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Assessing the Travel Data Needs for Vermont Transportation Performance Metrics

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A Report from the University of Vermont Transportation Research Center

Assessing the Travel Data Needs for Vermont Transportation Performance Metrics

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Assessing the Travel Data Needs for Vermont Transportation Performance Metrics

**Lisa Aultman-Hall and Glenn McRae
UVM Transportation Research Center
June 2014**

A Report for the Vermont Agency of Transportation

Executive Summary

Tabulating the travel data needs of Vermont stakeholders

The 2009 NHTS add-on data was used to

- update both the state-wide travel demand forecasting model as well as the CCRPC model;
- quantify total travel of Vermonters and in planning studies including Transportation energy reports; and
- research accessibility, public transit, ride sharing, and electric vehicles.

In addition to the above uses, stakeholders indicated travel data could serve to assess overall travel system performance including for special population groups, assessing land use plans and other policy issues.

Note: All potential users are not aware of this data resource and how it can be used. Outreach could be pursued for the 2009 data regardless of whether a 2015 add-on is pursued.

Assessing strengths and weaknesses of using the NHTS Add-on to meet the Vermont travel data needs

Strengths:

- Data includes a travel log or diary of all trips with their origins, destinations and mode for a minimum of one day.
- Few other data sources are appropriate for model calibration. Users expressed concern for use of non-Vermont data for this purpose.
- Part of the advantage of the state-wide Vermont sample was its lack of focus on metropolitan areas (other states focus data collection within MPOs).

Weaknesses:

- Outside of Chittenden County, the sample size of the 2009 NHTS Add-on is generally not sufficient for region specific analysis.
- Geocoding of origin-destinations was weaker than desired.
- Oversampling of special population groups is needed (transit riders, rural residents, older citizens, low-income residents, bicyclists, and pedestrians, and zero vehicle households).
- Low response rate of the phone-based method.
- Does not include long distance or overnight travel unless explicitly occurring on the travel day.
- One-day study focus may not suit more variable day-to-day trip making in rural areas and therefore it will take a larger sample to achieve the same accuracy in trip rates.

Alternatives for collecting VT travel data including frequency, key variables and budget considerations

1. Ways to best use the NHTS Add-on to meet its travel data needs.
 - a. Agree to an add-on sample of approximately the same size as 2009 and combine the 2009 and 2015 samples to create a more robust dataset, using the 2015 sample to include more oversamples of the populations and locations that were under sampled in 2009.
 - b. Purchase a larger NHTS add-on in 2015 in order to meet the goals and interests of all of the stakeholders.
2. Design and field a web-based survey as an alternative.
 - a. Include the core questions from the NHTS for compatibility and even sample aggregation across surveys. Advantages include the interactive maps that automatically geocode origins and destinations, the ability of participants to complete the survey at their convenience and lower overall cost.
 - b. Consider the option of a continuous survey. On-going surveys add new observations to a growing sample every year and smooth the cost of a survey to an agency over time.

Whatever approach is selected, the following data are key for a travel data set and meeting the policy and planning needs indicated by the Vermont stakeholders during this project:

- A travel diary with geo-coded origins, destinations and trip purpose
- Predictor variables describing individuals, households and vehicles
- Multiple days per year to capture rural travel variability
- A balanced sample by type of home location (full range of urban/rural)
- An oversample of non-motorized and transit riders
- A minimum sample size for each RPC
- Capture of seasonal residents

Estimated Costs:

- NHTS Add-on: \$225 / household
- Web-based Survey: \$80-100 / household

Costs for data analysis and management are in addition to these costs in either case.

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Introduction

Travel data, also known as household travel or activity data, usually consist of a travel diary or log of all of the trips (tours or trip chains) undertaken by an individual or a household during a given period of time (usually one day). These data are distinctly different from the more common traffic volume counts measured in vehicles per hour over days or months at specific locations in the transportation network. Travel diaries include an origin, destination, travel mode, departure time, travel time, distance and travel party for each trip. Moreover, very disaggregate information about the household, individuals, vehicles, workers and often attitudes are usually associated with the trip information (Figure 1). Travel datasets are large and complicated both for the data collectors and also in terms of participant burden. For example, the Federal Highway Administration's (FHWA) 2009 National Household Travel Survey (NHTS) dataset has 206 different variables organized into four data tables (Figure 2). Vermont's 1690 households reported 10,865 trips. However, the travel diary data is critical as it is the only source of data that allows analysts to estimate total vehicle miles of travel for different sub-groups or residents of different locations including their mode choices and spatial patterns.

There are three main objectives of this project that are intended to facilitate discussion of whether Vermont should purchase an NHTS Add-on sample in 2015:

- To tabulate the travel data needs of Vermont stakeholders,
- To assess the strengths and weaknesses of using the NHTS Add-on to meet the Vermont travel data needs, and
- To outline alternatives for collecting VT travel data including frequency, key variables and budget considerations.

Household data were traditionally collected in major Metropolitan areas where congestion management and mode shift were the original policy objectives. The only national household travel data are from the National Household Travel Survey (NHTS), previously the National Personal Travel Survey (NPTS), conducted in 1969, 1977, 1983, 1990, 1995, 2001 and 2009. The Add-on program allows states or Metropolitan Planning Organizations (MPOs) to purchase additional sample in their jurisdiction. This allows leveraging of funds for shared design, testing and execution. It also simplifies contracting and procurement processes as a pooled fund project structure is used. In recent years, another advantage is that the non-federal cost share is waived for states using their federal funds.

2009 NHTS v. 2015 NHTS plans

In 2009, 150,000 households and 300,000 people nation-wide were surveyed in the NHTS. The 2009 NHTS was a random digit landline phone survey with an overall 20% response rate (the rate for Vermont was 42%). For 2015, the FHWA is proposing an address-based sample in addition to a cell phone sample. An option for a GPS sub-sample is also being offered as a higher unit cost. Tables 1 and 2 indicate the agencies that participated in the

NHTS Add-on in 2009. To date, 6 state DOTs have made commitments to participate in the 2015 Add-on.

Figure 1: NHTS Summary of Content for 2009 (Source: FHWA 2011)

2009 NHTS summary of content	
<p>For Each Household: <i>Number of people, drivers, workers and vehicles</i> <i>Income</i> <i>Housing Type</i> <i>Owned or rented</i> <i>Number of cell phones*</i> <i>Number of other phones</i> <i>Race of reference person</i> <i>Hispanic status of reference person</i> <i>Tract and Block Group characteristics</i> <i>Internet Use & Delivery to households**</i></p>	<p>For Each Vehicle: <i>Make/Model/Age (year)</i> <i>Annual miles driven</i> <i>Commercially licensed**</i> <i>How long owned*</i> <i>Odometer reading</i> <i>Alternative Fuel**</i> <i>Primary Driver</i></p>
<p>For Each Person: <i>Age/Sex/Relation to reference person</i> <i>Driver status</i> <i>Worker status/Primary activity</i> <i>Internet use*</i> <i>Home deliveries from Internet shopping**</i> <i>Travel Disability*</i> <i>Effect of disability on mobility*</i> <i>Education level</i> <i>Immigrant status*</i> <i>Views on transportation</i> <i>Annual miles driven</i> <i>Incidence of public transit use in past month</i> <i>Incidence of motorcycle use in last month</i> <i>Incidence of walk and bike trips in past week</i> <i>School travel (children)**</i></p>	<p>Daily Travel Data: <i>Origin and Destination address (for Add-ons)</i> <i>Time trip started and ended</i> <i>Distance</i> <i>Means of transportation:</i> <i>vehicle type</i> <i>if household vehicle, which one</i> <i>if transit, wait time</i> <i>if transit, access and egress mode*</i> <i>Interstate Use**</i> <i>Tolls Paid**</i> <i>Trip Purpose</i> <i>Detailed purpose*</i> <i>Travel Party Size</i> <i>Last time of travel*</i></p>
<p>For Each Worker: <i>Full or part-time</i> <i>More than one job</i> <i>Occupation (four categories)*</i> <i>Workplace location</i> <i>Usual mode to work</i> <i>Drive alone or Carpool</i> <i>Usual distance to work</i> <i>Usual time to work**</i> <i>Work from home</i> <i>Usual arrival time at work</i> <i>Flexibility in work arrival time**</i></p>	

* added in 2001
 ** added in 2009

Figure 2: 2009 NHTS Data Tables (Source: FHWA, 2011)

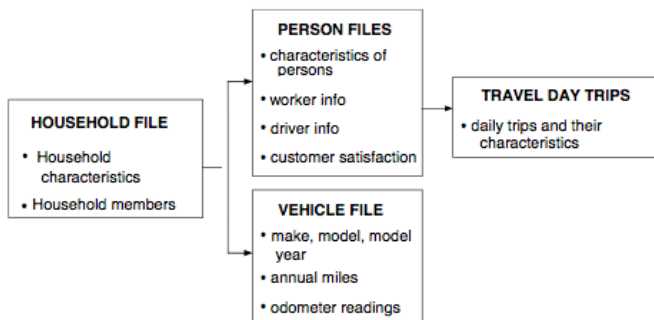


Table 1: 2009 State Add-on Participants (Source FHWA 2011)

Add-on region	Household target
California	18,000
Florida	14,000
Georgia	7,000
Indiana	2,857
Iowa	2,000
New York	14,102
North Carolina	5,000
South Carolina	4,500
South Dakota	1,500
Tennessee	2,000
Texas	20,000
Vermont	1,000
Virginia	14,342
Wisconsin	1,200

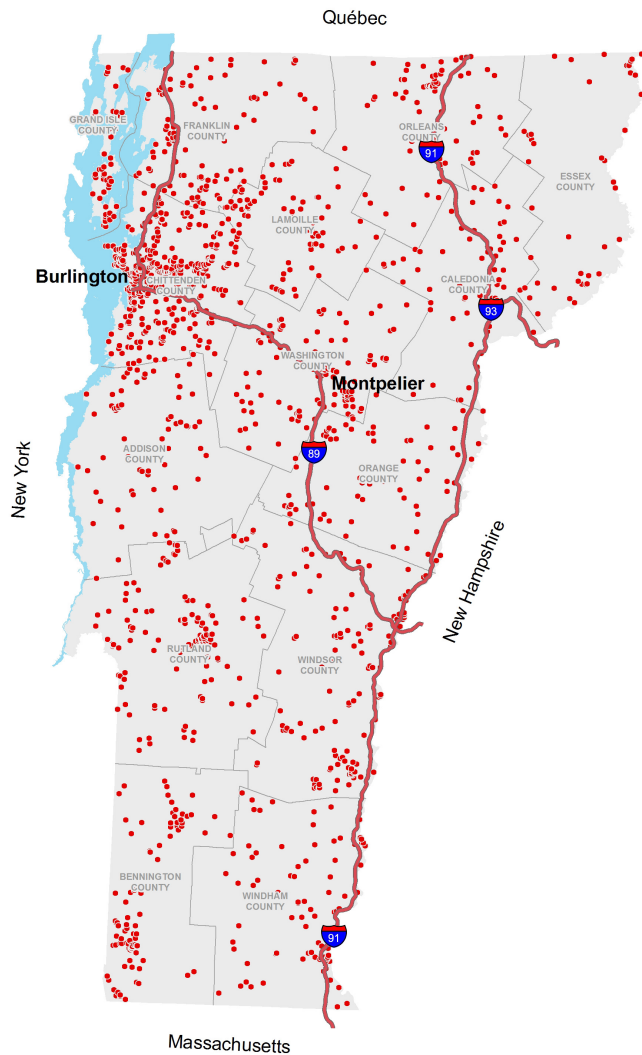
Table 2: 2009 MPO Add-on Participants (Source FHWA 2011)

Add-on region	Household target
Chittenden County MPO in Vermont	500
Linn County Regional Planning Commission in Cedar-Rapids	1,200
Maricopa Association of Governments in Arizona	4,286
Pima Association of Governments in Arizona	2,285
Piedmont Regional Transportation in North Carolina	5,000
Omaha-Council Bluffs Metro Area Planning Agency in Nebraska	1,200

In 2009, the Vermont Agency of Transportation (VTrans), the Chittenden County Regional Planning Commission (CCRPC) and the University of Vermont Transportation Research Center (UVM TRC) joined together to purchase a 1500 household Add-on sample in the NHTS. Figure 3 illustrates the location of households sampled in 2009. A minimum of 500 was specified for Chittenden County and the other observations were weighted to be representative at the county level. FHWA is suggesting the 2015 national sample will be 25,000 households and therefore the national sample for Vermont, without the Add-on, would include approximately 25 households.

The FHWA issued its guide for the 2015 Add-on program in December 2012. In Spring 2014, the UVM TRC conferred with the FHWA team for updates to the program for this report. The FHWA will soon release an RFP to hire a consultant to perform the NHTS. Commitments from Add-on agencies are due in the pooled fund project this July 2014. After the commitment is made a current contractor will work with each agency to design their sample and design 6 agency-specific questions. While a small amount of funding is due with the commitment, second and third installments are due in December 2014 and December 2015 respectively. The FHWA is currently estimating a May 2015 start to data collection. Final datasets are expected for delivery to Add-on agencies in Spring 2017. The Add-on program for 2015 is requiring a minimum contribution of \$220,000 but the exact price per household is not yet finalized so the sample size corresponding to a \$220,000 commitment is not known exactly.

Figure 3: 2009 NHTS Households in Vermont (N=1690)



Travel diary data were originally collected in the US for demand forecasting and infrastructure planning. As a result the travel data community is tightly linked to the demand modeling community and surveys including the NHTS have served the modeling community whether state or regional as primary consumers of the data. A planned change in 2015 will be to provide NHTS data weights for weekdays to better facilitate model calibrations. The 2009 Vermont data (total sample size 1690 with the Vermont observations from the national random sample) were used to update both the state-wide travel demand forecasting model as well as the CCRPC model.

However, the Vermont 2009 NHTS data were also used to quantify total travel of Vermonters, in planning studies such as the Economic Impact of Walking and Biking Study (2011, VTrans) and in UVM graduate student research on accessibility, public transit, ride

sharing, and electric vehicles. Travel surveys such as the NHTS provide a comprehensive view of all travel hopefully on a sample large enough to represent all travelers and travel patterns. Other data, such as that provided by the US Census which is limited to work trips which generally constitute about 25% of all travel, are more focused in their purpose. Similarly, transportation agencies and universities often designed focused surveys about travel behavior, attitudes or needs but they rarely include full travel diaries. In Vermont, VTrans conducts a long range transportation plan survey approximately every 10 years and CCRPC conducts a Travel Survey every 5 years. But these do not include a full travel diary. The UVM TRC and its partners have conducted several surveys in the last five years but only one included a travel diary for one day four times throughout the year. *The key feature or element of the NHTS that is the focus of this report is the data that comprises a travel log or diary of all trips with their origins, destinations and mode for a minimum of one day.* At this time, no planned Vermont-based surveys include a travel diary.

Methodology to assess Vermont Travel Data Needs

For this effort, the UVM TRC team with VTrans, identified individuals from state agencies and regional planning commissions with an interest in travel behavior, planning or policy questions that might require travel data. These individuals participated in roundtable discussions on April 17 and May 13, 2014 in Montpelier. A total of 23 individuals participated.

In addition, four groups of people were contacted by email and asked for their input on the NHTS and travel data for Vermont:

- Faculty, staff and student researchers of the University of Vermont (5 responses)
- Directors in other State agencies (2 responses)
- Analysts belonging to Vermont non-profit groups (2 responses)
- Consultants who work for, or are located in, Vermont (2 responses)

Feedback was received from approximately half of the individuals contacted. Vermont stakeholders were asked the following questions:

1. What policy questions do you face that benefit from travel data?
2. Thinking of the core travel data: miles, mode, destinations; what do you need beyond that?
3. Without the Add-on, is the NHTS of use to Vermont?
4. What population groups are under-represented in the NHTS?
5. Who else in Vermont should we ask about travel data uses and needs?
6. How do you use the American Community Survey (ACS) and Census Transportation Planning Package (CTPP)?
7. Are you concerned about a phone-based survey?

In addition to the Vermont stakeholders, representatives of the 2009 Add-on in other states and MPOs (Figure 2) were emailed and asked the following questions. Five email replies were received and one phone interview was conducted. Most indicated their NHTS data

were used for metropolitan areas and when rural data were used it was in the context of a state-wide planning model.

1. What policy questions do you face in rural areas that benefit from travel data?
2. Think of the core travel data measures: miles, mode, destinations. What do you need beyond these metrics specifically for non-metro areas?
3. What were the strengths and weaknesses of the 2009 NHTS for understanding travel in rural areas?
4. What population groups are under-represented in the NHTS?
5. What other data resources do you find useful for your non-metropolitan planning areas?

Finally, based on discussion at the April 17 roundtable in Montpelier, four members (two academics, one consultant and one member of an MPO) of the Transportation Research Board (TRB) Task Force on the Future of the NHTS and the TRB Committee on Travel Survey Methods were contacted and asked about their experiences with cell phone derived travel data. Email and phone replies were received.

The UVM TRC team also reviewed documents summarizing the 2009 NHTS as well as product information from newer travel data providers. The recent TRB Circular E-C178 from October 2013 summarizes national answers to the same questions posed for Vermont in this endeavor. <http://www.trb.org/main/blurbs/169627.aspx>

Travel Data Users in Vermont

The FHWA outlines the main uses of the Add-on data as trip generation rates, statewide or metropolitan travel trends, air quality analysis, model calibration and studies of travel for specific populations. The TRB Task Force on the Future of the NHTS released a TRB Circular in 2013 that expanded this application list to include energy, public health and safety topics. The Vermont users contacted in this project indicated travel data applications very similar to these trends that had been documented nationally.

The two most significant uses of the NHTS data were travel models and researchers. The professionals involved with the Vermont Statewide Model and the CCRPC regional model indicated satisfaction with the 2009 data. It was used for model updates as planned. Although they suggested desired improvements for the data, they indicated few other data sources are appropriate for model calibration. Stakeholders expressed concern for use of non-Vermont data, such as the national NHTS data, for model calibration. In addition to the models, consultants indicated use of the NHTS data for trip length distribution for traffic impact studies, calculation of user/market sheds, and predicting travel trends.

Researchers at the UVM TRC, made extensive use of the NHTS data to study travel behavior, especially rural travel behavior. Research topics also included market potential for electric vehicles. A total of 8 journal papers and conference presentations have been made to date. Research work using the 2009 NHTS Add-on continues. Part of the advantage of the state-wide Vermont sample was its lack of focus on metropolitan areas. Most other travel

demand and behavior research is conducted in larger cities. Having the data allowed the TRC to establish itself as contributor of unique research in the national transportation community.

Indirect users of the Vermont NHTS data were numerous. These included those who requested analysis from the two travel demand models but also users of the fact sheets, statistics and Transportation Energy reports. In general, these indirect users were interested in the amount of travel by Vermonters, but also energy, GHG emissions, and user satisfaction metrics. Vermont stakeholders expressed an interest in data related to active transportation and public health, trip lengths related to range for electric vehicles, and travel of non-Vermonters (tourists). The Agency of Natural Resources, the Department of Public Service, the Department of Health and the Agency of Commerce and Community Development all face policy questions and the need for metrics at this time for which travel data would be useful.

The regional planning commissions reported limited use of the data but expressed interest in sufficient sample for their region to enable policy analysis for special populations such as transit riders, senior citizens and non-motorized transportation users. Outside of Chittenden County, the sample size of the 2009 NHTS Add-on is generally not sufficient for region specific analysis. Average rates or trends might be accurate but any geospatial analysis within a single planning commission's area would have inadequate coverage.

Feedback from users and potential users of travel data in Vermont revealed a need for outreach and education about travel data and the NHTS in particular. Potential users are not aware of this resource and how it can be used. Such outreach could be pursued for the 2009 data regardless of whether a 2015 add-on is pursued.

Travel Data Needs

The travel data needs in Vermont can be categorized into four classes: a) models and travel analysis, b) quality of service, c) energy/GHG emissions and d) finance/funding.

Models and Travel Analysis: The Vermont users indicated an importance for origin and destination information as part of a travel dataset. This is not particularly surprising as origin and destination information is the unique attribute of travel data. Location is often coded into zones for travel model use. However, in the NHTS Add-on data the location was typically based on street address, nearest intersection, or zipcode centroids. 82% of home locations were matched using street addresses in the Vermont add-on sample (Sullivan 2010). Work is often a common origin or destination and 85% of Vermont workers in the 2009 survey had their workplace geocoded by street address. Only 58% of trips in the 2009 Vermont survey had both an origin and destination that was geocoded at the street address level of accuracy. Pursuit of better geocoding of origins and destinations in future surveys is important in three ways for Vermont stakeholders. First, zipcode centroids in rural areas are not accurate due to the large size of the zones. Second, geocoding is critical for model calibration which is the top use of the data. Third, RPCs indicated a desire to have this information for their individual regions. In addition to the origin destination

data, stakeholders indicated a need for measured annual vehicle miles of travel rather than estimated totals that were included in the 2009 NHTS datasets.

Quality of Service: Planners in particular indicated a desire and need to consider the mobility needs of special population groups. Although many of the attitudinal variables may be captured in existing VTrans and CCRPC surveys, in order to study or quantify the travel behavior of certain groups over sampling of these populations in a travel survey is critical. The following population groups were specifically mentioned by those interviewed: transit riders, rural residents, older citizens, low-income residents, bicyclists, and pedestrians, and zero vehicle households. It is typical to make these types of accommodations in a sample design and some level of Add-on specific sample design is to be offered by the FHWA in 2015.

Energy and GHG Emissions: An emerging policy question for planners, multiple state agencies and researchers is transportation energy use and emissions. In particular, the potential for electric vehicle (EV) adoption in Vermont is important to stakeholders. This desire for more information for EV related analysis was noted repeatedly in the national TRB Task Force work as well. Accurate origin and destination information is important for this question as well as identifying individuals and households as users or potential users of EV technology. Stakeholders requested questions regarding the motivation and attitudes questions related to EVs. These may be included in a travel diary survey or may be covered elsewhere.

Finance and Funding: The issue of transportation funding was only raised by VTrans and UVM stakeholders who can rely on the NHTS or travel data for measures of vehicle miles of travel (VMT) to consider VMT fees, tolling or other newer road pricing schemes. Although not mentioned in the roundtables, the issue of funding and costs is also critical to public transit and quality of service for special population groups especially low-income.

It is reasonable to ask if the travel data needs of Vermont could be met with national or other data sources if the NHTS Add-on or other travel survey were not conducted. The NHTS team and other researchers nation-wide have spent considerable resources assessing transferability of trip rates and travel patterns from region to region. The Vermont NHTS data has been contributed to some of these recent studies. In general, transferability is doable but not foolproof. Consensus on the team was that Chittenden County might be best suited for transfers of data from other regions.

Concerns of the Data Users about the NHTS

There were three types of major concerns expressed for the NHTS survey design. The first concern is that the sample is too small particularly outside of Chittenden County. This issue is within Vermont control and could be addressed if resources allow. The other concerns described below are either part of the FHWA design that cannot be altered by Vermont for 2015 or relate to the rural landscape of Vermont and cannot be controlled.

The 2015 NHTS will be an address-based sample conducted by telephone with an additional cell phone sample. There are significant concerns over whether a reasonable or representative sample of households can be contacted and surveyed using telephones of any type. Several jurisdictions, both state and metropolitan areas, have turned to on-line web-based surveys. Concerns for web-based surveys are also plentiful, specifically whether low-income and similar groups are systematically excluded. Both phone and web-based methods have biased exclusions and it is unclear which is less representative. It is clear that on-line surveys are less expensive. Phone surveys have the benefit of human to human communication and prompting for misunderstandings or short forgotten trips.

The 2015 NHTS will not include long distance or overnight travel unless explicitly occurring on the travel day (the last NHTS to include a longer period of time and long distance travel was in 2001). Long distance trip data collection is typically collected over a longer period such as 1 or 2 months since these trips are infrequent. This is important for Vermont for two reasons. First, in a rural state access to many personal services including medical care requires longer distance and overnight trips. This is an important aspect of quality of life and accessibility. Second, tourism is an important industry in Vermont. The NHTS only includes households within the study area and not visitors. Note also it is unclear how second home or seasonal residents will be included in the address-based sampling. If Vermont pursues an Add-on this factor must be considered during sample design.

The rural nature of Vermont impacts the quality of the NHTS as a source for travel data. The less accurate geo-coding especially that which uses zip code zones impacts data quality but may not be resolvable in a rural state. Because Vermont would likely purchase a relatively smaller sample, the impact of length of data collection requires attention. One might hypothesize that daily trip making varies more day to day in rural areas and therefore it will take a larger sample to achieve the same accuracy in trip rates. The 2009 NHTS was a one day survey. It is unclear whether 2015 will be a one or two day survey. However, the GPS option, while more expensive, will be multiple day.

Table 3 outlines the strengths and weaknesses of the NHTS for meeting the travel data needs of Vermont. The quality of geo-coding is not included as it may persist for all surveys.

Table 3: NHTS Strengths and Weaknesses for Vermont

Strengths	Weaknesses
Ease of procurement	Phone method weak
Cost share savings	Duplicates attitude and similar data collected elsewhere
Shared design costs	No control over timeline for data delivery
Spanish is included	Does not include travel by non-residents
Consistency over time and with nation	Expensive
	No analysis is included

Options for Collecting a Distinct Vermont Travel Survey

The following data are key for a travel data set and meeting the policy needs indicated by the Vermont stakeholders during this project:

- A travel diary with geo-coded origins, destinations and trip purpose
- Predictor variables describing individuals, households and vehicles
- Multiple days per year to capture rural travel variability
- A balanced sample by type of home location (more than urban/rural)
- An oversample non-motorized and transit riders
- A minimum sample size for each RPC
- Capture of seasonal residents

There are generally three methods for collecting household travel data at this time: a) phone, b) on-line or web-based, and c) passive cell phone and GPS (including smart phone). It is important to note in the third option that there is more than one method for location calculation. Cell phone tower triangulation is expected to have significantly less accuracy in rural areas compared to true GPS methods. Table 4 outlines the participant concerns for each of these methods, while Table 5 outlines the analysts' concerns. Together these tables suggest more strengths for web-based surveys.

Table 4: Participant Concerns by Travel Data Collection Type

Method	Privacy	Burden
Phone interview	Low	High
Web-based survey	Medium	Medium
Cell-phone	High	Low
GPS	High	Low

Table 5: Analysts' Concerns by Travel Data Collection Type

Method	Represent-ative	Geoaccuracy	Established Method	Post-processing Burden	Time to Data Availability
Phone interview	Low	Medium	Yes	Medium	Longer
Web-based survey	Medium	High	Yes	Low	Shorter
Cell-phone	Medium	Medium	No	High	Longer
GPS	Medium	Medium	No	High	Longer

There are several options within the NHTS for Vermont to meet its travel data needs. First, we could move forward with an add-on sample of approximately the same size as 2009 and combine the 2009 and 2015 samples to create a more robust dataset. This could allow the 2015 sample to include more oversamples of the populations and locations that were under sampled in 2009. Second, Vermont could purchase a larger NHTS add-on in 2015 in order to meet the goals and interests of all of the stakeholders.

Alternative surveys, including a web-based survey (which typically includes a phone-in option for those who cannot use the web) could be built for Vermont that include the core questions from the NHTS for compatibility and even sample aggregation across surveys. A phone survey has the benefit of human interaction to provide clarification and prompts, however response rate concerns, including accounting for cell phone only households, are significant and increasing with time. Web-based surveys are increasingly used including by the UVM TRC and CCRPC. Advantages include the interactive maps that automatically geocode origins and destinations, the ability of participants to complete the survey at their convenience and lower overall cost. The exact bias in terms of inclusion of demographic groups has not been studied.

Several private sector groups have started providing cell-phone based location data. Numerous university research groups in other states have written and are testing smart phone apps for travel data collection. These datasets have many traits, both strong and weak, in common with GPS-base travel data collection which started in 1996 in the United States. Both cell-phone data and GPS require significant processing and do not necessarily have the individual, household and trip purpose data usually desired. Methods to distinguish stops (such as a traffic delay) from trip ends (such as dropping off a passenger) are still under development. Most experts present these data sources that are still in their development stage as complements, not replacements, for the traditional travel diary survey.

The frequency with which an agency collects travel data has been widely debated. The TRB Task Force on the Future of the NHTS conducted a survey of user's nation-wide and recommended a 5-year interval. However, it is becoming more common to pursue continuous surveys. On-going surveys add new observations to a growing sample every year and smooth the cost of a survey to an agency over time. In some jurisdictions, panel surveys are conducted where the same individuals repeat the survey over time so that changes to travel patterns based on life stage and home/work locations can be observed.

The cost of travel diary surveys is significant. In 2009, the cost per completed household for the NHTS add-on was \$175. This price has not yet been set for the 2015 add-on but is estimated to be \$225 per completed household and \$350 for a household where the optional GPS component is used. Hartgen and San Jose (2009) conducted a study of 115 travel surveys between 1988 and 2009. The cost per completed household ranged from \$29 to \$298. Costs were corrected to 2007 dollars and the analysis did not reveal a large decrease in per household unit survey cost with increasing sample size. The average cost per completed household was \$132 in 2007. Adding a second day, which may be advisable in a rural area, was estimated to increase costs by 23-67%. It is important to note that both trip-based and activity-based surveys were included and that most surveys were phone-based. A consultant contacted informally for this project estimated web-based surveys with a travel diary cost approximately \$80-100 per completed household. Note that none of these costs include the analysis or management of the data resource after the survey.

Conclusions

The NHTS Add-on and travel data represents a solid resource for many Vermont stakeholders, especially for travel demand models and researchers. The NHTS Add-on program is a long-standing and well-established survey that offers VTrans consistency and ease of contracting. A 2015 Vermont Add-on sample could be designed to fill gaps in the 2009 data to meet targeted needs indicated by Vermont stakeholders.

However, the NHTS Add-on is an expensive option for obtaining household travel data. Web-based survey methods are now well-established, can be designed for consistency with the 2009 data and be conducted for half the cost. This cost savings could be used to double the sample size and make the data more useful to individual RPCs. Cell-phone methods for data collection are still in development phases and have concerns for rural coverage.

Participants in this study expressed concern over the amount of work required to transform data into a usable format with models. The older more mature GPS-based methods, including smart phones, are prohibitively expensive. The UVM TRC project team concluded that either a 2015 NHTS Add-on (data available in 2017) or similar web-based household survey (available within approximately 90 days of data collection) are viable options for Vermont. The timing of a web-based survey could be coordinated with the VTrans long-range planning survey and the CCRPC transportation survey.

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