Emerging Issues in Travel Behavior Analysis

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ABSTRACT
This paper is a resource paper on emerging issues in travel behavior analysis that have implications for the future of the National Household Travel Survey (NHTS) in the United States. The paper provides an overview of recent trends in activity and travel behavior research, both from a behavioral perspective and a methodological perspective. Based on these recent and emerging trends, the paper presents a series of suggestions regarding how the future NHTS can be enhanced, augmented, and modernized to serve the future needs of planners and researchers in the field. In particular, the paper suggests that the NHTS move towards an activity-based time use survey format incorporating questions about attitudes, perceptions, values, information acquisition and use, and decision making processes. In addition, it is suggested that a component of the NHTS be converted into a multi-day rotating panel to provide data on both short- and longer-term behavioral dynamics. These suggestions need to be weighed carefully against the increased respondent burden and survey costs that might be involved with their implementation.
1. DATA NEEDS FOR EMERGING ISSUES AND CHALLENGES
Recent and emerging travel behavior issues have important implications for the future of travel data collection in the United States, and particularly for the NHTS. This section aims to identify the data that are needed to address the recent and emerging issues in travel behavior analysis and to feed the analytical models and tools of the future.

Before discussing the data implications, it should be noted that this section focuses on what may be done differently in the future in relation to what is done now in most U.S. travel data collection efforts, particularly in the NHTS. There are, however, many aspects of the NHTS that are very useful and appropriate for the future. Regardless of recent and emerging issues in travel behavior analysis, it is imperative that the NHTS continues to be a rich source of information for basic demographic, socio-economic, and travel information. The NHTS should continue to collect data on household and person characteristics and basic travel characteristics to facilitate longitudinal analysis of travel behavior and demand characteristics. Emphasis should continue to be placed on collecting data about all aspects of travel across all sections of the society including special groups of interest and hard to reach populations such as the elderly, children, minorities, illiterate, low-income, zero-car households, immigrants and non-english speaking populations, transportation disadvantaged populations, and so on. Survey methods that can better capture information on short and infrequent trips, particularly non-motorized trips, should continue to be implemented so that the complete picture of travel is obtained for each respondent. The full continuum of travel, including both short and long-distance trip making, should continue to be captured in the NHTS in the future. The focus of this section is to answer the question: what can be done differently and how can the NHTS be enhanced, without sacrificing the comparability of surveys over time, while serving the needs of the community in the future?

1.1 Activity and Time Use Data
Clearly, the profession is moving in the direction of activity and time use based analysis and modeling of travel demand. Activity and time use data offer great benefits in terms of the level of activity detail, reporting of short and infrequent trips that might be missed in traditional trip diary surveys, and explicit focus on the time and space dimensions (Harvey, 2003). Activity and time use surveys can be used to obtain both in-home and out-of-home activity and travel information that is crucial to understanding the relationships among in-home and out-of-home activities and among household members. The questions related to substitution and complimentarity of in-home and out-of-home activities can only be addressed and modeled when such data is available. The most powerful example of this is the whole question of how technology use at home might be affecting out-of-home activity engagement and travel. Activity and time use data could offer information about internet use, computer use, and cell phone use in the context of a daily activity-travel pattern.

New models for travel demand forecasting are going to increasingly rely on travel survey data that includes detailed information on activity episodes, time use patterns, and in-home and out-of-home activity engagement. Microsimulation models of travel demand that have been implemented or are in various stages of development, although perfectly capable of utilizing traditional trip diary survey data, would benefit immensely from the availability of detailed
activity and time use data on in-home and out-of-home episodes. While some may question whether national level data would ever be used to estimate and calibrate components of activity-based microsimulation models, there are two arguments that may address this question. First, just as national level data have been made available for estimating and calibrating/validating four-step models, so can national level data be used to do the same for activity based microsimulation models. Second, the NHTS is seeing plenty of interest from states and MPO’s interested in participating as add-ons. If the NHTS is going to offer rich activity and time use information useful for estimating and calibrating activity-based microsimulation models, there may be even more interest from individual MPO’s and states in participating as add-ons.

The real question is whether a national household travel survey such as NHTS needs to collect such detailed activity and time use information. There is a survey called the American Time Use Survey (ATUS) that is being undertaken by the Bureau of Labor Statistics (BLS). Detailed activity and time use information is available from ATUS. However, ATUS does not separate the travel episode from the activity episode making it very difficult to use the data for activity-based travel demand analysis. Thus, although switching the NHTS to an activity-based time use survey may involve some duplication with the ATUS, it appears that an activity and time use based survey design for the NHTS would offer unique and measurable benefits to the profession. If nothing else, the activity and time use based format would simply offer richer and more complete trip information, without seriously affecting the ability to compare statistics and characteristics across surveys over time.

The added survey response burden associated with activity and time use surveys can not be ignored. In this context, consideration should be given to introducing substantial GPS-based and other technology-based data collection devices and methods into the NHTS. The technologies are now quite advanced, tools for analyzing and synthesizing the large amounts of data are available and reliable, and the data collected would be very accurate. The survey respondent would have to only provide some of the ancillary data, but would not be burdened with having to report each and every variable associated with a trip or activity. Spatial and temporal information, in particular, would be automatically recorded by the technology. Another major benefit of using this technology is that detailed route choice data would become available. In general, travel surveys have not collected route choice data and introducing a sizeable GPS component into the NHTS can provide route choice data. Such data would be very useful in moving forward the state-of-the-art in route choice analysis and network modeling.

1.2 Attitudes, Values, Experiences, and Perceptions
Travel behavior surveys have traditionally not included much in the way of questions aimed at getting at people’s attitudes, perceptions, values, and experiences. This is because most travel surveys are seen as sources of data for modeling travel demand, developing and calibrating travel forecasting models, and obtaining quantifiable statistics and rates about travel and demographics. As attitudes, values, experiences, and perceptions are not easily quantifiable and are generally never included as explanatory variables in any model system (because they can not be forecast), travel surveys have not included these questions and components. In addition, including these types of questions increases the length of the questionnaire and raises the response burden.
This is precisely where the NHTS should step in and make a difference. While many urban area and regional travel surveys may not include such questions, the NHTS should make an explicit attempt to include a major attitudinal survey component in the future. The NHTS should serve as a basis for understanding behavior, explaining behavior, formulating policy, and intelligently assessing the kinds of impacts that alternative policies might have on demand and behavior. The NHTS is probably not going to be used as the basis for travel demand forecasting models in many areas of the country. But, the NHTS can give a periodic glimpse into the national pulse on priorities, attitudes, perceptions, and values regarding transportation. The availability of such data makes it possible to potentially identify and isolate spurious causation from true causation. In addition, although the survey length and respondent burden issues would apply to the NHTS as well, careful survey design and administration methods may be able to alleviate such potential problems. Also, it is possible that people are more amenable to answering questions where they get a chance to express their own opinions and beliefs in the hope that providing such information will make a difference in decision making.

Some of the topic areas in which data about attitudes, values, and perceptions can be collected include:

- Perceptions of the personal and household action space with respect to both time and space dimensions
- Attitudes, values, experiences, and perceptions related to the performance, comfort, convenience, and importance of different modes and their attributes
- Attitudes, values, and perceptions towards alternative land use configurations including their own residential and work location situations
- Priorities and attitudes towards the environment including noise, air quality, water quality, and fuel consumption and cost
- Attitudes, values, and perceptions related to the use, availability, and reliability of technology and information including intelligent transportation systems, in-vehicle navigation and safety systems, internet communications, and traveler information
- Attitudes and perceptions towards different vehicle types, styles, sizes, and fuel mixes
- Attitudes, values, and perceptions of pricing schemes, cost structures, and tolls/fares

Having data such as the above can be very useful both at a national and local level for formulating policies and understanding/explaining how travelers might react to alternative policies.

1.3 Dynamic and Process Data

Much of what is studied and modeled in travel behavior research is dynamic in nature. The repeated cross-sections that the NPTS/NHTS data sets represent have been very useful for studying macro-trends in demographics and travel characteristics over time. However, they have not been as useful for studying micro-trends at the disaggregate level and determining lags and leads in behavior, potential causes and effects underlying behavior, and processes that contribute to dynamics in behavior.

There are short-term dynamics such as day to day dynamics in trip making, departure time choice, mode choice, vehicle occupancy, activity engagement, destination choice, and so on. In the medium- and long-term, there are dynamics related to auto ownership, work location choice,
residential location choice, and school location choice. Capturing these dynamics is fundamental to understanding how travelers adapt and change in response to their environment, interact with numerous agents, and make decisions.

The time is ripe for the NHTS to introduce a component that explicitly examines dynamics in travel behavior. At the most fundamental level, there may be merit to converting the NHTS to a two- or three-day activity/travel diary survey to get rich information about day-to-day dynamics in travel demand. At least one of the multiple days could be a weekend day so that comparisons between weekday and weekend day activity and travel patterns can be made while controlling for individual characteristics. Day-to-day dynamics are useful to quantify and understand exposure measures from a variety of standpoints – congestion, safety, pricing, environmental justice, and equity.

At a higher level, it is also time to examine the potential to convert a part of the NHTS into a panel sample. Perhaps 10 or 20 percent of the sample could be a panel sample that is tracked continuously with refreshments added as needed. A part of the NHTS could be made a rotating panel where households are deliberately removed and entered into the panel component during each NHTS. This component of the survey sample would have to be contacted frequently to minimize attrition. However, the data itself may still be collected at the usual NHTS survey years. Having a panel component associated with the NHTS would allow the tracking of longer term dynamics that are difficult to track in typical shorter-term panel surveys. As many local agencies have not been able to undertake panel surveys of their own, the NHTS would fill a much needed gap in understanding dynamics of behavior over longer time spans. At each survey point, the panel component could be asked additional retrospective questions regarding their auto ownership, residential and work locations, and so on to get a fairly complete picture of the dynamics that occurred between two successive NHTS survey contacts.

In this context, one may also wish to consider the notion of “process” data. Earlier in the paper, it was mentioned that greater focus is being placed on understanding behavioral processes that lead to outcomes and decisions that are observed and measured in travel diary surveys. It is certainly possible that “processes” that drive dynamics in behavior can be inferred from a panel survey component. However, even with such disaggregate dynamic data, one must infer processes. The processes are not necessarily directly observed or articulated by the respondent. The analyst observes the behavioral unit at two points in time and then draws inferences about the possible process that might have contributed to the transition from one state to another.

Thus, behavioral process data must be considered distinct and separate from longitudinal, dynamic, or panel data. In fact, one might be able to obtain behavioral process information directly from a cross-sectional survey by asking a series or set of questions that aim to obtain information on how and why certain events occurred and activities or trips were undertaken. There is no way that the NHTS can be converted into a full fledged process survey or can even be augmented with a detailed process survey. That would simply be too complex, expensive, and burdensome. However, it is very possible to include a small set of questions within the standard survey that are targeted towards understanding behavioral processes. These may take the form of open-ended qualitative research type questions that ask individuals to articulate how
and why certain decisions were made or choices were exercised. For example, here are some possible questions that could be asked of a respondent:

1) How did you decide when to depart to work today?
2) How did you and your spouse decide who would drop off/pick up the child at school today?
3) Which of the activities that you undertook today did you plan at least 24 hours in advance? Which activities did you undertake at the spur of the moment?

Such questions can offer valuable insights into how people make decisions, interact with other agents, and plan and execute activities. Similar questions regarding information acquisition and use (for example, in acquisition of new automobile, in choosing a residential location, etc.) can also prove valuable in determining the kinds of information that should be made available to individuals to help in their decision making processes. Qualitative research methods that are aimed at analyzing responses to such open-ended questions should be employed to maximize the benefit of including such questions in the NHTS.

1.4 Opportunities, Flexibility, and Constraints

Although many models of travel demand deal with travel choices and time-space constraints, there is very little data that is collected about these aspects. In the past, travel behavior researchers have successfully related many aspects of travel demand to various socio-economic and demographic characteristics. Yet, there was much variation in travel behavior that went unexplained. How much of this variation is truly random? While some of the unexplained variation may be explained by attitudes, perceptions, and values, one can not deny the role played by constraints, flexibility, and opportunities in shaping travel choices and behavior.

There are a variety of constraints that shape individual travel behavior. These include:

- Modal constraints pertaining to the availability of different modes of transportation in time and space including automobile, transit, bike, or walk facilities.

- Institutional constraints that deal with the constraints associated with opening and closing hours of institutions such as businesses, schools, banks, medical facilities and post offices in addition to work schedule related constraints.

- Household and personal constraints that include physiological constraints where a person must spend a minimum amount of time for sleeping, personal hygiene, etc. and household obligations that involve household maintenance, child care, meal preparation, etc.

- Information constraints are those related to the availability of information, dissemination of information, and the amount of information that a person can realistically gather and process at any point in time.

While the above constitute constraints, there are also opportunities and varying degrees of flexibility with respect to various activity and travel attributes that shape individual travel behavior. For example, one may consider the following:
• Locations of activities: There may be alternate locations (opportunities offer flexibility) where certain activities such as shopping, banking, and personal errands may be conducted. The set of destination opportunities and the flexibility they offer would affect destination choice.

• Timing of activities: Certain activities may be flexible in their timing, either within a day, within a week, or even within a month. Knowledge of flexibility regarding timing, scheduling, and sequencing of activities may be critical to understanding how activity agendas are developed and executed.

• Modal options: What are the modal options available for the trip? What modal options could have realistically been used to accomplish the activity, trip, or journey? In other words, a clear definition of the modal choice set is needed to understand the mode choice decision process.

• Parking options: There are possibly different locations with a variety of cost structures for parking an automobile. What are the different parking options in terms of locations and cost structures? This question addresses both the opportunities and the flexibility available in parking location choice.

Collecting data on such constraints, opportunities, and flexibility may offer a basis for further explaining the variation in travel behavior observed in travel data sets.

1.5 Supporting/Secondary Data
Recent developments in travel survey methodology and the integration of activity and time use concepts with travel behavior research have been accompanied by rapid enhancements in the quality, richness, and level of detail and accuracy of activity and travel records. In other words, the profession has done a good job of collecting data related to travel “demand”. However, as discussed throughout this paper, understanding and explaining the variation in travel demand and the relationships among land use, technology, travel behavior, health and well-being, and constraints and interactions calls for collecting and appending a variety of supporting and secondary data to the travel demand data. The NHTS is a prime candidate for accomplishing such data integration and for building comprehensive travel databases that serve a wide variety of policy contexts and planning applications. In fact, the 2001 NHTS did make a significant stride in this direction with the integration of the Claritas variables representing land use measures (ORNL, 2004).

Some of the supporting and secondary data that may be collected either within the NHTS or appended from secondary sources include:

• Technology availability and use patterns: If the NHTS were converted to an activity- and time use based survey, then explicit information about technology availability and technology use episodes (both at home and outside home) may be collected explicitly. This would be a welcome development for those interested in understanding the relationship between technology and travel. However, even if the NHTS were to remain
a pure trip-based survey, information regarding technology availability and use can be collected and made available in the data sets. Household and person-level technology availability and average daily or weekly usage statistics can be asked of the respondent to have a reasonable measure of the level of technology adoption in the household. Travel behavior can then be studied in the context of the technology availability and use.

- **Personal/public health data:** The debate regarding the contribution of the natural and built environment on travel choices, activity lifestyles, and health and well-being is not going to go away anytime soon. In fact, it is likely to only get more intense as health care concerns and costs rise in the future. But would people feel comfortable providing personal health information in a survey of this nature? People do agree to participate in clinical studies on a regular basis; however, they generally do so under the condition and assumption that their health information remains private and anonymous. It is highly unlikely that people would provide accurate information about height, weight, blood pressure, waistlines, heart rates, asthma attacks, blood sugar levels, and so on. Either respondents would not be interested in disclosing such information or they would not know the information themselves. Within the NHTS, it would be possible to include questions that attempt to measure the nature of the lifestyle in general. Questions that pertain to frequency of walking, bicycling, hiking, exercising, and other physical activities may offer some insights into the person’s general lifestyle. Beyond that, it would be necessary to see if there are any secondary public health data sources such as those available from the National Institute of Health (NIH) and Center for Disease Control (CDC) that can be used to augment and enhance the NHTS with aggregate health statistics and measures.

- **Transportation supply data:** Quite often, it is desired to use major travel survey data sets such as the NHTS to understand travel demand in the context of the transportation supply and network level of service. Network level of service variables for each mode appended to individual travel records would be of tremendous benefit to travel behavior researchers developing models of mode choice. Understanding how travel demand and transportation choices are related to transportation supply is directly related to issues of induced and suppressed demand, mode and departure time choices, and route choice. The NHTS could be used for a wider variety of behavioral and planning analysis if these types of variables were added to the databases.

- **Land use data:** The NHTS has already made significant strides in augmenting the travel records with land use data through the use of the Claritas variables. The inclusion of such variables is very useful for analyzing the relationships between land use (the natural and built environment) and travel behavior. It is envisioned that these variables and this capability in the data set will see increasing use in the years to come as people become more and more familiar with these variables and how to interpret them. In the 2001 NHTS, nine additional derived variables were added to each record to describe the characteristics of the areas where the NHTS survey respondents live. These variables were derived from 2000 Census data and estimated forward to 2002-2002 by Claritas, Inc.
2. CONCLUSIONS
This paper is aimed to serve as a resource paper for the Workshop on Emerging Issues in Travel Behavior Analysis. The paper provides an overview of the many emerging issues, challenges, and questions that travel behavior researchers are concerned with and that transportation planners are being asked to address, model, and understand. In this context, the paper also provides an overview of the new methodological and modeling paradigms that are defining the field and identifies the directions that travel demand modeling and travel behavior research are likely to take in the years to come.

This section provides a summary of what is being said in this paper. The fundamental question of interest for this workshop is: what are the major trends and issues that are characterizing and defining travel behavior research and what data do we need for addressing these trends and issues? The emphasis in this concluding section of the paper is not on issues, questions, and topics for which the NHTS already provides adequate and sufficient data, but on focus areas where the NHTS falls short. For example, demographic and socio-economic trends in the United States will continue to shape travel behavior for many years to come. However, that aspect is not identified here simply because the NHTS already does a superb job in collecting such information. Due to the limited time available and the myriad issues of interest to the community, the discussions at the workshop should probably revolve around topics where the NHTS has traditionally not been a rich source of data.

For each focus area identified here, the data implications are summarized and presented. The state-of-the-art in travel behavior analysis is characterized by:

- **Focus on emerging questions and trends (e.g., technology, public health, quality of life)**
  Travel behavior research is focusing on emerging questions and trends related to the implications of telecommunications and technology use on travel behavior, the interaction of individuals with their natural and built environment, the impact of transportation infrastructure and land use patterns on travel choices, active lifestyles, and obesity, and the role of transportation in people’s quality of life.

  The NHTS can be augmented in several ways to help address these emerging questions:
  - Convert to an activity- and time use based approach to obtain explicit information on in-home activities including technology, internet, and telecommunications use and availability.
  - If NHTS remains a trip-based survey, then collect general information about daily or weekly patterns of technology and telecommunications availability and use.
  - Ask specific questions related to daily or weekly patterns of walking, bicycling, hiking, running, exercising, and so on to obtain information about active lifestyles.
  - The NHTS should continue to collect all information about demographics, socio-economics, vehicle fleet information, and household location.

- **Focus on activity engagement and time use**
  The travel behavior research arena is clearly focusing on the activity- and time use based approach to travel demand analysis. Most new microsimulation modeling systems being
developed around the world are activity-based models that explicitly consider the time dimension.

- Convert to an activity- and time use based approach to obtain explicit information about activity episodes both in-home and out-of-home. Detailed time-space data associated with each activity episode should be collected. Provide the ability to collect information about secondary and tertiary activities, thus measuring multi-tasking that happens in daily life.
- If the NHTS remains as a trip-based survey, collect general information about the daily or weekly rhythms of in-home activity engagement patterns so that some basic relationships between in-home and out-of-home activity engagement can be studied.

• **Focus on constraints, interactions, and inter-dependency**
  There is an increasing recognition that travel behavior of individuals can not be modeled accurately unless there is explicit consideration of the time-space, modal, household, personal, institutional, and information constraints under which people make travel choices. Similarly, it is very important to consider interactions and inter-dependency among households, among household members within households, and among a broad array of agents that make up the urban activity system.

  - Collect information about constraints including work schedule constraints, school schedule constraints, modal availability, and household or personal constraints (e.g., when do you have to be home to take care of children?).
  - Collect information about flexibility associated with schedules and constraints. How late can you report to work? How early can you leave work? How late can you arrive home? Similarly, collect information about flexibility and alternative opportunities for destinations, modes, and timing of activities.
  - Collect information about “with whom” and “for whom” various activities are conducted. This provides valuable information about interactions, joint trip making, trade-offs in activity engagement, and inter-dependency in activity engagement.

• **Focus on behavioral processes/dynamics/learning/adaptation for microsimulation**
  A major emphasis area in the activity and travel behavior research arena has been in understanding the behavioral decision making processes that lead to the revealed outcomes measured in surveys. Decision making processes underlying activity and travel engagement, mode choice, trip chaining, time of day choice, destination choice, residential location choice, work location choice, vehicle fleet composition, and a host of other choices have been the subject of much research in the recent past. It is envisioned that the availability of this type of data will allow the identification and unraveling of true cause and effect relationships underlying activity and travel behavior.

  - Convert the NHTS to a two- or three-day activity/travel diary survey where at least one day involves collecting data on weekend travel behavior.
  - Introduce a rotating panel component into the NHTS where a portion of the survey sample is observed repeatedly and subjected to a rotating panel scheme.
  - Within the scope of the NHTS, it would be difficult to include a full-fledged set of survey components that purport to collect behavioral process data. As such, it is
not recommended that the collection of behavioral process data become a major part of the NHTS.

- However, within the scope of the NHTS, it is very possible to include several questions that are open-ended and aim to gather information about people’s decision making processes. These questions would ask people to report how and why they made a certain choice, with whom they may have discussed and negotiated prior to making a choice, what information they may have gathered and used prior to making a choice, and so on. It is recommended that a set of carefully crafted questions be included in the NHTS (and in all U.S. household travel surveys) for getting a glimpse into decision making processes.

- Some of the questions may take the form of stated preference, stated tolerance, stated intention, stated adaptation, stated choice, or stated prospect type questions (Bradley, 1988; Lee-Gosselin, 1996). Such questions can offer valuable insights into behavioral processes and make the NHTS a more powerful resource for transport policy analysis. However, it is not likely to be feasible to incorporate a major stated preference type survey into the scope of the NHTS. The survey would simply become too complex and burdensome for the respondent.

- **Focus on attitudes, values, experiences, and perceptions**
  Attitudes, values, perceptions, and experiences play an important role in shaping travel behavior. Unfortunately, most travel surveys do not bother to collect such information. The NHTS could potentially play a key role in filling this gap by gathering information about people’s opinions and beliefs.

  - Include a section in the NHTS that asks people questions related to attitudes, values, experiences, and perceptions. These may be simple rating-type questions (importance ratings, agreement ratings, satisfaction ratings, etc.) and/or more open-ended questions where people report on specific experiences or opinions. These questions could cover attitudes and perceptions of time and space, lifestyle, modes of transportation, congestion, pricing and cost structures, vehicle use, residential neighborhood, and land use patterns.

- **Focus on a holistic approach to travel behavior analysis**
  The entire travel behavior research field is moving towards a more holistic approach to the understanding and modeling of travel behavior. Travel is no longer being observed and modeled in isolation. Travel is now modeled in the context of activities, time-space interactions, agent-based interactions, transportation network supply characteristics, land use characteristics, lifestyle variables, and land use characteristics. As such, it may be useful to augment the NHTS data sets with secondary and support data that allows a more holistic approach to travel behavior analysis. Secondary and support data may include:

  - Modal network level of service variables
  - Land use variables and characteristics associated with residential and work locations
  - Public health statistics and exposure measures associated with neighborhoods, census geography, or other spatial units for which such data is available.
Finally, it should be noted that the suggestions being made here will not come without a cost, both in terms of actual dollar costs for conducting the survey and collecting the data and in terms of questionnaire length and respondent burden. These are very important considerations that must be taken into account when determining the future format and scope of the NHTS. Participants, both in this workshop and in the Survey Methods workshop, will have to carefully weigh the trade-offs among data desired, data needed, respondent burden, and survey cost before developing specific recommendations for the future NHTS.

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