Resource Paper for Survey Methodologies Workshop

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The total methodological design of interrelated surveys to provide data for analysis, understanding, and modeling of household and personal activity, time use, and travel behavior is addressed. Evolving trends in models in response to current and emerging planning and policy issues are discussed to set the stage for developing data collection needs. Survey design issues are discussed, and the needs for the cross-sectional, single-day household survey of revealed behavior (revealed preference) are discussed in the context of the availability of other, often more appropriate, methods, namely stated preference/stated choice experiments and multiday, panel surveys. Sampling and sample design are discussed, first with regard to a single-day survey, then as affected by multiday design and the economies and other benefits introduced by the use of stated preference surveys and longitudinal panels. A brief description of recent and ongoing surveys in the United States is given.

Metropolitan transportation planning and policy analysis in the United States is undergoing a major revival in the 1990s. The renewed interest in urban transportation planning and policy analysis comes in the wake of the requirements contained in the recently enacted Intermodal Surface Transportation Efficiency Act (ISTEA) and Clean Air Act Amendments (CAAA). The rule-making based on these two pieces of legislation also sets forth considerable challenges for transportation planners and policy analysts It is becoming clear that new analytical capabilities and related data are needed to support current and emerging planning and policy analysis in the nation's metropolitan areas, particularly in areas that do not meet National Ambient Air Quality Standards ("non-attainment areas").

The professional transportation community has started grappling with the technical issues raised by the recent legislation and rule-making, but the resolution of many of the issues will take substantial research and development effort. As part of this process, data collection needs are being scrutinized. One of the prime sources of data used historically in metropolitan transportation planning is what has been termed the "home interview survey" and what is now commonly called the "household travel survey" (see discussion in the following section). As a result of the new needs, as well as the advances in technology and a variety of sciences, there are challenges and opportunities in developing household travel survey methodologies for the future. The renewed interest in regional transportation planning studies has resulted in recent efforts to collect metropolitanwide data sets despite the prediction just a few years ago that travel surveys in the 1990s would be very small scale, both in terms of the sample size and the geographic coverage (*1*).

The purpose of this paper is to provide a framework to guide and structure the discussion at the Survey Methodologies Workshop at the conference on Household Travel Surveys: New Concepts and Research Needs. The paper raises and frames the many methodological questions that need to be addressed in designing household travel surveys that meet current and emerging transportation planning and policy analysis needs. This paper deals only with the collection of data about personal travel behavior. Freight and commercial movements are not considered here, although these trips are coming to be recognized as important in metropolitan transportation planning.

The charge to the Survey Methodologies Workshop focuses attention on sampling in the design of a household travel survey. We have, however, interpreted our responsibility (and, implicitly, that of the workshop) more broadly, since sampling design and many of the other decisions to be made in designing a household travel survey are interdependent. For example, the sample size needed to estimate a population parameter describing daily travel with a specified level of precision depends on whether the respondents are asked to report their travel for a 1-day or a multiday period. In any event, we have interpreted our charge more broadly for another, related reason. None of the other workshops at the conference is concerned with the total design of household travel surveys, so we have taken that responsibility upon ourselves, although we do not deal with many aspects in detail.

Household Travel Surveys in Perspective

We consider a household travel survey to be a survey in which data are gathered on the personal travel behavior of the members of a sample of households. What distinguishes a household travel survey from other travel-related surveys is that in a household travel survey the household is the sampling unit, and the personal travel behavior of the members of the sampled households is the subject of the inquiry. Conventionally, travel behavior is requested only of those more than 5 years old. However, some recent surveys include all members in the sample households (e.g., the survey conducted in 1994 in western Oregon and southwest Washington).

The earliest household travel surveys in the United States were carried out during the mid-1940s. The earliest household travel surveys were of a special type known as a home interview survey, in which an interviewer visits the home of each selected household, typically on the day following the day for which the household members were asked to report their travel. We note here that in some fields the term household survey implies that the survey is conducted in the household (*2*). But we believe it is important to think of the home interview survey as a special case of a household travel survey, with the latter being conducted by telephone, mail, personal interview, or some combination of these methods of contact and retrieval.

The earliest household travel surveys had a number of other characteristics They were retrospective surveys in that the respondents were asked to recall their behavior on a previous day, typically the day immediately preceding the interview day. Earlier surveys had no prespecified interview day (there was usually a mailed introductory letter, close to the target day); later surveys sometimes included both an introductory letter and a phone call to set up the interview day. This reliance on respondents' ability to recall their travel on the previous day was probably mitigated by the advantages of a face-to-face interview and the interviewer's ability to probe for "missing" trips.

The earliest household travel surveys were conducted on very large samples, ranging from 4 percent in the largest urban areas to 20 percent in small urban areas. Large samples were needed in the early surveys because of the aggregate nature of the models in use at that time (based on aggregated zonal attributes) and because of the lack of any prior information on the phenomena being studied. In any case, large sample sizes were needed to provide data to estimate the zone-to-zone origin-destination matrix. Usually simple random sampling was used for these early surveys, with the sample frame being a street address directory or utility billing list.

Over the years, the conduct of household travel surveys has changed considerably First, beginning in the mid to late 1970s, urban areas conducting household travel surveys started making do with a much smaller sample size This trend was made possible by the introduction of disaggregate models, which make far more efficient use of the data than do aggregate models. Specifically, the use of disaggregate choice models for the mode choice phase of the four-step modeling framework led to the use of a relatively small household travel survey, generally supplemented by an on-board survey to provide additional information on the public transit modes of travel (since in many cities a random sample would give too few transit cases). The use of such enriched, choice-based samples in model estimation was greatly facilitated by the work of Lerman and Manski (*3*), which showed how one should weight the observations from such a sample to obtain unbiased parameter estimates in a multinomial logit choice model.

To our knowledge, the last home interview surveys in major U.S. metropolitan areas were those undertaken in Portland and Baltimore in 1977 and the survey in Dallas in 1984. The Portland survey was a simple random sample of 1,000 households taken from a street directory base. The Baltimore survey also used a sample of 1,000 households. Half were sampled by an area probability sample, and the other half were chosen by oversampling in areas where transit usage was high (*4*). In the early 1980s, household travel surveys started to use other methods for contacting sample households and retrieving the travel and related data. In 1980, for example, Caltrans conducted a household travel survey of 2,000 households in the San Francisco Bay Area using a telephone survey. Reinke (*5*) reports that this survey was deemed successful because it was conducted at a much lower cost than a home interview survey and the response rate was more than 50 percent In 1981 MTC conducted a similar telephone-based travel survey of 7,200 households in the Bay Area to update its 1965 data base.

Telephone surveys have a number of potential drawbacks, but the disadvantages can be mitigated by careful survey design. As discussed in the section on sampling, a case can be made for the use of address-based sample frames, in which case nontelephone households could be physically contacted with either in-home or mailback retrieval, in essence a hybrid approach. There is some controversy over the use of multiple reminders and mailbacks versus telephone retrieval (or in-home surveys). Stopher (*6*) made the case, on the basis of a small sample pilot of the 1991 Boston survey, that there was a poorer response from mailback than with telephone retrieval but that the response from larger households was better with mailback.

The information we attempt to collect in household travel surveys has increased in quantity and complexity in recent years, and the trend is toward the collection of even more data of a more complex nature As a result, perhaps, the charge to the methodologies workshop suggests that the workshop consider the possibility of returning to the use of in-home interviews for conducting household travel surveys. Of course, a major issue in the use of in-home surveys is the cost of conducting such surveys. Purvis (*7*) recently estimated that the 1965 Bay Area Transportation Survey of approximately 30,000 households would cost more than $200 per household in today's dollars. This is more than twice the cost of the 1990 Bay Area Transportation Survey (a telephone-based survey) However, if there are substantial potential advantages to be gained from home interview surveys, their reintroduction should be carefully considered.

The reality of neighborhoods suffering from high levels of personal violence (usually coincident with low income) raises a question concerning the ability to motivate poorly paid survey staff to aggressively recruit and interview households under these circumstances. The emergence of gated enclaves of the wealthy along with their private protective services raises the question of accessibility to recruit and interview these households We might thus end up with even more nonresponse bias than with a telephone survey. Stecher et al., in another resource paper for this conference, note that it is not clear that the in-home survey will give improved response rates.

The household travel survey is only one approach for obtaining personal travel information, the other common ones being on-board surveys, employer-based surveys, and roadside origin-destination surveys. As noted earlier, on-board surveys of transit riders are used to supplement the information obtained in household travel surveys by providing information on "rare behaviors," especially concerning infrequently used modes. To our knowledge, choice-based sample enrichment for bicycle and walk travel has not been attempted in the United States—the difficulty of getting a random sample intercept for these modes may be insurmountable, and self-selected samples are not useful for model estimation. Employer-based surveys are also useful sources of information on personal travel, particularly for the journey to and from work, and might be very useful as we examine the effectiveness of employer-based TDM measures. Roadside origin-destination surveys, however, have become rare, being replaced by license plate intercepts followed by mailed out or telephone contact travel surveys. The Dallas-Fort Worth area recently fielded a direct roadside interview survey with good success, which may lead to a resurgence of this method. Of course, new possibilities for collecting personal travel data are becoming available through the use of advanced technologies (the subject of another workshop at this conference)

Current and Emerging Household Travel Data Needs

Data collected in household travel surveys can serve a number of purposes, although the conventional use of household travel survey data is for the estimation and calibration of travel forecasting models to be used in predicting network flows under a variety of alternative transportation plans and policies. In this paper we focus on the collection of household survey data for the development of travel forecasting models, but we recognize that such data can be useful for a number of different purposes. First, models that are not incorporated in the conventional travel forecasting model set can be developed For example, as suggested by Harvey and Deakin (*8*), household travel survey data could be used to develop models of car use that describe the likelihood of a cold start being made. Second, household travel survey data can be used to monitor trends in personal travel and to assess the extent to which planning and policy objectives are being met. Third, household travel survey data can of course be used to conduct fundamental studies of travel behavior, although such studies sometimes require data that would not normally be collected in a "routine" household travel survey

The data that are mandated for vehicle miles traveled tracking and emissions inventories do not come from household travel surveys but are mandated to be taken from the Highway Performance and Management System (HPMS) count program. This source, however, does not account for cold starts and the cold start mode of travel, which are the primary determinants of emissions and hence air quality. As Harvey and Deakin (*8*) point out, there is a danger that because some data are mandated, nonmandated data needs, such as household travel surveys, might be overlooked

The effect of travel demand management measures (congestion pricing, parking pricing, improved transit service and bicycle facilities, as well as employer-based actions) must be evaluated. These measures can have effects anywhere in the individual decision structure—the decision where to locate home and workplace, to travel, or to change route, mode, activity or trip pattern, or time of day for activity and travel.

The CAAA essentially requires consideration of the effect of transportation infrastructure investment on the location of jobs and housing development (as the law was written, the rules or federal regulations are less prescriptive). This leads to the need for integration of the land use-transportation analysis and forecasting paradigm.

The CAAA requires much more realistic simulation of emissions than is currently included in the modeling structure, namely vehicle use by type by time of day by road segment. When this requirement is combined with TDM actions, the postprocessing approach often practiced is inappropriate. Furthermore, the Congestion Management System (CMS) requires responsiveness to the effects of the operational and vehicle priority changes envisaged In particular, Intelligent Transportation System (ITS) implementation can affect travel demand in all of its dimensions. The ITS component of CMS will be heavily dependent on real-time data acquisition, which is not addressed here.

It is clear that new travel forecasting models are required and that the current "four-step" paradigm is not well suited for use as a policy analysis and planning tool in the era of CAAA and ISTEA. In fact, the limitations of the conventional paradigm have been well known for a long time, but they have been highlighted by the needs of the current planning and policy analysis environment The development of a new paradigm for travel demand forecasting in response to CAAA and ISTEA began in earnest in the United States when the Federal Highway Administration (FHWA) issued an RFP in August 1992 asking proposers to develop such a framework. Four teams were selected to undertake this task, and their reports were submitted to FHWA by the middle of 1993. Subsequently, a synthesis of the recommended approaches was prepared by the Volpe Transportation Systems Center. During this period the Travel Model Improvement Program (TMIP) was established, funded by the U S Department of Transportation (FHWA, FTA, and OST), the Environmental Protection Agency, and the Department of Energy. The latter program is also sponsoring the development of TRANSIMS, an urban transportation microsimulation tool, by the Los Alamos National Laboratory.

Naturally, the four reports to FHWA differed in the recommended directions for a travel forecasting framework, yet a number of common threads can be found in these reports More important, in the past year a consensus has emerged concerning the characteristics of a framework for travel forecasting to meet current and emerging policy analysis and planning needs. The characteristics include microanalytic simulation of travel demand and network flows, with travel demand being modeled over the course of a 24-hr day or longer period, not as a set of independent trips (as is the case in the current framework), taking into account the dependencies in the travel patterns of members of a given household Furthermore, in the emerging paradigm, travel is modeled as a dynamic phenomenon that derives explicitly from the need or desire to participate in activities that are spatially separated from one another.

The derived demand nature of travel has been recognized for more than 30 years, but the existing framework for travel forecasting (which is essentially the same as that developed for the earliest urban transportation planning studies nearly 40 years ago) does not really treat travel as a derived demand (Similarly, until recently, our data collection procedures also focused on trips rather than activities.) This approach to travel demand modeling is generally referred to as the activity-based approach.

Cross-sectional, revealed preference data focused on trips, rather than activities, is extremely limited for addressing many of the current policy questions and for use in the emerging approach to travel forecasting. To answer many of these policy questions there is a need for both stated choice/stated preference data for hypothetical questions and longitudinal data describing revealed responses to endogenous (e.g., family structure) and exogenous (e.g , change in supply of land and transportation infrastructure, travel cost, and parking supply) stimuli. Data on linked household decisions, including the use of time for household activities and travel, are needed for a sufficient description of behavior. The latter is included in the more recent surveys, as described later, and is covered by another workshop at this conference.

The development of stated choice experiments that clearly deal with response to change stimuli in a multidimensional and holistic fashion is challenging and will also be discussed at another workshop at the conference. The use of stated choice and stated preference for travel model development is becoming common in Europe and Australia. Models built from such data can be used for policy analysis and can be incorporated, using either joint or sequential estimation with revealed preference data, to develop regional predictive models. Stated preference is essential to estimate the direction and size of likely response to many of the TDM actions proposed—actions that either fall completely outside current experience or are far outside the range of current experience (e.g., congestion pricing of roads or gasoline selling at $4.00 per gallon). Again, this topic is covered by another conference workshop.

Methodological Issues in Household Travel Surveys

In designing a household travel survey, many factors have to be considered and a multitude of decisions need to be made. The decisions range from the size of the sample down to the detail of the type of paper on which the recruitment letter will be printed (if one is used)

The charge for the Survey Methodologies Workshop clearly focuses on sampling issues. However, as noted earlier, we have chosen to include a number of related issues in our discussion. We first discuss survey design issues that are not generally considered sampling issues but that we believe must be considered in conjunction with sampling design questions in designing a contemporary household travel survey. We then discuss sampling design, and we conclude this section by considering how sampling design and other aspects of survey design are interrelated.

Survey Design Issues

In designing a household travel survey, there are important methodological questions concerning (*a*) the completeness of the activity reporting (i.e., only activities requiring travel versus all activities), (*b*) the period for which respondents are asked to report their travel and related behavior, (*c*) whether the survey is cross-sectional or longitudinal, and (*d*) whether the survey is to include only data on existing travel behavior [so-called revealed preference (RP) data] or information about respondents' preferences for hypothetical alternatives is also to be included in the survey [so-called stated preference (SP) data] These four issues, the last three of which are closely related to sampling design questions, are discussed below. In any case, one could argue that the length of the period for which respondents are asked to report their behavior, and whether the survey is a cross-sectional or longitudinal one, are really sampling issues. In fact, Hautzinger (*9*) points out that when we conduct a travel survey we are really sampling from a space of people and days. That is, when we prepare a sampling plan for a travel survey, we select whom we will survey and for which days we will ask them to report their travel.

Trip-Based, Activity-Based, and Time Use Surveys

Traditionally, household travel surveys have focused on travel, and the typical question in such surveys had the form "Where did you go?" followed by other questions about the trip In some recent surveys the format has been modified to focus on activities by asking questions such as "What did you do?" Stopher (*6*) refers to the latter type of survey as an activity survey, but the survey to which he refers (Boston, 1990) collected information only on out-of-home activities. To make the distinction clear, Pas and Kitamura (*10*) refer to surveys in which both in- and out-of-home activity information are obtained as time use surveys. A discussion of the field of time use research and its relationship to travel modeling is given by Pas and Harvey (*11*).

There are a number of reasons for collecting activity or time use data. First, if we wish to understand and model travel as a derived demand, we need to focus on the activities that are linked by the trips. Second, the activity or time use approach to travel surveys, particularly the latter, places the travel in the context of the respondent's day and hence facilitates recall of short, infrequent trips. Finally, to examine in-home activity substitution under constrained transportation supply or increased costs, information on in-home activities is important. In addition, multiple activity stops away from the home might be an important response to situational change.

The other matter of importance is the evaluation of the transport system under constrained supply, or "What is an acceptable level of service?" There is evidence of a time trade-off of discretionary activities where travel times for the work activity are high (*12*). It could be that many of these discretionary activities are what constitute "quality of life" and that the impact of congestion may be better measured as activities forgone rather than V/C ratios (*13*)

If this is true, the use of time is an important concept, and a full accounting of activities is needed. This is also consistent with the utility theory that is the basis for current models—the disutility of travel is offset against the utilities of activities.

Experience in Portland, where a full activity (or time use) survey was conducted recently, does not suggest that the respondent burden or response rates were significantly affected. For those who were recruited, the response rate (completions) was 63 percent, using a strict definition of completeness—an activity diary for all members of the household, no partials accepted. This is not out of line with experience with recent travel activity (only) surveys, especially considering that the Portland survey was a 2-day survey The biggest problem is to explain to respondents why nontravel activity is important in a travel survey

Traditional trip-based surveys can be used to infer the activities associated with the trip. However, the number of trip purposes is usually very limited in travel surveys, making it difficult to clearly define discretionary activities in any meaningful way. The trip purpose definition is also not consistent with the activity definitions in the richer set of data obtained in traditional time-use surveys, a possible source of secondary information on time use. In the Portland study, 28 activity codes under 5 groupings (household sustaining, social, personal enrichment, recreation and other diversions, and other) were used. The intent is to let the data reveal what is and is not discretionary, rather than using ad hoc assumptions.

Length of Reporting Period

Historically, respondents in household travel surveys were asked to report their travel behavior for a 24-hr period (generally the previous day), although it is well recognized that travel patterns vary from day to day. For example, one generally does not go shopping and do banking each day, although such activities need to be done from time to time This conventional approach is presumably based on the belief that if a random sample of households is drawn and samples of households are random across the days of the week, the behavior of households of a given type on different days of the week will be observed. (Only weekdays were sampled in the early studies.) In this way, a sample representative of the population of households and days of the week is obtained, and the average behavior of the households, or the behavior of households on the average weekday, can be modeled. Whereas the conventional approach might make sense if the only interest is in modeling average behavior, it might not be the most cost-effective way to collect data. Furthermore, it does not provide information that might be important in modeling response to TCMs, for example.

If there is day-to-day variation in personal travel behavior, additional information is obtained by asking respondents to report their travel for more than a single day. How much more information is obtained from a multiday survey, of course, depends on how much day-to-day variation there is in personal travel behavior. Furthermore, each additional day in a multiday survey presumably provides less information than the previous one, on the average, increases the possibility that some trips are not reported due to respondent fatigue, and affects respondents' willingness to participate in the survey because of the additional burden. In any event, the cost of each additional survey day needs to be traded off against the increased information obtained.

Research undertaken quite some time ago showed that a substantial proportion, on the order of 50 percent, of the variation in personal trip generation rates was attributable to within-person, day-to-day variation when data for 5 consecutive weekdays was examined (*14*). Pas (*15*) also showed that for a relatively wide range of assumptions about the marginal cost of collecting data for additional days, the optimal number of days for a multiday survey was approximately 2 (from the point of view of parameter estimation in a linear trip generation model). This analysis did not, however, take into account respondent fatigue and a possible increase in nonresponse rate.

The research just mentioned was conducted with data collected in Reading, England, in 1973. A recent study, using 3-day survey data collected in Seattle, showed that similar levels of day-to-day variation in trip generation rates and daily time used for travel exist in the United States (*16*) Furthermore, it may well be that in the context of activity/trip chaining models, the level of day-to-day variation is even larger, thus making multiday surveys more cost-effective in this case. Results recently reported by Ma and Goulias (*17*), using data from the Puget Sound (Seattle) Transportation Panel, suggest greater day-to-day variability in activity patterns than in travel patterns.

Whereas there is some indication that respondents report fewer trips toward the end of a 7-day survey (*18*), it is unlikely that respondents in a 2-day survey would underreport travel on the second day. In fact, Pas and Sundar (*16*) found no evidence of decreased levels of reporting in subsequent days in the 3-day survey conducted in Seattle.

Beyond the question of cost-effectiveness for model estimation, a multiday survey provides information that cannot be obtained in a traditional single-day survey. For example, from a 1-day survey one cannot learn about what has been referred to as "part-time carpooling," where commuters carpool 2 or 3 days per week but not on all days. In addition, multiday information is needed to understand and model the possible multiday effects of TDM/TCM actions. The other opportunity with multiday diaries is the possible inclusion of weekend as well as weekday data, further adding to the understanding of weekly activity patterns, as opposed to daily patterns.

Longitudinal Data

Traditionally, household travel surveys were cross-sectional. Data were gathered that essentially took a snapshot at one point in time. More than 10 years ago researchers started emphasizing the need to collect, analyze, and model longitudinal data to understand behavioral responses to situational change [an early assessment of longitudinal surveys in transportation is given by Hensher (*19*)]. However, the first suggestion for the use of panel data in transportation modeling seems to be that by Worrall (*20*), who suggests that longitudinal data are needed for proper modeling of urban travel and location decisions as well as for monitoring purposes (This idea emerged from an NCHRP project on monitoring urban travel conducted by Garrison and Worrall in 1966, but the report was never published—probably because the researchers' ideas were far ahead of their time.) Worrall's paper suggests the use of a "permanent response panel—analogous to the consumer panels employed in market research" to collect longitudinal information on location preferences, daily activity sets, and daily travel patterns of urban households. Interestingly, not only did research by Garrison and Worrall point to the idea of panels for collecting urban travel and related data, it also raised the idea of the other form of longitudinal data discussed here, namely, multiday data. In fact, Worrall's paper suggests the possibility of using smaller samples for 2-, 5-, or 7-day surveys as opposed to larger samples for a single day.

Longitudinal household travel surveys can take a number of forms:

- Repeated cross-sectional surveys,
- Before-and-after surveys, and
- Panel surveys.

The panel, which is the most commonly used longitudinal survey method in transport planning, is a repeated survey (wave) of the same sample of respondents. The period between waves depends on the behavior being analyzed. It could be a before-and-after survey—weeks to months, an analysis of automobile ownership transactions (6 months or triggered by an action), travel behavior changes, or a housing transaction analysis (perhaps annual). A multiday survey, in fact, can be thought of as a very high frequency panel of short duration In this type of survey the sociodemographic characteristics of respondents remain constant and the external environment, including the transportation level of service, is generally treated as constant except for cases in which day-to-day changes in departure time or route have been examined specifically as a function of the respondent's experience on previous days (*21*)

Longitudinal data and models have a number of advantages relative to cross-sectional data and static models (22). Most important, the use in forecasting of a model based on cross-sectional data from one point in time represents the "longitudinal extrapolation of cross-sectional variations" (*22*). That is, in forecasting with a model based on cross-sectional data, we essentially apply cross-sectional elasticities derived from differences across different observational units as if they represented the longitudinal elasticities that reflect the change in behavior, for each observational unit, that is brought about by a change in an explanatory factor. Goodwin et al. (*23*) show that this approach is valid only under the following very restrictive assumptions: (*a*) the behavioral response is immediate (i.e., no time lag or lead), (*b*) the magnitude of the behavioral response is the same regardless of the direction of change (i.e., symmetrical response to change), and (*c*) the behavioral response is independent of the past history of behavior.

Of course, the validity of these assumptions cannot be examined without longitudinal data. As the recent summary of transportation-related panels provided by Hensher and Raimond (*24*) shows, there have been a number of such studies, primarily in Europe, over the past 10 years. The first major panel for transportation studies was the Dutch National Mobility Panel, which began in 1984 and ran through 1989 (*25*). The first general-purpose transportation panel in the United States is the ongoing panel in Seattle (*26,27*). Empirical evidence from panel studies is accumulating and indicates that the foregoing conditions under which one can use models based on cross-sectional data to make forecasts are not valid in the context of travel and related behaviors (*28,29*).

As noted by Kitamura et al. (*30*), dynamic models based on longitudinal data allow for the "explicit incorporation of behavioral dynamics including lags and leads in response time, asymmetry in response, behavioral inertia and habitual response patterns (e.g., brand loyalty)." Such models are therefore able to provide more realistic descriptions of behavior in which present decisions affect future behavior and are affected by past decisions.

A panel survey provides information that simply cannot be obtained from a repeated cross-sections design. For example, if one used the repeated cross-sections design to study changes in car ownership, one could estimate the overall change in car ownership but could not identify the fact that some households increased their level of car ownership while others decreased or maintained the same level of ownership. Goodwin (*29*) reports a variety of examples of the rich interpretations that can be made from panel surveys that would be masked by repeated cross-sections designs.

Issues with the use of panels include sample maintenance and replacement, panel attrition and conditioning, weighting and use of panel data, and the introduction of the dimension of change in response over time (it is not clear that we have the tools to develop models of choice under this last condition). The problems of attrition and conditioning and techniques to deal with these problems have been extensively examined in the context of the Dutch National Mobility Panel (*31–33*). Attrition was particularly severe in the Dutch National Mobility Panel, and only 33 percent of those in the first wave completed all 10 waves (the waves were 6 months apart). In the Puget Sound Transportation Panel, particular care was taken to reduce attrition by maintaining contact with the sampled households beyond the needs for data collection. In the case of this survey, 81 percent of the Wave 1 sample completed Wave 2, whereas 63 and 55 percent of the Wave 1 sample completed Waves 3 and 4, respectively. Interestingly, both the Dutch National Panel and the Puget Sound Panel were multiday surveys in addition to being panel surveys. The Dutch survey used a 7-day diary, whereas the Puget Sound survey used a 2-day diary. As noted earlier, analysis of the data collected in the Netherlands indicated a systematic decrease in trip reporting over the course of the week

An important continuing issue in panel surveys is the need for good information on the frequency of occurrence or base shares of interesting behaviors that may be rare or sparse, particularly for a panel sample that would probably be smaller than a cross-sectional sample. However, it is possible that cross-sectional surveys could be replaced by carefully conducted panel surveys.

Stated Choice/Preference

SP surveys and derived models are the subject of another workshop (and resource paper) at this conference. However, this subject must be introduced here because the incorporation of an SP survey can have a large effect on the sample needed in the revealed preference household survey

This approach to data collection is very efficient in parameter estimation because of the use of a factorial design of the sample, maintaining orthogonality, and much information can be obtained from each respondent with the use of multiple scenarios per respondent. The use of this technique can also reduce the need for complexity in the RP portion of the household travel survey. SP is particularly useful for transit modeling, where there is a need to ensure a full range of attribute variables for parameter estimation. If SP is fully utilized, a much smaller RP sample is needed. The RP survey becomes essential for providing estimates of base shares, which are important for scaling or calibrating SP models. SP can also include nonobservable (in RP) variables (e.g., the value of a guaranteed seat or personal security), providing parameter values for these attributes It may be the most useful source of information for nonvehicular modes of travel. It is the only conceivable source for models and policy analysis of new situations and speculative hypotheticals (e.g., congestion pricing and telecommunications effects) The major limitation in the use of SP is the difficulty of a design that includes the added complexity of activity pattern or trip chain changes as a part of the response to situational change.

Design of the RP sample is simplified under this strategy. The main requirement for the RP sample is the provision of information on behavioral shares—the size for "unambitious" model estimation. That is, the recommended strategy is to make use of the strengths of each of these techniques, while mitigating their weaknesses by using combined data to estimate our models. There has been a flurry of activity on this front (*34–42*)

Sampling and Related Issues

Sampling Frame

The sample for household activity and travel behavior should clearly be a random sample of households that is as representative as possible The most commonly used selection approach is random digit dialing of household telephone numbers There is a strong case to be made for the use of street address directories or electric/gas utility lists The telephone universe clearly omits the poorest households, and upwards of 50 percent of households in large urban areas are unlisted, leading to telephone recruitment in a "cold call" situation. Combined with telemarketing saturation, this leads to a large number of refusals to participate (the recruitment rate was only 52 percent in the Portland market in 1994–1995). Another strong argument for an address-based sample frame is in the use of urban design stratification schemes. The random digit dialing of unlisted numbers makes prestratification very difficult. As a practical recruitment matter this would also mean the ability to send an introductory mailer before the recruitment telephone contact. Unlisted numbers would have to be visited for recruitment, an added cost, and households without phones would also be included.

Sample Size

For simplicity we only discuss the RP home interview survey at this stage, assuming a 1-day diary and a cross-sectional survey. The effects on sample size of multiday and longitudinal designs as well as SP enrichment are discussed in the next section.

As a general statement, we tend to deal with responses with sparse representation of behaviors of interest and to look at behaviors that may be redefined during model specification (e.g , number of modes to be considered by the number of trip purposes to be considered, trip or activity chain classification). We do not think that there is any a priori way of determining the sample size, especially when we are dependent on the survey to determine the behavior frequency (there is rarely an independent estimate). In any case, when we intend to use the data to estimate a number of different models, it is hard to determine the sample size needed to meet the needs of all the models, and it certainly becomes very difficult to try to optimize the sample with respect to a variety of models. As Axhausen (*43*) notes, we use the same survey to provide data for models working at "quite different time horizons and levels of social complexity. For example, there are short term models, such as mode choice and departure time choice, long term models, such as car ownership or work place choice, models with simple social contexts, such as destination choice of individuals, and models of high social complexity such as the allocation of the household vehicle." Furthermore, the models operate at varying levels of spatial complexity.

There has been research on sample size for transportation modeling, especially in the late 1970s and early 1980s. However, it has primarily been aimed at trip generation for a predetermined set of purposes using cross-classification models (*44,45*) or at multinomial logit models primarily of mode choice (*46–48*) The modeling demands are now much more rigorous. For example, we do not know of any work dealing with sample size needs for nested logit models or the best sampling plans for such models.

There is an accepted rule of thumb among disaggregate modeling practitioners that at least 30 cases of a behavior classification to be modeled must be present in the data. We have heard of the desire for 100 observations, but it is doubtful that this is a practical goal. It is clear that this leads to questions of sample stratification or choice-based sampling, or both, to obtain enough observations of desired rare behaviors without drawing an immense random sample that might be financially impractical. [The number of households for recent and current household travel surveys in the United States ranges between 400 (Pittsburgh) and 16,000 (Los Angeles) for a 1-day survey.]

An example might be to estimate the number of households required to adequately sample bicycle users for work trips, where an independent estimate of share is available (Census). Assume the average share for a region is 1 percent and that there are 1.2 workers per household, who travel to work 85 percent of the time (allowing for vacation, sick days, etc.). To get 30 bicycle journeys we would have to sample 2,941 households. This is derived as follows. (no. of occurrences required)/(expected frequency of occurrence) = 30/(.01*1.2*0.85). This is an absolute minimum, allowing no room for error. There is reason to believe that bicycle trips are forgotten or discounted by the respondent in a trip-based survey and are therefore underreported. This was certainly the case in the 1985 Portland survey, where 4,900 households did not yield enough bicycle trips for modeling the mode choice for this mode of travel.

The situation becomes more complex when we expect many attribute parameters to be needed (e.g., walk time, wait time, in-vehicle time and cost, automobile ownership, and household size, to delineate the decision space for transit choice). Where transit ridership is low (typically 3 to 10 percent for the western United States for work and 1 to 3 percent for other purposes) and there is a desire to separate by mode of access (walk, transit, car), we may be looking for 300 to 400 cases at a minimum to be able to estimate a model The problem is exacerbated by the lack of good a priori knowledge of the frequency distribution of a desired modeled behavior (transit percentage for a nonhome trip with a work end, for example). When we consider the possibility of estimating models on the basis of trip chains or journeys from home and back, it is clear that no definitive answer can be given at present.

There is usually a practical sense of how much money is available for a household travel survey, and the sample size is often dictated by the budget. This being said, the recommendation of the authors is to get as many samples as can be afforded and to maximize the information given by the sample by stratification and other techniques. It is our opinion, on the basis of experience of one of the authors, that at least 4,000 household survey days are required to estimate a fairly unambitious, traditional model (six trip purposes and five modes), which would not include bicycle use, if the sample is a simple random one (Portland, Oregon). With the development of models directed toward activity-based modeling (see earlier discussion), with the explicit consideration of time use, it is likely that a very large purely random sample would be needed in some cities if revealed preference models were to be the only accepted techniques for collecting travel-related data, as is the current U.S. practice. A discussion of the interrelationships among sampling and other survey design issues (the use of longitudinal panels and stated choice experiments) is given later.

Sampling Technique

Random Sample

By definition the sample must be randomly drawn for unbiased model estimation. It is not necessary, however, to have an unstratified (regionwide) random sample, since this would produce a wasteful abundance of information about the most common behaviors and insufficient information on less common behaviors of interest. Of course, this is a very inefficient strategy.

Cluster Sample

The main reason for cluster sampling is to minimize costs in fielding in-home surveys. Should the data from the census long form no longer be available, it is probable that all or a portion of the activity and travel behavior survey will have to be collected at the home (see later discussion under Survey Weighting and Expansion) In this case, cluster sampling should be considered—the clusters would still have to be randomly drawn.

Choice-Based Sample

This approach has historically been used for trip-based modeling, where on-board transit survey data (supposedly randomly drawn) have been used to enrich the household sample data. In the context of models of activity patterns or trip chains, a survey of trips (e.g., on-board) would not be useful. However, an on-board intercept of transit users to identify a subset of households with transit use is appropriate, and these households would then be included in the sample for the household travel survey. This technique was used for a sample of automobile access to transit travelers in the 1994 Portland survey and for transit riders in the Raleigh-Durham survey (1994–1995). When used as an on-board intercept for a choice-based sample of households in Eugene, Oregon (1994), where 25 percent of the transit riders are children, problems with randomness became obvious. The question of asking children for their phone number or where they live is difficult, and children cannot commit their household to be a survey respondent. For a choice-based sample to be useful, an independent estimate of base shares for nonwork activities is needed, which is not usually available in the United States. Designing an intercept technique for pedestrian and bicycle use and for telecommunications effects may prove impossible.

Stratified Sample

This strategy makes sense if the strata are used to maximize the chance of getting the desired samples of rare behaviors. On the other hand, this approach is counterproductive when the sample is politically or arbitrarily stratified, which is common practice in the United States, for example, to provide representative data at the county or city level. There is a direct compromise when there is confusion between collecting descriptive data for member jurisdictions (or modeling data that are jurisdiction specific) and collecting data for model estimation The rule of thumb in collecting 30 to 100 unbiased cases of rare behavior to be modeled still holds—if there are five counties a 500 percent increase in the sample size is needed for local model estimation. With normal budget constraints, the compromise often results in no models for rare behavior and more data than needed for modeling common behaviors, a very inefficient approach

Geographic stratification to maximize efficiency has great promise. This technique was used in the Oregon-Southwest Washington 1994 household activity and travel survey and in the Triangle Transit Authority's 1994–1995 activity and travel survey. The approach used in these recent surveys entails stratifying by urban design character—"oversampling" areas where mixed use and a good pedestrian and bicycle environment exist increases the probability of observing pedestrians, bicyclists, and transit riders. Similarly, oversampling the exurban and rural locations to get better information on household location choice characteristics and travel patterns for households with poor urban accessibility is useful. First returns from the Portland part of the Oregon-Southwest Washington survey suggest reasonable success with very rich data. This approach was used in the 1977 Baltimore survey mentioned earlier in this paper.

Survey Weighting and Expansion

The following discussion is in the context of the United States and U.S. sources of independent data, since that is the experience of the authors.

The primary reason for expansion weights is for the production of descriptive statistics, trend tracking, mandated measurement of goal attainment, estimation of base shares for calibration of stated choice models, and the use of choice-based samples. They are not often needed in disaggregate model estimation from random or random stratified sample data Similar techniques are needed to prepare an estimate of households for base year aggregate model calibration and application

The first stage is the estimation of stratum weights to develop a simple expansion to the universe of households. This is dependent on the stratum definition. In the case of a geography by urban design stratification, a classification of all households by stratum is required (a GIS overlay approach is practical here). Each stratum can then be proportionally expanded This obviously requires the availability of a data base of households by location for the survey year The second stage is to determine the factors needed to carry out a socioeconomic weighting to account for nonresponse bias and nonrepresentativeness of the survey respondents. This can be carried out using a combination of the Public Use Microdata Sample of individual households of the Bureau of the Census and the data tabulations at the tract and block group level

Similar methods are being explored by the Los Alamos National Laboratory and researchers at the National Institute of Statistical Sciences to develop "synthetic" household populations for use in urban microsimulation models [Beckman (*49*) describes one such approach].

Loss of Census Long Form

There is currently a move to collect only those census data needed for population enumeration for representative voting purposes as laid down in the Constitution. The long form data on household socioeconomics and structure would be lost. There is also a move to go to "continuous measurement"—collection of a smaller sample annually that could yield added information on a timely basis, with 3- to 5-year aggregation used to create a larger sample similar to the current decennial cross section. The latter approach would not lose much and would be very useful for modeling endeavors such as household location.

Complete loss of the long form sample would lead to the need for a much tighter fielding of household surveys—probably of larger size. These surveys would need to provide good estimates of the base distributions directly. The use of a sample frame similar to the census enumeration technique (master address file), probably with some telephone pickup and in-home interviews for nontelephone households, would be required. Nonresponse in travel surveys would become a major issue, with the need to push for in-home surveys of telephone nonrespondents. Careful stratification can minimize the problem, but overall control would have to be much tighter. This could possibly double the per household costs for a survey. The household survey would become important for the underlying distributions of household structure currently available intermittently from the census. An alternative would be to conduct a "census style" survey of a larger set of households, with a subset being subject to the activity and travel survey.

Interrelationships Among Sampling and Other Survey Design Issues

Multiday and Longitudinal Panels

Multiday

Previous research (*15*) has examined the relationship between the number of days in the survey period and the sample size for a given level of precision in the estimated parameters in a linear regression trip generation model of person travel. One can achieve a given level of precision in the estimated parameters with either a 1-day sample or with a smaller multiday sample because additional survey days yield increased information. The size of the multiday sample, relative to the size of the 1-day sample, depends on the level of day-to-day variability in the travel phenomenon being modeled. However, because of the economies inherent in conducting a multiday survey (design, sampling design, sample recruitment, and so forth are essentially the same for a 1-day survey as for a multiday survey), one might be able to achieve a given level of precision for less cost with a multiday survey, or one might be able to increase the precision of the parameter estimates for a given survey cost. Using the data collected in Reading (see the section Survey Design Issues), Pas shows, for example, that a 2-day sample would yield about a 20 percent reduction in cost, for the same precision in the parameter estimates, under the assumption that the variable cost (or cost per day) of the survey is 25 percent of the fixed cost In this case, it turned out that the sample size for the 2-day survey would need to be approximately 67 percent of that for the 1-day survey to yield the same level of precision in the parameter estimates. However, even if the cost savings were lower, the additional information provided by the 2-day survey would make this the more desirable approach.

Longitudinal Panel

We do not know comparable efficiencies to be obtained from a panel survey in terms of the precision of the parameters in an estimated model. However, the relationship between the sample size needed for a two-wave panel survey (N_p) and the sample size for a repeated cross-sections survey (N_c), to yield the same precision in the estimate of the change in some variable between two points in time, is given by Smart (*50*) on the basis of results of Kish (*51*), as follows.

$$N_p = N_c/(1/1 - R)1/2 \qquad (1)$$

where

N_p = sample size for the panel survey,
N_c = sample size for the repeated cross-sections survey, and
R = correlation between the two surveys (for the variable of interest).

Smart reports an example, based on data in Kish, of estimating changes in car ownership on an annual basis In this case, R was found to be approximately 0.8, so that the sample size for a panel survey would be less than 0.50 (about 0.45 to be more accurate) of that needed for a repeated cross-sections survey to yield the same precision in the estimate of the annual change in car ownership.

Of course, the lower the correlation in the variable of interest across the two time periods, the smaller the sample size reduction brought about by the use of a panel survey. However, even if the correlation were only 0.5 (thus indicating a high level of change over time in the variable of interest), the sample size for the panel survey could be about 0.7 of that for a repeated cross-sections survey. Even in this case, the use of a panel survey would lead to substantial cost savings. For example, in the case where R = 0.5, if a repeated cross-sections survey of 1,000 observations yielded a precise enough estimate of the change in the variable of interest, then a panel survey with about 700 observations would yield the same level of precision in the estimate of the change. Allowing for attrition, and taking account of the cost per unit in the case of a panel survey versus that in repeated cross-sections, the cost of a panel survey would be about 60 to 70 percent of that of a repeated cross-sections survey.

Another example follows, using 1990 to 1994 costs: Whereas a household survey costs about $100 for a single day and $130 for a 2-day survey when all costs are allocated (survey and sample design cost are added to the cost of sampling, recruiting, and retrieving and validation of responses), the marginal cost of sampling, recruiting, and retrieving is about $75 to $85 per respondent. In a multiple wave, the design and sample are in place, and recruitment of previous respondents tends to be successful. Because of more successful recruitment, estimates of the cost for successive waves (after the first) are $55 to $75 per household, and perhaps lower It has been estimated that the repeat waves cost about $45 per household in Seattle (discussion with E Murakami).

The trade-offs in sample size here are less clear. Whereas the per household costs in subsequent waves are about half the initial wave cost, and each wave adds considerable information, the ability to capture rare behaviors is reduced by the smaller base sample size. Assuming the latter issue could be dealt with in other ways, the cost-effectiveness of a longitudinal design can be explored as follows. A base of 2,000 sample households could (assuming attrition rates similar to those in Seattle) drop to 1,400 households by Wave 4, giving 6,800 household-days at the same cost (assuming a subsequent wave cost rate at 50 percent of the initial wave) as 4,400 household days in a 1-day cross section. [Initial cost = x, total cost = 2,000*x + x/2*(1,800 + 1,600 + 1,400). 6,800 household-days at $4,400x, the $4,400x would obviously buy 4,400 household-days as a single nonrepeated cross section.] Thus, a longitudinal design could provide about a 50 percent increase in household days for the same price as a single cross section. The major benefit of a panel design, however, is the increased availability of temporal change information. This data source is of particular benefit to undertaking transactions modeling of automobile ownership and dwellings

A base longitudinal survey of, say, 1,500 households, with continuing replacement of attrition and a rotation of new households in each 5-year period, carried for 10 years, could give 15,000 household days for about $1,000,000. [Start with 1,500 at $150,000 ($100 each), rotate/replace 300 households per year ($30,000 per year), resurvey 1,100 households at $50 each ($55,000 per year), total cost = $150,000 + 9 * $30,000 + 9 * $55,000 = $915,000, with an ongoing annual cost of $85,000 per year] The same number of household-days with a 1-day survey would cost about $1,500,000, on the basis of recent U.S. costs. Alternatively, 10,000 household-days could be obtained at the same cost. The longitudinal survey, however, carries much more valuable information.

Multiday and Longitudinal Panel Interaction

It is clear that a combination of longitudinal and multiday techniques can be used to reduce the total cost per unit of information. In the preceding case an approximation would be to reduce the sample size from 1,500 to 1,000 households for 2 days each, yielding the same information at about a 20 percent savings in cost. Another reason to combine panels with multiple days is that when one tries to estimate change in travel behavior from, say, two waves of a panel survey, one is better off with multiday data. Otherwise, the change is confounded by day-to-day variability Therefore, one may infer change where none has taken place, or one may infer stability where change has taken place. In a recent study, Mannering et al. (52) reported that activity models estimated with the 2-day diary data from two waves of the Seattle panel appeared to be unstable over time, but they acknowledge that day-to-day variability (which is only partially captured by a 2-day diary) may have partially confounded their results.

It is not known by the authors whether any statistical work on the problem of optimal sample design for a multiday panel survey has been attempted or completed. This is an area for future cooperative research with statistical scientists.

Stated Choice/Preference

With the need to consider the many complex TDM/TCM strategies, urban design effects, and nonmotorized travel, the question of the appropriateness of revealed preference techniques can and should be argued. The household survey soon begins to take on the attributes of the White Knight in Lewis Carroll's *Through the Looking Glass*, becoming impractically top-heavy Attempts to answer all possible questions are, perhaps, doomed.

A method considered in detail at another workshop at this conference, stated preference, is relatively inexpensive on a per survey basis. In Portland an extremely complex pricing survey cost less than $50,000 (road pricing, congestion pricing, parking pricing, and fuel pricing for commuters) This was for a design with 15 choices, 15 attributes, and 400 respondents each giving 8 responses Simpler surveys (new mode effects on existing corridor travel patterns, for example) can be in the range of $20,000 to $30,000. The use of this technique to investigate currently rare behaviors (e.g., bicycling) can significantly reduce the demands on the size and complexity of the revealed preference surveys (household surveys) The inclusion in the SP survey of alternatives that are used and have revealed behavior to scale the stated choice models is important The availability of known underlying shares is also important. The need for large samples of rare behaviors in revealed preference (household) surveys to get a rich range in needed explanatory variables is reduced or removed

RECENT EXPERIENCES AND CURRENT PLANS FOR HOUSEHOLD TRAVEL SURVEYS IN THE UNITED STATES

Most metropolitan areas in the United States entered the 1990s with travel demand models that had been developed using data that were woefully out of date In some areas the last household travel survey had been conducted in the 1960s, but given the changes that had taken place through the 1980s in household structure, employment location, and travel patterns, even data sets that were only 10 years old were inadequate for modeling current travel behavior

A number of metropolitan areas in the United States undertook a household travel survey to coincide with the 1990 census of population. More important, a large number of metropolitan areas have either very recently completed a household travel survey, are in the midst of undertaking such a survey, or plan to undertake such a survey this year These studies have generally been motivated by the recognition that current data are needed to update existing travel demand models. Furthermore, there is increasing awareness of the need to collect the data that are needed to develop the next generation of travel forecasting models.

An examination of household travel surveys undertaken in 1994 or planned for 1995 shows a trend toward collecting household travel data that can be used both for existing travel forecasting models and the emerging model framework. The current wave of household travel surveys can be characterized by the following features:

- The focus is on activities rather than trips (at a minimum, an "activity format" is used for asking the questions, although in-home activities are not always included).
- Information is collected on in-home activities in a number of cases.
- There are variations in the level of detail and the approach for collecting in-home activity information (we are still learning how to best obtain such information).
- A multiday reporting period is used in some of these surveys.
- The surveys are stated preference surveys, which sometimes follow a revealed preference survey.
- Some are the first wave of a planned or proposed panel survey.
- Sampling is generally by telephone number, although some efforts have been made to sample households that do not own telephones.
- Geographic or other stratification is used to obtain information on rare behaviors.

- A multiphase approach, using telephone (CATI) and mail-out, is emerging as the standard approach for recruitment and retrieval. The phases can be summarized as follows: (*a*) recruitment letter mailed to sampled households; (*b*) recruitment telephone call made (with key sociodemographics obtained early in the call); (*c*) memory jogger or diary, or both, mailed to respondents; (*d*) reminder call made on the night before the travel days; and (*e*) retrieval telephone calls made—usually multiple calls used (or mailback) to get information from all intended household members.

IMPORTANT ISSUES

It could be hypothesized that a combined multiday panel integrated with stated preference surveys (possibly at each wave of the panel survey) is the most efficient design. Some might consider this to be a radical suggestion, but it should be kept in mind that Worrall suggested almost 30 years ago that multiday panel surveys be considered for urban transportation studies. Whereas there is a long wait for the first data, much more information is obtained in the long run. A continuing annual expense, for a panel survey, may be more easily institutionalized in a public agency budget. The stated preference instruments could first be used to estimate the basic time and cost elasticities for specific market segments. Subsequent SP surveys would address the burning policy questions of the day.

Rather than recommending a direction for household travel surveys, we would prefer to think that this resource paper has raised many of the important issues for discussion, clarification, and then, it is hoped, the development of new directions in the collection of data for policy sensitive models of household activity and travel behavior We list a series of issues to guide the discussion at the workshop

To make the best use of funds to be spent on data collection requires that we spend some money now on research and development for household travel survey methods. We need to be creative and not be constrained by past practices if we are to develop sound procedures for the household travel surveys of the future.

1. Should we set the highest-priority research topic as the issue of developing the "best" combined methodology mix—also known as total design?
2. What is the optimal allocation of a (fixed) data collection budget for a period of N_Y years, in terms of the number of households N_H, the number of days N_D, and the number of waves N_W?
3. The issue of designing the sample to get a reasonable estimate of base shares from revealed preference surveys (especially a smaller panel) is a challenging one. Success here also makes the stated choice approach much more utilitarian. Do we know the right stratification scheme? How does this affect the choice of sample frame?
4. The integration of stated preference means that we need to know more about the optimal design of the common attributes for joint estimation and the techniques to create an efficient combined design. What do we know about this? How much formal research has there been?
5. Is the possibly greater nonresponse bias of multiday surveys a real and quantifiable disincentive to the use of such surveys? Another workshop at this conference will address this issue.
6. Could a lower frequency (say 2-year intervals) provide useful information from a panel survey? How much information would be lost? Of course, a lower frequency would enable the use of a larger panel (and hence allow for better estimates of the base shares) or reduce the annual survey cost.
7. Is a national panel used to develop the response to change metric useful and combinable with occasional household surveys and stated choice surveys at the local level? Do we need panels in every major metropolitan area in the country?
8. Travel surveys seem to be getting harder and more demanding, whereas the public is subjected to telemarketing and surveys to the point of distraction. Is this an argument for smaller coverage panels and the use of the frugal stated preference? Or is this an argu-

ment for passive surveys of travel behavior (to be discussed also at the workshop on new technologies)?

9. Is there evidence that differences in response rates between multiday and single-day surveys in the United States are so great as to suggest not using a multiday approach?

10 Similarly, what are the differences in the response rates for cross-sectional versus panel surveys in the United States? Are they different enough to make one preferable to the other?

11. How much is known about panel attrition and conditioning, especially in the United States? Do we need more research here or do we have enough?

12. Is it time to use address-based sample frames, given the difficulties raised by unlisted and no-phone households?

13. Should we use in-home retrieval for no-phone households?

14. Which is better, mailback or telephone retrieval?

15. Consistency (surveys monitoring change) versus new surveys for information on changing behavior and response to new policy concerns should be considered.

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The authors have also gained considerable insight and information from meetings of peer review panels on model specification and survey needs for several studies in the United States These include Portland (panel on models, 1992; panel on survey methods, 1994), Raleigh-Durham-Chapel Hill (Triangle Transit Authority, panel on models, 1992; panel on survey methods, 1993), Honolulu (1993, 1994), Dallas-Fort Worth (1994), and New York (1994). It is impossible to disentangle the sources of ideas, since these meetings included a wide range of academics and practitioners, among them Carlos Arce, Bill Allen, Jim Benson, Dan Brand, Patrick De Corla-Souza, George Dresser, Tom Golob, Dave Hartgen, Greig Harvey, Ron Jensen-Fisher, Ryuichi Kitamura, Arnim Meyburg, Michael Morris, Elaine Murakami, Chuck Purvis, David Reinke, Jim Ryan, Will Schroeer, Gordon Schultz, Gordon Shunk, Frank Spielberg, Cheryl Stecher, Peter Stopher, and Johanna Zmud.

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