3,831) reported on diaries completed by someone else, and most of the remainder (10,605+7,939), or 29 percent of the self reporters, reported their own travel without having completed a diary. Thus, there is again a clear difference among the cases in this category although it is perhaps not as large as among the group of self-professed proxy reporters because in this case the majority of cases involve the subjects reporting on their own behavior or personal characteristics.

Table 96: Proxy Reporting of Persons over 13 years of Age in NPTS 95

		Who completed the diary?					
		Self	Other	No one	No diary	Missing	Total
Proxy interview?	Yes	8,497	4,022	3,178	1,873	38	17,608
	No	41,154	3,831	10,605	7,938	116	63,644
Total		49,651	7,853	13,783	9,811	154	81,252

Second, there is a need to ensure that the information necessary to define whether a report is a proxy report or not is included in the data. Merely asking a respondent whether they are making a proxy report or not will, on its own, not be sufficient to distinguish among cases. Information must be provided to allow the analyst to determine whether the subject is someone who could report their own information, whether the subject recorded the information being reported, and whether the person reporting the information is also the subject. It is suggested that information of this nature is needed in both interview and self-administered surveys so that an estimate of proxy reporting can be obtained irrespective of the type of survey conducted. It has been suggested in the past that self-administered questionnaires do not afford a reliable means of determining proxy reporting but even interview-type surveys rely on the integrity of the respondent for some of the information needed to identify a proxy report. Because there is relatively little incentive for a respondent to falsify information on, for example a question on who

prepared the information being reported, it would seem advantageous to include questions that allow identification of proxy reporting in all types of surveys.

Third, there is a need to evaluate the levels of proxy reporting produced. That is, how are levels of proxy reporting to be interpreted in terms of data quality? Beside the necessary proxy reporting for children and those unable to participate in the survey at the time, the tolerable level of proxy reporting among other household members needs to be specified.

Looking at the analysis reported in Table 97, it is clear that even a relatively moderate level of proxy reporting (22%, based on Table 96) can induce large errors in certain trip purposes. At the same time, not all capable respondents are likely to participate. Diehard refusals are probably better handled using proxy information rather than spending an inordinate amount of effort to convert the individual or forego all information on the individual entirely. Using the example of the NPTS 95 data shown in Table 96, the number of proxy reports would be 4,022+3,178+1,873+3,831, or 12,904 out of the 81,098 cases for which the source of the information is known. Thus, using the above definition, the level of proxy reporting in the NPTS 95 data is 15.9 percent (12,904/81,098).

To be able to estimate the level of proxy reporting as defined above, the necessary information must be included in the data. Thus, it is necessary to record in each data set information that would allow the suitability of the subject to be determined (e.g., age, language barrier, sickness) as well as information similar to that recorded in the NPTS 95 data which asked "Who completed the diary?" If no diary is involved, respondents are to be asked whether they are reporting on behalf of themselves or someone else. If no interview is involved, a question is to be included in the questionnaire or diary asking the respondent to state whether they are reporting their own data or that of someone else. These questions must be posed in the questionnaire for mail-back responses, and to the respondent for telephone retrieval and/or telephone surveys. The options for each of the above questions should be "self", "someone else", or "no one". If the data which are reported have been prepared, or recorded, by the subject, then it is self-reported irrespective of whether that person actually reports the information or not and irrespective of whether the information was prepared in advance, involved writing it down, or was generated spontaneously at the time of data collection. When it is not known who prepared or recorded the data transmitted, the case is omitted from the calculation of the level of proxy reporting in the data.

Table 97: Differences Between Proxy and Self Reporting in the 1995 NPTS (Greaves, 2000)

Category	***Purpose***					
	Home-Work	*Home-School*	*Home-Shop*	*Home-Other*	*Non-Home-Based*	*Total*
Self, Diary	0.89	0.11	0.70	1.73	1.82	5.26
Proxy, Diary	0.99	0.22	0.49	1.35	1.28	4.33
Self, No Diary	0.89	0.14	0.45	1.18	1.19	3.75
Proxy, No Diary	0.67	0.22	0.22	0.70	0.50	2.30
Total	0.86	0.14	0.57	1.46	1.49	4.52

Other data sets that have information on proxy reporting, such as the North Central Texas Council of Governments (NCTCOG) data, have different questions identifying proxy reporting which makes the comparison difficult. For example, in the NCTCOG data the question was asked during the telephone retrieval "what is your relationship to the person who filled out the form?" However, the questionnaire that was sent out in advance of the travel day and which the respondents used to record their household, vehicle, and travel information, informed them that while telephone retrieval would be conducted they should mail back their completed questionnaires. Under these circumstances, individual respondents were less likely to provide their own information during the telephone retrieval. Of the 12,172 persons in the sample, 4,711 (39%) identified themselves as the person who filled out the form suggesting that the rate of proxy reporting was 61 percent. However, with the definition of proxy reporting suggested above, the true rate of proxy reporting could only be determined if information on who completed the questionnaires

relative to the subject of each questionnaire was provided. Recommendations on using proxy reporting as a data quality measure are provided in section 2.7.4 of the Final Report.

10.5 Q-6: VALIDATION STATISTICS

10.5.1 Definition

Validation is the process of verifying the authenticity of collected data by recontacting a sample of households. It is used in interview-based surveys to determine whether the interviewer actually conducted the interview and whether the information obtained is accurate (TMIP, 1996, p. 6-171). It can also be used in self-administered questionnaires where the validation survey then usually involves a face-to-face or telephone interview to check the quality and completeness of data (Richardson *et al.,* 1995, p. 241).

Validation surveys typically involve a limited set of key questions only. These usually include identifying and trying to make contact with the person involved in the original survey, and verifying a few trips reported by the respondent. Validation surveys are conducted to ensure the authenticity and integrity of the data.

10.5.2 Design and Use of Validation Surveys

Validation surveys have been relatively rarely performed in travel surveys in the past. From a review of nine recent studies (1991 California Statewide Survey, 1993 Wasatch Home Interview Travel Survey, 1995 Origin Destination Survey For Northwestern Indiana, 1996 Bay Area Travel Survey, 1996 Broward Travel Characteristics Survey, 1996-97 Corpus Christi Study Area Travel Survey, 1997-98 Regional (New York, North Jersey) Travel Household Interview Survey, 1998-99 Greenville Travel Study, and the 2000 Southeast Florida Regional Travel Characteristics Survey), only one reported conducting a validation survey. Validation surveys are not popular because of the time and effort involved and the need to explain to each interviewee why they are being contacted again. However, the mere fact that interviewers know that validation surveys will be conducted is often enough to discourage them from being lax in the execution of the survey, or, in extreme cases, of falsifying information (Richardson *et al.,* 1995, p. 248). A second advantage is that validation surveys provide information that can be used to assess the quality of the survey data. To use statistics from validation surveys to assess the quality of a survey, variables that feature in the statistic must be identified, their combination in a statistic must be formulated, and the ability to interpret the values must be developed.

Each interview in the validation survey must be conducted by someone different to the one who conducted the initial interview. Validation surveys must be conducted progressively throughout the travel survey so that problems can be identified and remedied, and interview standards are maintained throughout the study. Whenever possible, the validation survey must be conducted with the initial respondent.

The questions included in the validation survey must not be verbatim quotes from the earlier survey but, rather, should express the same question in different terms. Also, the questions should be phrased as if further information is being sought, rather than that the purpose is to verify the integrity of the data gathered earlier. The questions should not ask for detail that the respondent has difficulty in recalling, while still asking something that would be difficult to guess. For example, in validating a trip, a feature that is relatively easy to remember but difficult to fabricate, is the approximate time spent at the destination of the trip, or the number of accompanying persons on the trip.

It is suggested that the following set of core questions be included in every validation survey conducted:

1. Did you complete the initial survey? (yes or no). If "yes", go to question 3 below. If "no", go to the second question below.
2. Did someone else in your household complete the survey? (yes or no). If "yes" go to question 3 below. If "no" terminate the validation survey.
3. Select a trip that the respondent is likely to remember from among the trips reported in the initial survey and note the time spent at the destination. Ask the respondent to recall the trip in question and to report the approximate time spent at the destination.

If the answers to both of the first two questions are negative, then these two questions identify a household that apparently was never surveyed. This may be due to a lack of knowledge on the part of the person being interviewed, forgetfulness, or a case of genuine falsification of an entire interview. The interviewer conducting the validation survey must discretely determine which one of these possibilities is the most likely. For those who admit to being interviewed, the third question provides a brief check on the trips reported. Due to the difficulty of recall, only large differences should be considered evidence of possible falsification.

The tolerable limits of falsified information are a matter that must be decided by each agency commissioning a travel survey. The main purpose of the validation survey is to identify and remedy problems within the survey company. An indirect purpose is to act as a disincentive to interviewers when they know that validation surveys are conducted. Falsification of data by interviewers is likely to be dealt with very severely in survey companies. However, anecdotal evidence suggests that it does exist and that, under pressure to reach certain goals, interviewers will develop very innovative ways in which to introduce such data. Statistical analysis of reported data is often used to detect the lack of randomness, and particularly the change in the relationship among variables that characterizes falsified data (Richardson *et al.,* 1995, p. 248-249). Validation surveys may be directed to cases identified through such analysis. Recommendations on using validation surveys, and suggested acceptability levels are provided in section 2.7.5 of the Final Report.

10.6 Q-7: DATA CLEANING STATISTICS

10.6.1 Definition

Data cleaning or data checking is an activity that is conducted almost routinely in travel surveys. It involves checking and, where possible, correcting data values that can be identified as being incorrect. It is usually performed as soon after the data are retrieved as possible. This is to enable queries to be made while the information is still fresh in the memories of the respondents. For errors that are caused or accentuated by the survey process, it also allows timely correction.

10.6.2 Data Cleaning and Its Use as a Quality Indicator

A review of nine recent travel surveys showed that all of these studies conducted error checking with subsequent call-backs to respondents and correction of data where possible. Thus, it is common practice to perform data cleaning. What is not common is to use statistics of this operation in assessing the quality of the data. If the incidence of errors is assumed to be indicative of data quality then statistics of error incidence can serve in this role.

Current practice of detecting and correcting errors in travel survey data tends to vary from survey agency to survey agency. While it is common practice to call respondents back to retrieve missing data on critical data items, the feasibility and logic checks used by agencies, and the practice of calling respondents back on these items, varies from agency to agency. There is also no common definition of what the critical data items are with the result that counting how many "errors" or queries are identified in a survey is not a good measure of data quality. What is needed is a standardized list of data items that are "critical" for the purpose of counting missing values, and a standardized set of checks to detect out-of-range, inconsistent, or illogical responses in data. In addition, the "flagging" of such cases in the data and the statistics that are derived from these values must be a required feature of future travel surveys so that they can be easily detected.

Ideally, error checking should be conducted at the time of data collection by the interviewer (Richardson *et al.,* 1995, p. 264). CATI and CAPI surveys can help achieve this by incorporating range, logic, and consistency checks in the program, as well as procedures that detect missing information beyond merely missing information on a data item. For example, if the travel portion of the survey does not include travel on every person in the household, the interviewer should be prompted to verify that the person or persons who reported no trips were indeed immobile during the survey period. In self-administered surveys, illegible writing, misspelled street names, and illogical or inconsistent statements, must be addressed by the reviewer as soon after self-administered surveys are returned as possible.

The number of variables differs from survey to survey. In addition, the potential to generate missing values or erroneous responses differs from variable to variable. For these reasons, it is recommended that the estimation of data quality from the data cleaning process be restricted to the data cleaning required among the set of core questions recommended for a travel survey (see "Minimum Question Specifications" in section 4.1). Using a fixed set of variables allows an equitable comparison among data sets. The following index provides a mechanism to measure the incidence of cleaned data items in a data set:

$$\text{Data Cleaning Statistic (DCS)} = \frac{\sum_{n}^{N}\sum_{i}^{I} count(x_{i,n})}{N \times I}$$

where,

$x_{i,n}$ = ith data item of respondent n

$$count(x_{i,n}) = \begin{cases} 1 \text{ if i}^{th} \text{ data item of respondent n was cleaned} \\ 0 \text{ otherwise} \end{cases}$$

N = number of respondents in survey

I = number of minimum (core) questions

The DCS statistic above measures the proportion of the core question data that underwent cleaning. It will vary from zero, when no cleaning occurred, to a maximum of 1 when all data on the core questions were cleaned. It is recommended in section 2.7.6 of the Final Report that this statistic be reported in all future travel surveys without specifying what are acceptable and what are not acceptable values of the index.

10.7 Q-8: NUMBER OF MISSING VALUES

10.7.1 Definition

The number of missing values in a data set is a measure of how much information was not collected. If expressed as a proportion of the total number of data items in the data set, it serves as a measure of the relative information content of the data. Thus, it could be used as a measure of data quality.

It is important to define what a missing data item is and what it is not. As described in section 8.3, recommended coding practice is to distinguish between non-responses that are refusals, those where a respondent does not know the answer to the question, and those in which a response would not be applicable. Among these categories, only responses where a respondent either refuses or does not know the answer, are truly missing values

10.7.2 Missing Values as a Quality Indicator

The need for standardized procedures arises from the fact that no common practice exists with respect to the definition of missing values and how they may be measured to give an overall assessment of missing information, and hence quality, in a data set. Standardizing these aspects of missing data measurement will allow setting of minimum requirements that would be universally understood and would allow comparison among data sets using a common measure of assessment.

Missing values can be defined as data items where respondents have:

- Failed to provide a response because they refuse to divulge the information, or
- Are unable to provide an answer to the question because they do not know the correct answer.

Given this definition of missing values, a missing value index can be calculated that is the proportion of missing data items among all the data items in the data set. That is, the following missing data index can be calculated:

$$MVI = \frac{\sum_{n=1}^{N}\sum_{i=1}^{I} x_{i,n}^{*}}{\sum_{n=1}^{N}\sum_{i=1}^{I} x_{i,n}}$$

where,

$MVI = \text{Missing Value Index}$

$$x_{i,n}^{*} = \begin{Bmatrix} 1 \text{ if data item i of respondent n is missing} \\ 0 \text{ otherwise} \end{Bmatrix}$$

$$x_{i,n} = \begin{Bmatrix} 1 \text{ if a response to variable i is applicable to respondent n} \\ 0 \text{ if a response is not applicable} \end{Bmatrix}$$

$I = \text{number of variables}$

$N = \text{number of respondents in data set}$

Recommendations on the use of this index as a quality indicator are provided in section 2.7.7 of the Final Report.

10.8 Q-9: ADHERENCE TO QUALITY STANDARDS AND GUIDELINES

10.8.1 Background

One of the ways to improve the quality of data is to have a checklist of actions that must be performed or standards that must be met in each survey. Such a checklist is not currently accepted or used in reporting on household and personal travel surveys.

10.8.2 Checklist of Quality Indicators

An example of a checklist of actions is the "Survey Design Checklist" listed in Appendix C of Richardson *et al.,* (1995). However, a more encompassing set of requirements, which cover all aspects of the survey process from management, through quality control, to survey design, subcontracting, inspection and testing, and product delivery and storage have been suggested by Richardson and Pisarski (1997). Using principles promoted by the International Standards Organization (ISO) and applying them to travel surveys, they have developed a list of 55 aspects of a travel survey that collectively describe adherence to ISO standards (Richardson and Pisarski, 1997, pp. 27-28).

A comprehensive checklist of activities or standards that each survey should perform or comply with, will help ensure that individual aspects of the survey are not overlooked or neglected. The degree of compliance with these requirements in each survey can serve as an indirect measure of data quality. If the checklist is standardized, the measure can also be compared among surveys. To be able to use the degree of adherence to quality guidelines as a measure of data quality, the quality guidelines must be defined. Further, to be able to use the measure of adherence from survey to survey, the items that make up the quality guidelines must be fixed. Thus, a need exists to standardize the items that make up the quality guidelines for all travel surveys so that a stable, comparative measure of data quality can be developed. This may prove difficult to do since it depends on the definition of standards on all included items and setting standards on some of these items may be beyond the scope of this project.

The items identified by Richardson and Pisarski (1997) form the basis of the items included in this measure, but rather than including all items in that list, it is suggested that a subset of relatively easily-collected item values be used in the analysis. From the original 55 items identified by Richardson and Pisarski (1997), ten questions have been compiled to assess the quality of the survey process. These are listed in section 2.7.8 of the Final Report.

CHAPTER 11

11. References

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