BACKGROUND

Paper Objective
The primary objective of this paper is to introduce and discuss survey methodology considerations for the next series of personal travel surveys conducted by the Department of Transportation. After a brief discussion of the current National Household Travel Survey (NHTS) design and issues, a broad range of methodological and design considerations will be introduced - often in the context of other Federal surveys and household travel survey experiences. In addition, the following questions are posed that must be carefully considered in designing the next series of personal travel surveys. It is hoped that the paper and these questions will stimulate thinking and discussion at the Travel Survey Methods Workshop.

- Does the current design allow the NHTS to fulfill major objectives of the survey?
- Can daily and long-distance travel effectively be captured in the same survey effort?
- What changes should be considered to improve the overall quality of the NHTS data?
- What are the most important improvements?
- How might new technologies be incorporated into the design?
- What other effective methods in other surveys have been implemented to improve response rates?
- How can these changes be implemented, yet allow for the ability to monitor travel behavior trends?

History and Current Methodology
The 2001 National Household Travel Survey (NHTS) combined a daily travel survey, the Nationwide Personal Transportation Survey (NPTS), and a long distance travel survey, the American Travel Survey (ATS). Both predecessor surveys were last conducted in 1995. The goal in combining the two surveys was to build a more comprehensive picture of household travel, while reducing the cost and respondent burden.

The 2001 NHTS design primarily employed the design of the 1995 NPTS with an expanded and more detailed long distance travel section of trips of 50 miles or more added at the end of the interview. The design consisted of a cross-sectional, random-digit dial (RDD) sample of approximately 26,000 households and 60,000 persons nationally, with additional samples in nine states and metropolitan areas. All interviews were conducted via telephone using a two-stage data collection design. Interviews were conducted over a 14-month period, March 2001 to May 2002.

Five states (Hawaii, Kentucky, New York, Texas, Wisconsin) and four metropolitan areas (Baltimore, MD; Des Moines, IA; Lancaster, PA; and Oahu, Hawaii) purchased additional sample for their areas through the NHTS “add-on” program.
2002, to capture travel throughout the year. Sampled households (with matched addresses) were first sent an advance letter with a five-dollar incentive, followed by a telephone screener interview to collect basic household information, and finally an extended telephone interview to collect trip detail from all household members on their assigned travel day and travel period. The ‘travel day’ was pre-assigned for each household to ensure equal representation among days of the week and across the entire year. The ‘travel period’ for long distance travel was defined as the four-week period prior to and including the travel day. Attempts were made to collect travel information on all persons in the household. In order to be considered a completed or useable household interview, interviews had to be obtained from at least 50 percent of all household adults. Proxy interviews were required for all children under 14 and were allowed, only in very limited situations, for adult household members.

**Issues and Constraints**

One of the greatest challenges of any statistical survey is producing high quality, useful data with limited budget and resources. This will likely be even a greater challenge with the next series of personal travel surveys. In 2002, the Department of Transportation commissioned the Transportation Research Board (TRB) and the Committee on National Statistics (CNSTAT) to review and evaluate the NHTS. The committee suggested several improvements that will need to be carefully addressed in the next survey. In addition, Federal statistical surveys are obligated to adhere to the policy and guidelines of external stakeholders, most notably Congress and OMB. In June 2004, OMB in conjunction with the Federal Committee on Statistical Methodology (FCSM), drafted a revised series of standards and guidelines for all Federal surveys. Finally, confidentiality legislation, the Confidential Information Protection and Statistical Efficiency Act of 2002 (CIPSEA) enacted in December 2002, mandates more stringent procedures pertaining to the collection, protection and release of Federal survey data. This legislation has significant implications for the data accessibility of the NHTS and can impact what data is collected.

With the exception of modest changes, the NHTS design remained largely consistent for the collection of daily travel with that of the 1995 NPTS design. Thus, the repeated design helped to preserve daily travel trend analysis over time. The long distance travel component, however, underwent significant change in definition, content, and methodology as compared to the 1995 ATS. Following are some key issues faced in conducting the 2001 HTS and some important considerations for the next series of passenger travel survey(s).

**Sample size and methodology significantly changed for the long distance component.** The number of sampled households was reduced from almost 70,000 (1995 ATS) to 26,000 (2001 NHTS). The long distance trip definition was also revised to include trips of 50 miles or more away from home (as compared to 100 miles in the previous survey). Long distance trips were

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2 The paperwork Reduction Act of 1995 requires Federal agency requests submitted to the Office of Management and Budget, “to use effective and efficient statistical methodology appropriate to the purpose for which information is to be collected and directs OMB to develop and oversee the implementation of Government-wide policies, principles, standards, and guidelines concerning statistical collection procedures and methods”.


5 See Appendix A for a more comprehensive list of changes in survey design.
collected once for a four-week reference period, as compared to four waves of interviewing over a one-year period. These changes resulted in a sample of far fewer long distance trips, diminished ability to track long distance travel trends, and difficulty in producing annual and seasonal long distance travel estimates. In addition, the smaller sample size all but eliminated the ability to produce lower level geographic estimates and analyze travel flows.

Response rate to multi-stage telephone survey was 41 percent. One of the largest challenges for the 2001 NHTS was obtaining a high response rate, primarily in an attempt to reduce the impact of nonresponse bias likely in surveys with lower response rates. In spite of many efforts – use of incentives, refusal aversion training for interviewers, refusal conversion – the 2001 survey achieved a household response rate of 41 percent. Given the complexities of the survey and the difficulty of achieving high response rates in an RDD design, the response rate was considerably lower than what is commonly expected in a Federal statistical survey and the survey was only reluctantly approved by the Office of Management and Budget (OMB).

Technology with positional information should be considered in future surveys. Research in the last ten years suggests that using GPS and, perhaps, cellular phone technology can be effective tools in capturing trips that are often missed using self-reported methods. Costs of incorporating these technologies have dropped dramatically as hardware costs decline, particularly in light of the FCC E911 directives for positional accuracy for emergency calls. While there are many potential benefits to be gained, the decision must also consider the potential trade-offs in cost, data quality, and statistical reliability.

Consideration of alternative sample design and data collection methodology. In addition, the next series of passenger travel surveys should consider different sampling strategies and data collection methodologies to address concerns related to coverage, nonresponse, timeliness and operational efficiency.

SURVEY DESIGN CONSIDERATIONS

Alternative Survey Designs
Survey designs can generally be classified into two broad categories on the basis of whether they obtain repeated measurements on the sample of units over time. Panel surveys do and cross-sectional surveys do not. In the United States, most travel surveys rely on one-time cross-sectional designs to collect information on travel consumption and behavior (Tourangeau et al.
The NPTS/NHTS series can be most accurately described as repeated cross-sectional design, since essentially the same survey is repeated over-time with different samples, using very similar survey questions and procedures. Given the significant changes in long-distance travel collection in the 2001 NHTS, the 1995 ATS is more accurately defined as a single, cross-sectional survey. (Although respondents were interviewed four different times similar to a panel survey, this design was used to pool estimates over a one year period and not analyze the change within households between interviews.) Table 1 below describes four common travel survey designs, along with a brief description of advantages and disadvantages, and examples of each.

<table>
<thead>
<tr>
<th>Description</th>
<th>Single Cross-sectional</th>
<th>Repeated Cross-sectional</th>
<th>Longitudinal Panel</th>
<th>Rotating Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>A single sample of households or individuals complete survey during a single period of time</td>
<td>Different samples of households or individuals complete survey for multiple periods of time</td>
<td>Same sample of households or individuals complete survey for multiple periods of time</td>
<td>Same sample of households or individuals complete survey for multiple, specified time periods. Sample gradually/occasionally replaced with new sample (cross between repeated cross-sectional and longitudinal designs)</td>
</tr>
</tbody>
</table>
| Advantages | • Provides “snapshot” of behavior for given time period  
• Typically provides more representative sample of population of interest  
• Eliminates potential response bias due to respondent “conditioning” resulting from participating multiple times | • Provides “snapshot” of behavior for given time periods  
• Typically provides more representative sample of population of interest  
• Eliminates potential response bias due to respondent “conditioning” resulting from participating multiple times  
• Allows for comparisons of population between field periods (assuming similar survey conditions) | • Allows for analysis of change in behavior of same units due to changes in environment and other factors (cause and effect analysis)  
• Cost and resource efficiencies in subsequent waves from building off of previous interviews | • Allows analysis of change in behavior of same units due to changes in environment and other factors (cause and effect analysis)  
• Allows for long-term analysis of population change (longer than the duration of a longitudinal study)  
• Cost and resource efficiencies from building off of previous interviews |

Table 1. Comparison of Four Survey Designs for Passenger Travel Surveys

12 Modest changes were implemented between data collections to improve overall data quality. These revisions did introduce difficulty in analyzing trends across years. See Appendix A for a more detailed description of changes.
### Disadvantages

<table>
<thead>
<tr>
<th>Single Cross-sectional</th>
<th>Repeated Cross-Sectional</th>
<th>Longitudinal Panel</th>
<th>Rotating Panel</th>
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<tr>
<td>Disadvantages</td>
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<tr>
<td>• Does not permit analysis of changes over time; can’t track trends</td>
<td>• Limited change can be implemented across enumerations to allow for population trend analysis</td>
<td>• High respondent burden and panel attrition</td>
<td>Though often less than non-rotating panel, still subject to:</td>
</tr>
<tr>
<td>• Operationally, higher costs often incurred to initiate a project; costs and resources not evenly distributed and maintained</td>
<td>• Does not allow for analyzing behavior and change among same sample units</td>
<td>• Response bias due to respondent conditioning</td>
<td>• High respondent burden and panel attrition</td>
</tr>
<tr>
<td>• Potential ‘telescoping’ effects</td>
<td>• If continuously conducted or with small time lag between enumerations, cost and resources more evenly distributed and maintained</td>
<td>• High cost of respondent tracking (e.g., following ‘movers’)</td>
<td>• Response bias due to respondent conditioning</td>
</tr>
<tr>
<td></td>
<td>• Potential ‘telescoping’ effects</td>
<td>• More complicated weighting and estimation</td>
<td>• High cost of respondent tracking (e.g., following ‘movers’)</td>
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<td></td>
<td></td>
<td>• Potential ‘seam’ effects</td>
<td>• Even more complicated weighting and estimation</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Potential ‘seam’ effects</td>
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### Examples

<table>
<thead>
<tr>
<th>Single Cross-sectional</th>
<th>Repeated Cross-Sectional</th>
<th>Longitudinal Panel</th>
<th>Rotating Panel</th>
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<tr>
<td>The American Travel Survey (1995)</td>
<td>National Household Travel Survey</td>
<td>Dutch National Mobility Panel</td>
<td>German Mobility Panel</td>
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<tr>
<td></td>
<td>American Community Survey</td>
<td>Puget Sound Transportation Panel</td>
<td>Current Population Survey</td>
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<td></td>
<td>UK National Travel Survey</td>
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<tr>
<td></td>
<td>Sydney Household Travel Survey</td>
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</table>

Other countries have transformed many large cross-sectional and panel surveys into continuously repeated surveys for many of the same reasons currently given for transitioning the decennial census “long form” into the continuously collected American Community Survey. Primary reasons have included: (1) to ‘flatten’ the budget for all years, rather than to have high peaks in periodic data collection; (2) the ability to retain staff expertise, both in field implementation, data processing, and data analysis; and (3) improved estimates over time (i.e., national level data are more timely while retaining the ability to make small area estimates over time). Some examples of national household travel surveys that are conducted continuously include:

- The U.K. Travel Survey—ranges from 3,500 to 10,000 households per year
- The Household Travel Survey (HTS) for the Greater Metropolitan Region of Sydney, Australia—about 5,000 households per year
- The German Mobility Panel (MOP) which is a rotating panel (see below).

However, as smaller samples are collected each year, multiple years of data are required for reporting sub-populations, including geographic sub-regions or sub-groups based on socio-demographic or economic characteristics, such as a specific age or income group.

### Sample Design

#### Sample Frame

For the purposes of making objective statistical inference, the sample must be selected using probability methods, that is, where everyone in the target population has a known, non-zero
probability of selection (Kish 1965). Likewise, the sample frame utilized in a national probability sample must be complete, accurate, and up-to-date to ensure adequate representation of the larger target population. For telephone surveys, problems with completeness of frame include the growing number of persons who have a cell-phone only, and which are not included due to costs incurred by potential respondents for in-coming as well as out-going calls, and the small number of households without telephones. For address-based surveys, the completeness of the address list must be evaluated. For example, the Census Bureau has a “Master Address File” which is updated with USPS Delivery Sequence File. Omissions of certain groups in the sample frame can introduce coverage bias due to the exclusion of these groups.

To the extent that the non-telephone households differ from telephone households in their travel behaviors, coverage bias makes the results less representative of the US population. According to the 2000 Census\textsuperscript{13}, the number of households without telephone service was estimated to be 2.4 percent. While the number of households without telephone service has decreased in the last decade, the number with cell-phone only is rising. A recent analysis using the February 2004 Current Population Survey supplement has estimated the number of cell-phone only households as high as six percent (Tucker, et al. 2004). In addition, these households were found to be disproportionately single-person, central city, and renters.

Address frames are subject to errors of omission as well. In the pre-test of the 2001 NHTS, it was estimated that the address frame had addresses for 90 to 95% of households.\textsuperscript{14}

As a result of continued problems with population coverage (and low response rates,) the future of RDD-only designs remains in question. A number of other sample frame options exist, but each introduces other disadvantages related to survey costs, data collection methodology, response rates, and estimation. The following is a discussion of sample frames currently being used by other national surveys, along with some associated benefits and limitations.

<table>
<thead>
<tr>
<th>Table 2. Alternative Sample Frame Designs</th>
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<tr>
<td><strong>Area frame</strong></td>
</tr>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
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<td><strong>Disadvantages</strong></td>
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</table>

\textsuperscript{13} http://www.census.gov/hhes/www/housing/census/historic/phone.html\textsuperscript{14} “Issues in the 2001 Address vs. List-assisted design” FHWA document. (need date/web address!)
typically much more expensive since sampled households can not always be interviewed by less expensive data collection modes, such as by mail or telephone. • precision of resulting survey estimates is often negatively impacted due to clustered (areas) sample design.

limitations sometimes make this option unaffordable • appropriate, accurate lists do not always exist (or can be accessed)

burden and fatigue resulting from prior survey participation

coverage can become and issue if list not updated or new growth in area not accounted for

sampling, weighting and estimation • can increase overall data collection costs (especially when combining with area frame)


Others on the horizon – Other sample frames alternatives are currently being researched, yet they still pose many coverage issues and operational difficulties for household travel surveys, even as a dual-frame and/or mixed-mode approach. Internet surveys, for example, offer limited household coverage with less than half (41.5 percent from 2000 Current Population Survey\(^\text{15}\)) of U.S. households having access to the internet. Offered as another alternative data collection mode they have appear to have more merit, but results to date have been mixed with frequent reports of low response and other data quality issues. In addition, the use of cellular telephone sampling frames is also limited since no comprehensive list of cellular telephone numbers exists. Cell phones also pose additional operational barriers since they are used in much different ways than fixed-line phones (e.g., turned off for long periods of time). (Steeh 2003).

Sample Size
The number of units to sample is another key decision in the survey design. In choosing the required sample size, these factors should be considered:
- the desired level of precision for the survey estimates (including at needed levels of geography and for subgroups)
- the sample design and resulting design effect
- factors likely to impact achieved sample size – nonresponse, eligibility rates, and attrition (for panel designs)


\(^\text{20}\) Reliable aggregated estimates can be made for the nine census regions (and divisions based on metro size and presence of rail). An exception to limited geographical analysis is the selected ‘add-on areas; nine states and metropolitan areas purchased additional sample for their areas to allow for reliable estimation for their area.
With these factors in mind, the 2001 NHTS was designed to achieve interviews from approximately 25,000 households and 60,000 individuals within these households. This resulted in the collection of approximately 250,000 daily trips and 45,000 long-distance trips. This sample size allows for reliable estimation of many national-level trip characteristics for both daily and long-distance travel, but affords very limited estimation for lower levels of geography. Long-distance trip analysis was greatly affected by the sample size. The 2001 NHTS captured less than five percent of comparable trips captured by the 1995 (i.e., non-commuting trips of 100 miles one way,) resulting in the inability to make state estimates or analyze flows between states and major metropolitan areas. In addition, only limited analysis can be performed for rarer transportation modes (e.g., trips by bus and train) and for certain sub-populations (e.g. elderly travelers). Increasing the sample to ensure reliability of estimates at lower levels, measure flows, and produce reliable estimates for rarer groups is a very costly proposition requiring a substantial increase in sample size to produce reliable estimates.

Subgroups of Interest

As mentioned above, the NHTS sample size posed limitations in specific analyses due to limited sample for geographic and demographic subgroups. The 2001 NHTS national design includes one strata for metropolitan areas (MSA) with rail service, but otherwise does not oversample specific, rarer groups. Historically, the NHTS sample design and size has limited the analysis of several important transportation modes and groups. A description of a few of these follows:

Transit Users - Personal vehicle use dominates passenger travel accounting for nearly nine out of 10 trips taken by persons in this country. Analysis of lesser used but important transportation modes, such as transit, is limited due to both the small sample and, in some cases, geographic sensitivity. Analysis of transit behavior has relied heavily on decennial census information on the share of transit for “usual mode to work,” and the NHTS for transit share for all trips, regardless of purpose. These results are often cited by Congress in decisions related to transit investments. Through the add-on program in the NHTS that allows states and metropolitan planning organizations to purchase additional sample, there is a disproportionate number of cases in certain geographical areas. For example, the New York state add-on sample in the 2001 NHTS also resulted in an unintended benefit. The New York metropolitan area has nearly 40% of the U.S. transit market based on the FTA National Transit Database. The addition of the New York add-on sample allowed for unique analysis of transit behavior in an area representing the largest share of transit use. The added sample, reweighted for national estimation, also provided modest gains in precision for transit estimates at the national level.

Households Without Vehicles - From the 2001 NHTS, approximately eight percent of households were determined to be without a vehicle ‘for regular use’. In the United States, households without vehicles are thought to include two main groups: (1) people who live in high density urban neighborhoods (like Manhattan, downtown Chicago or San Francisco or Washington, D.C.) with high transit and taxi accessibility, and (2) recent immigrants and have not acquired a car. (Murakami, 2003; and Pisarski (1996). Those in the second group may be less likely to participate in a national travel survey for several reasons: (1) language barriers, and (2) potential distrust of government activities, (3) different concerns about privacy and confidentiality.
Race and Ethnic Groups—African Americans have been less likely to respond to travel surveys than white households. There has been little documented on participation rates by Hispanic households to transportation surveys. However, larger households are more likely to fail to complete travel surveys as the burden of reporting is greater, and this finding may affect participation by Hispanic households (Murakami, 1992; DRCOG, 2000; Nustats, 2003; and Nustats, various report in 2004). Contrino and Liss (2004) conducted research on nonresponders in three regional surveys (Atlanta, Phoenix, and Ohio) and found that in all three studies, minority and low income groups were more likely to be nonrespondents. As a result, Contrino and Liss recommend oversampling for low responding and special interest population groups, and using targeted approaches for recruitment and retrieval, as well as the use of post-stratification weights to adjust for low participation. Oversampling strategies, if effectively employed, can be a valuable mechanism for producing more reliable estimates for specific subgroup analysis. However, assuming the overall sample size remains constant, it can also result in a loss of precision for national estimates. In addition, while oversampling may reduce the variance of these estimates, it does not necessarily reduce the potential nonresponse bias.

Household versus Within-Household Sampling
Many transportation analysts and modelers require data from all members of households for use in their analysis and models to capture joint decisions and household interactions. Consequently, attempts were made in the NHTS to interview all household members and only households where at least half the household members were interviewed were considered complete or ‘useable’. Approximately 85 percent of NHTS useable households did result in complete enumeration of the household members. These households were provided with an additional set of weights to allow users the choice of using only those households with complete enumeration. Complete enumeration of a household is a challenging task and has negative impacts on the response rate. In the last several years, transportation researchers (Erhardt 2000) have begun to investigate whether changing the sampling unit to a person, rather than a household would improve response, while maintaining the ability to simulate travel for a household.

Data Collection Methodology

Mode of Data Collection
Another key decision in travel surveys is the mode of data collection. Similar to sample design, each choice of data collection mode has inherent advantages and disadvantages. Selection of an appropriate mode requires careful consideration of many factors, not the least of which is coverage of the target population. While the method of data collection might be largely dictated by the population coverage and sample frame, other common determinants include survey costs, response rates, and data quality issues. Mode selection can also be influenced by the complexity and length of the survey and timeliness needs.

Table 2 provides a summary of four popular modes of data collection modes – In-person, Telephone, Mail, Internet - along with associated features of each.

<p>| Table 2. Description and Comparison of Data Collection Methodologies |
|---|---|---|---|
| In-person | Telephone | Mail | Internet |</p>
<table>
<thead>
<tr>
<th>Description</th>
<th>In-person</th>
<th>Telephone</th>
<th>Mail</th>
<th>Internet</th>
</tr>
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<tbody>
<tr>
<td>Interviewer travels to respondent’s home or office and administers questions in face-to-face interview</td>
<td>Interviewer contacts respondent and administers questions over the telephone</td>
<td>Questionnaire mailed to respondent and is returned by mail or data retrieved by telephone</td>
<td>Respondent completes survey on web</td>
<td></td>
</tr>
</tbody>
</table>

| Coverage | Most complete | Omits non-telephone households | Similar to in-person depending on how the addresses were obtained | Only households with internet connection or access to internet |
| Response Rate | Highest of all modes | Intermediate | Among the lowest | Among the lowest |
| Data Quality | Highest of all modes | Intermediate | Lowest of all modes | Intermediate; mixed results |
| Cost | Most expensive (this often leads to geographically clustered sample cases, leading to a reduction in the effective sample size.) | Intermediate | Among least expensive | Among least expensive (though high start-up cost compared to data collection cost) |

As this table illustrates, in-person data collection typically yields the most complete coverage, achieves the highest response rate, and produces the best quality data. Not surprisingly, in-person interviews are also the most expensive of the four modes. For this reason, telephone and mail modes are more commonly used despite well-recognized trade-offs in data quality. Telephone interviews have been the most commonly used collection method in the United States over the past twenty years, as field costs for personal visits increased to prohibitive levels and other obstacles to personal interview have arisen (e.g., personal security, gated communities, etc.)

The 2001 NHTS used a telephone collection methodology. Telephone interviews are often preferred over mail-back methods for travel/activity surveys as it allowed for more probing for complete reporting of trips. In addition, because the NHTS captures travel by all household members, telephone retrieval allowed for correction/validation of travel among household members.

Mixed-mode approaches are commonly used to strike a balance between survey costs and data quality issues - most often response and coverage. A commonly used approach, as in the ACS, is to use the least costly mode for initial contact, followed by a more costly mode for nonresponse follow-up, such as using a mail survey with telephone nonresponse or a telephone survey with in-person nonresponse follow-up. In dual-frame designs aimed at improving coverage, different modes are often required to capture the sampled units from each frame. While a mixed-mode approach can offer an effective mechanism for improving response and coverage, it also potentially introduces bias resulting from mode effects (i.e., a difference in responses due entirely to the method of data collection). Therefore, it is important to first evaluate the trade-off of improved coverage and response with potential response error (bias) before deciding on a mixed-mode methodology. Recognizing the greater likelihood that future surveys, including the NHTS, will need to allow for multiple modes of data retrieval, appropriate research on modal influences on travel behavior data collections will be needed.
Electronic or computerized data collection options are also commonly used for the entirety of the interviews, or as an alternative methodology. The NHTS used a computer-assisted telephone interview (CATI) with an additional option for reporting specific information via the web. Use of CATI was especially beneficial for the NHTS, allowing for trip rostering and capture of trips made for multiple household members. Therefore, trips already capture during preceding interviews, could be verified by a subsequent household member instead of captured anew. Computer-assisted designs, require more upfront planning, and increased time to implement compared to paper-and-pencil, but result in faster access to data and higher quality control as the need for data entry from paper forms is eliminated. In the future, there are opportunities for better integration of geographic information and other location-based data with computer-assisted interviewing, whether by telephone or in-person.

Nonresponse-minimizing techniques

The NHTS is not alone in dealing with nonresponse. During a recent presentation in June 2004 for the Committee on National Statistics, Robert Groves presented an overview of the status of current household nonresponse, which included these four elements:

- Falling cooperation rates in the developed world (de Leeuw and de Heer, 2002)
- Greater decline in one-time surveys vs. longitudinal surveys (AAPOR, 2003)
- Greater decline in telephone than face to face surveys (increasing noncontacts)
- Greater decline in unit nonresponse than item nonresponse.

Many efforts were implemented in the 2001 NHTS design to achieve as high a response rate as possible. For example, respondents were sent incentives prior to contact. Interviewers were provided with special refusal aversion training, and refusal conversion efforts were attempted with survey nonresponders. Here are some factors thought to contribute to nonresponse in the NHTS.

- **Multi-Stage** telephone data collection ([RDD sample design](#)) with no **nonresponse follow-up**
- Short **data collection window** (interviews were allowed up to 6 days) and 2-stage contact
- Attempts to enumerate **all household members**. Strict requirements for interviews (at least 50% of adult household members had to be interviewed before a case was considered complete
- Limited **reference period** of travel
- Limited **proxy** allowance
- **Interviewer** assignments
Stages of Contact to Complete Interview

Most cross-sectional household travel surveys utilize a multi-stage approach for interviewing households about their travel. As with the NHTS, advance letters introducing the survey are first sent, followed by a telephone contact to conduct a basic household-level screener interview. Respondents are mailed a travel diary, with information retrieved by another telephone interview. In any multi-stage approach, nonresponse can occur at each stage and compounds the overall nonresponse rate. In the 2001 NHTS, the recruitment rate was 58.2 percent, and the subsequent completion of the extended survey was 70.8 percent. The composite response rate was 41.2 percent.22

Nonresponse Follow-up Studies

The 2001 NHTS did not include a non-response follow-up survey. Traditionally, low response rates have been suspected of resulting in more biased results. There is also evidence where higher nonresponse results in more bias supporting the traditional thinking. However, more recent research (Groves et al.) has also cited examples of surveys with high nonresponse and low bias, and interestingly, some attempts to reduce nonresponse resulting in greater bias.

Nonresponse follow-up (NRFU) surveys have not yet been incorporated as standard practice in activity and travel behavior surveys. Some exceptions include work done by Richardson (2003) in Australia, and a small test funded by FHWA in Denver in the late 1990’s. The Victorian Activity and Travel Survey (VATS) in Melbourne, Australia, conducted in-home interviews with a sample of non-respondents to the main mail-back survey. Indications that non-respondents to mail-back surveys are more like early respondents than late respondents surveys in daily trip rates. In the DRCOG project, a brief mail-out/mail-back survey was conducted for non-respondents to an RDD telephone survey (for those which an address could be found). Small cash incentives were found to double the response rate to the NRFU survey. They did not find statistically significant differences in household trip rates between the households who completed the full survey compared to those in the “quick refusal” and “non-contact” households. Therefore, the hypothesis that these non-respondents to the telephone survey leads to underreporting of trips was not supported.

For the American Community Survey, the U.S. Census Bureau found that response rates varied widely, with particularly low mail-back responses in neighborhoods that were predominantly Native American (17 percent), Hispanic (34 percent), and African American (35 percent) (U.S. Census Bureau ACS Evaluation report series, May 2002). The original plan for the ACS non-response follow-up and tested in their pilot, was a one in three field follow-up. The response rate to the field follow-up has been uniformly very high (between 92 and 95 percent). The Census Bureau now plans to implement differential non-response follow-up, with higher follow-up rates in areas with low mail-back returns (U.S. Census Bureau, 2004).

Data Collection Window
Current NHTS methodology requires that an interview be completed from a respondent within six days of the assigned travel day. For respondents who neglect to complete a diary, recall errors are felt to be much higher after six days, especially for daily travel. The limited six-day window also eliminates the confusion of referencing the particular travel day that was assigned (e.g., Tuesday this week as opposed Tuesday last week). Although the six-day data collection period appears to help in reducing response problems, it could also potentially contribute to nonresponse – especially considering attempts are made to interview all household members within this relatively small window. In addition, potential bias may also be introduced in the capture of long-distance travel. Respondents who travel often and for longer periods of time away from home, will be more likely to be away from home and thus more likely not to respond.

Reference Period
Daily Travel: As previously mentioned, the reference period for ‘travel day’ in the NHTS is a pre-assigned one-day period (from 4:00 a.m. on travel day through 4:00 a.m. the following day). Other national travel surveys, such as the U.K. National Travel Survey and the German Mobility Panel use a seven-day diary. The longer reference period allows for examination of travel variability over a longer period. For example, a respondent may not go grocery shopping each day, but only once a week. Similarly, a respondent may ride transit only two days a week. These longer reference periods, however, are more burdensome and typically achieve very low participation rates and may result in fewer trips reported each day as the survey period continues. The Dutch National Mobility paper found significant “trip reporting fatigue” in a 7-day diary (Golob et al (1986)).

Cost efficiency might suggest that a smaller sample with larger reference period should be considered in order to continue generating similar numbers of trips overall. However, moving from a larger sample size with a one-day reference period to a smaller sample with a longer reference period would create additional estimation issues for lower geographic levels and subgroups. Though we might have the same number of trips, the effective sample size would be lower given the increased correlation between trip reports. Given current criticisms, reducing the household sample size - thus requiring more aggregation on characteristics and even more limited analytic potential - would not likely be perceived as an improvement.

Long Distance Travel: The NHTS reference period for long-distance travel was the 4-week period before and including travel day. Therefore, if a respondent’s travel day was July 30, their assigned travel period would be July 3-30. This brings into question the respondent’s ability to accurately recall trips for this period, and telescoping effects are potentially introduced (i.e., they might be reporting trips taken outside the travel period, e.g. on July 1-2). Due to the rotating nature of the travel period, it further introduces difficulties in producing seasonal and annual estimates of long distance travel. Introducing longer, more salient reference periods, however, can also be problematic. For example, given that the respondent is interviewed only once, it is unlikely that he or she would be able to accurately recall all trips for one year, not to mention the burden of this request.

In the 1995 ATS design, respondents were interviewed quarterly over a one-year period. This methodology allowed for bounding and dependent recall of previous trips, thus reducing
telescoping effects. As is common in panel designs, however, time-in-panel or conditioning effects were also evidenced by the declining trip rates in later waves of interviewing.

Proxy Allowance and Effects
Only limited proxy reporting for adult household members was allowed in the NHTS resulting in approximately 80 percent of interviews being conducted with the respondent. Self-reports are preferred in travel surveys due to diminished accuracy and completeness in trip reporting often experienced when proxy analysis is allowed. In one travel survey conducted in Toronto, researchers found that home-based discretionary and non-home based trips were underreported by proxy, with gender being a related factor (Badoe and Steuart, 2002). Bose and Giesbrecht (2004) found in the 2001 NHTS that average trip rates for persons interviewed by proxy were much lower than those for who reported for themselves. The average daily trip rate was 4.5 for self-reports as compared to 3.7 for proxy reports. One is more likely to have proxy report in the NHTS if one is male, a non-driver, has less education, is away from home on travel day, or has a disability that affects travel. Proxy reports also tend to have fewer daily, long distance, walk & bike trips and transit usage.

Interviewer assignments
Brog’s continuing work assigns “caseloads” to individual interviewers or “motivators” (Brog, 1983). His methods primarily rely on mail-out/mail-back techniques, with telephone calls used for reminder calls, and for queries when responses are missing or have other problems. Because the 2001 NHTS uses telephone retrieval, it is nearly impossible to assign cases to an individual, as call-backs are scheduled over many different hours, and different days of the week. A small test was completed in 2002 in the Washington, D.C. region and a small team was assigned a case load. The survey period was very compressed, and thus results are inconclusive but seemed positive (Freedman and Machado, 2003). In de-briefing the interviewers, the interviewers felt more confident and comfortable when making subsequent phone calls. Some respondents said they wanted the first caller to call them back, not someone else on the team. One of the drawbacks was that the current scheduling software was not optimized for team assignments.

Questionnaire Design
Improvements in questionnaire design should be to assist the respondent in providing complete and accurate information that the analyst is attempting to collect. The main issue for travel surveys is to assure that all trips are reported, otherwise, they become a serious problem of item non-response. Techniques that have been used to improve reporting include:

- Clear definitions of what travel is to be captured,
- different diary designs, and
- different approaches to capture trips, activities, and time use
Daily Trips: A daily trip in the NHTS was defined as each time the respondent went from one address to another. One of the greatest difficulties in travel surveys is to capture short stops, as people may neglect to report them for several reasons:
   a. reporting burden, every stop generates a series of questions adding time to the phone retrieval time,
   b. they are considered incidental and therefore, the respondent assumes that the researcher is not interested in knowing, and
   c. easy to forget (pick up milk, cigarettes)

Long Distance Trips: In contrast, people in the United States do not have a good estimate of distance, so questions about trips of over 50 miles in length are often over-reported (in spite of interviewer aids such as maps). Respondents will often report trips that are closer to home than the long distance definition. In processing of both the 1995 ATS and the 2001 NHTS, 20-25 percent of long-distance trips were later excluded after the calculated route distance illustrated that these trips were under the specified mileage required (i.e., 100 miles for the 1995 ATS and 50 miles for the 2001 NHTS). Current issues facing the next collection of long-distance data include trip length criteria, the amount and type of detail most important, and how to define and collect trips or journeys with multiple stops and/or side trips.

Diaries and Recall Aids

Diary formats have evolved primarily through focus group testing. Some of the questions on the visual appearance and format of travel/activity diaries include:
   • Should answers be open-ended or fixed. If fixed, check boxes have been generally applied. Some diaries ask people to read a code list and to enter the code in each box.
   • Should the diary primarily be a “memory jogger” and include only some of the questions about each trip, or include all questions that will be asked in the CATI retrieval. NHTS is more like a memory jogger, as some questions are asked on the phone that are not included on the diary form.
   • If respondents will not read instructions on how to complete the diary, what can we do to help them complete it to meet our needs? The 2001 NHTS added a pictogram showing “activities” and “trips” as an example.

In addition, respondents for the NHTS were also mailed a map delineating a 50-mile radius from their home location. Although the map was somewhat misleading, it is thought to have served as an effective memory jogger.
A couple of pilot tests have been conducted (Bachu et al, 2001; and Stopher et al, 2004) using passive GPS, and then supplying a map to respondents to use as a recall device. They found that people were able to recount their trips, even two weeks later by looking at the printed maps showing their GPS-recorded travel. This approach relies on map-reading ability of respondents. In the Australian pilot (Stopher et al, 2004), respondents were also given the option of looking at a tabular description of stop showing street names, arrival times and travel times.

**Trip-Based Versus Activity-Based (Time Use) Surveys**

During the last couple of decades, travel behavior researchers have become increasingly focused on activity-based travel survey approaches. (The first known use of an activity diary was first used in a regular travel study in Belgium in 1986-1987.) This is due in part to the desire to understand people's travel in the context of their daily activities and allows analysts to bring this context into travel analysis and modeling. Activity approaches allow transportation researchers to examine the activities and relationships that generate the need for travel (Harvey 2003). Traditional trip-based travel surveys, such as the NHTS, enumerate all trips taken by persons during a specified time period, followed by the collection of trip detail that typically includes - origin and destination, time, purpose, mode, etc. Activity-based travel surveys, on the other hand, collect all activities undertaken by the respondent in the given time period. Trips are captured as just another activity. Much of the trip detail is not directly asked, but is inherent to the activity diary structure and can be derived. Harvey’s review of approximately 10 activity surveys, showed that travel accounts for approximately 19 percent of reported activities.

Time use surveys recently conducted in Europe have found a lower proportion of persons who are “immobile,” that is, not making any travel in a given day, compared to a travel survey. For the French, 8 percent were “immobile” in the time use survey, compared to 17 percent in a travel survey (Armoogum et al, 2004). One hypothesis is that the reporting of “no trips” in a travel survey is that the answer is given as a “soft refusal.” Now that the American Time Use Survey data are available, it is important for transportation analysts to do a similar comparison.

While some preliminary comparisons between trip-based and activity-based surveys have been performed, additional research is still needed. Important measures – trip rates, trip frequency distributions – should be analysed across survey type under while controlling for the survey conditions. While some research has shown that activity surveys offer produce better data quality, it is still unclear what trade-offs there may be between quality and cost (Pendyala 2004).

**Newer Technology**

**GIS/GPS** – Over the last several years, several passenger travel surveys have introduced multiple approaches for integrating GPS into travel surveys. Most commonly these have included - vehicle-based passive surveys, person-based passive surveys, and vehicle-based interactive surveys. Original benefits were expected to be: reduction of missing (unreported) trips; improved accuracy of travel distance and time; routing and speed data heretofore unobtainable; ability to capture longer periods of travel.
Between 2001 and 2004, several regional household travel/activity surveys have incorporated a GPS component as a sub-sample to their household diary (Wolf, 2004). The ability to capture unreported trips (item non-response) has ranged widely from 20 to 80 percent. Zmud and Wolf (2003) find that unreported trips are most likely to be trips less than 10 minutes. Household characteristics leading to less complete reporting include having 3 or more vehicles, having 3 or more workers, annual income below $50,000, and persons younger than 25 years.

One of the most exciting passive GPS studies is the Commute Atlanta project (FHWA value pricing pilot) with 365 days of 1-second GPS data for over 450 household vehicles. This long period of data collection allows for examination of variability of travel, and better understanding of long distance trips made by private vehicles. A “sunset clause,” in which the data must be destroyed within 6 months of the end of the project, on the data availability is one major handicap of this project.

How a GPS component could be incorporated into a national survey raises many questions, as completeness of response in self-reported diaries, compared to GPS-recorded information may be linked to demographic characteristics such as English-language capability, education, and metropolitan characteristics such as population size, density, and transportation network complexity.

**Cell Phone**

Several tests have been conducted to trace personal movements using cellular/mobile phones. Some advantages of mobile phones relative to a GPS system is that they function underground and inside buildings more often, and the density of cellular base stations/towers is higher in the most dense urban areas. Also, the market penetration of cellular phones is very high, so the cost of equipment is low. The cost of on-going data transmission can be a factor.

In Germany, Wermuth et al (2003) have tested tracking of cellular phones for a long distance survey. Recently, Kracht (2004), also in Germany, is testing the use for tracking daily personal travel, especially as many phones already have the capability of recording and storing the position (cell) over time. The positional accuracy afforded by cellular phone is much less than using GPS, so while gross measurements of distance and travel time are achievable, specific routes or travel modes are less likely to be determined without greater respondent interface.

**Web utilities**

Using the Internet as a response method is becoming more robust, however it has more often been applied to shorter origin/destination travel survey, e.g., after license plate capture with a mail-out postcard, and responses allowed either by mail-back or internet. One test using full-fledged Internet response for household travel diaries, completed by Resource Systems Group (2002), showed higher interest among young men, and older men with higher incomes. In a regional test, the ability to incorporate a pre-geocoded electronic yellow pages was an advantage for selecting destinations. However, in the 2002 National Transportation Availability and Use Survey conducted by BTS, only three out of over 5000 respondents chose to complete the survey using the web option.

**FUTURE CONSIDERATIONS**
**Preserving Trends**

Obviously, any changes made to the design of the future NHTS series has obvious impact on the ability to monitor travel behavior trends. Any change will need to be carefully weighed and trade-offs made between needed improvements and the continued ability to track trends over time. Although minimal changes were made to the capture of daily travel, certain changes were introduced that obscured the ability to detect what was an actual change in travel behavior versus a change due solely to methodological or definitional differences. For example, additional probes were added to the 2001 NHTS to better capture more incidental types of trips thought to be underreported, such as walk and bike trips. As a result, the number of walking trips reported increased significantly from 1995 to 2001. Due to this change, it is not possible to delineate what was a real change in walking behavior as compared to the improved capture of walking trips. As previously described, the substantial changes in the collection of long distance travel severely limited the ability for longer distance trend analysis.

**Workshop Goals**

During the workshop, we hope that participants will share their ideas on how to improve survey quality, improve response rates, reduce non-response bias, and incorporate new technologies, while simultaneously attempting to maintain or reduce costs, and maintain the ability to monitor trends.
REFERENCES:


Zmud, J. and J. Wolf. “Identifying the Correlates of Trip Misreporting: Results from the California Statewide Household Travel Survey GPS Study” Presented at International Conference on Travel Behaviour Research, Lucerne, Switzerland, 2003.
Appendix A

Improvements and changes in the 2001 NHTS as compared to the 1995 NPTS:

1. Travel taken by persons younger than five years old are enumerated,

2. More emphasis on walk and bike trips by prompting specifically for these trips,

3. If one did not travel on the designated travel day, then information on the most recent trip was collected,

4. If one did not travel during the designated travel period (the 28-day period when data on long distance trips were collected), then information on the most recent long distance trip was collected,

5. Information on access and egress to the transit station was explicitly collected,

6. The travel period was a 28-day period in 2001 but a two-week period in 1995, and

7. Long distance trips in 2001 were those with the farthest destination 50 miles away from home while the criterion in 1995 was 75 miles

In addition, a number of questions were added to (or data elements later derived from) the 2001 NHTS to cover emerging trends pertinent to personal travel behavior:

At the Household Level.
- Cell-phone ownership
- Number of phone lines owned and how they were used (voice, fax, modem)
- Vehicle fuel consumption and annual fuel cost

At the Person level.
- Internet access and frequency and location of use
- Travel disability and its effect on mobility
- Primary activities during “last week”
- Explicit coding of multiple jobs
- Broad categories of occupation
- Immigrant status
- Frequency of walk & bike trips during the week prior to the interview day

At the Individual Daily Trip level.
- More detail on trip purpose
- Access and egress modes to transit stations

At the Individual Long distance Trip Level.
- Access and egress modes to airport, train station, etc.
- Overnight stops & purpose of stops
- All modes used at the final destination

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23 (include ORNL link as reference)