

Standing Committee on Travel Survey Methods (ABJ40)
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A Century of Travel Surveys Informing Transportation Investments

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INTRODUCTION

Transportation expenditures in the United States account for over five percent of the Gross Domestic Product with 2015 expenditures estimated at \$972 billion (1). The annual federal transportation budget has been near \$77 billion since 2017 (2). However, even with billions of dollars of funding, the nation lacks the financial capacity to meet its transportation needs, with every state carefully selecting projects with the highest benefit/cost ratio for funding.

Since the passage of the Federal-Aid Road Act in 1916, all levels of government have been using transportation surveys to determine both existing and future transportation needs. HRB Bibliography No. 11 (3, pg. 6) states:

The early transportation surveys were based on two fundamental principles of management. The first is that the mileage and type of improved highways developed must be such as to meet the public demand and adequately serve traffic needs. The second is that the highway program must be financially sound.

These principles still hold true today, and travel surveys are being asked to do much more than they were a century ago. Today, not only do state departments of transportation use travel demand, economic and air quality models based on travel surveys to select infrastructure projects that meet future demand, but USDOT requires these analyses for their discretionary programs, such as FHWA's BUILD (4) and FTA's FAST (5).

Travel surveys have been and continue to be the basis for transportation investment decisions. With the advent of Big Data, changing dynamics of travel and time use, transformational mobility alternatives (e.g., transportation network companies (TNC)), more complex questions are being asked of travel survey data and the Transportation Research Board has positioned itself to proactively respond.

TRAVEL SURVEY METHODS – LAST 100 YEARS

While small-scale origin-destination surveys had been conducted previously, the first large scale survey was conducted in Tennessee in 1923 (3). By 1929, travel surveys had been conducted throughout the United States, including in California, Connecticut, Maine, New Hampshire, Ohio, Pennsylvania, and Vermont “for the purpose of providing such accurate knowledge of traffic on the highways of the state and of translating this knowledge of present and expected future traffic into a plan of highway development which would satisfactorily and economically meet traffic requirements on the state highways (6, 3).” In 1927, the Ohio survey was the largest at that time and collected surveys at 1,158 locations with the Department's Road Use Survey staff of 50 (3, 7).

Roadside Interview Surveys

Throughout the 1920s and 1930s, surveys were conducted at highway locations by one of three methods: personal interviews, postcards, and license plate recording. The goal of these surveys was to determine locations that needed highway infrastructure, such as bridge crossings or bypass routes, and to estimate the amount of traffic that would use the proposed project. Survey stations using either the interview or postcard methods required all traffic to stop at the survey site and either respond to a personal interview collecting detailed origin and destination information, or to receive a postcard to fill out and return at their convenience. Figure 1 shows an example of a postcard from Fulton, New York (8). Collected data would include state of registration, place of ownership, purpose of trip, origin, destination, number of passengers, and routes taken for passenger vehicles. There were additional fields of truck capacity, commodity, and type of tires for commercial vehicles (3). These are generally the same items collected today.

1	NEW YORK STATE TRAFFIC SURVEY	O	D	S
Trip is in Direction Traveling When Card Was Received WHERE DID THIS TRIP START ?		Check One (Only) In Each Group		
If in Fulton <i>(Write in Number and Name of Street, or Nearest Intersection, or Plant, or Well-known Building)</i>		DIRECTION OF TRIP 1. <input type="checkbox"/> From Home Garage 2. <input type="checkbox"/> To Home Garage		
If outside Fulton <i>(Write in Locality and State)</i>		1. <input type="checkbox"/> Passenger Car 2. <input type="checkbox"/> Light Truck 3. <input type="checkbox"/> Heavy Truck		
Trip is in Direction Traveling When Card Was Received WHERE DID THIS TRIP END ?		1. <input type="checkbox"/> Work 2. <input type="checkbox"/> Shopping 3. <input type="checkbox"/> Other		
If in Fulton <i>(Write in Number and Name of Street, or Nearest Intersection, or Plant, or Well-known Building)</i>		1. <input type="checkbox"/> Parked at Curb 2. <input type="checkbox"/> Parking Lot 3. <input type="checkbox"/> Storage Garage 4. <input type="checkbox"/> Did Not Park		
If outside Fulton <i>(Write in Locality and State)</i>		Parked for Hrs.		
Routes followed <i>(Write in Names of Major Streets, or Route Numbers, in the order traveled, in or near Fulton on this trip)</i>		THANK YOU!		

Figure 1. Fulton, New York Postcard Survey, 1948

By the late 1940s, postcards were used for more than just intercept surveys. To obtain a more comprehensive picture of travel in a region, several methods were employed simultaneously. A cordon around a study area is established and traffic counts are taken at roads crossing the cordon. Postcards are sent to vehicle registrants within the cordon (Figure 2) while intercept surveys are taken at the cordon crossings. With a large sample, the area could be divided into zones/districts and trip tables could be developed from the multiple surveys.

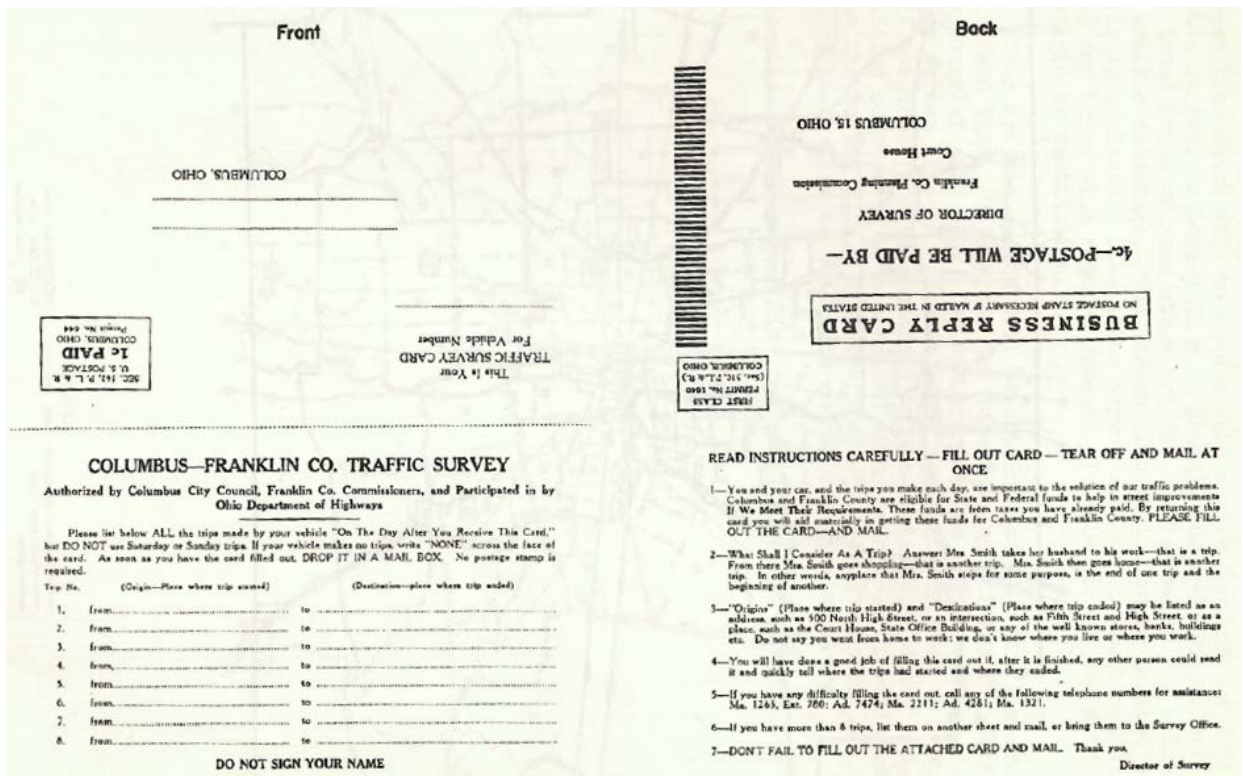


Figure 2. Columbus, Ohio Postcard Interview Survey, 1948

License plate recording was used when traffic traveling through a region was of interest, such as with bypass studies. For this survey, the surveyors recorded vehicle registrations and plate numbers at multiple cordon stations, which were then used to create external flows through the area. One of the first of these studies to be published was conducted in Lafayette, Indiana in 1931 (9).

Home Interview Surveys

Barkley states “It is a paradox of modern highway history that the state-wide planning surveys, which were largely undertaken to evaluate the needs of the rural road system, emphasized the seriousness of the urban traffic problem (3).” Thus, new methods were needed to capture travel being conducted in the urban areas as the roadside interview methods would both create too much delay and capture too few respondents. The first survey considered to be a home interview survey (HIS) was conducted by the Ohio Department of Transportation in 1942 in Toledo (Figure 3). Students at public and private schools were directed to take home surveys and have each worker (i.e., each adult in the household who worked outside of the home) complete one. This survey was supplemented by intersection counts and was expanded based upon the number of workers by census tract.

WAR EMERGENCY TRANSPORTATION STUDY

Form 1

by the CITY OF TOLEDO

in conjunction with

TOLEDO NATIONAL DEFENSE COUNCIL

and

OHIO DEPARTMENT OF HIGHWAYS Highway Planning Survey

U. S. FEDERAL WORKS AGENCY Public Roads Administration

The State, City and Civilian Defense officials who are charged with planning civilian defense and construction of streets and roads need to know more about the driving habits of the public. With the cooperation of the Joint School Defense Committee and the Superintendent of Schools the above officials are asking you to help get these facts.

PLEASE TAKE THIS FORM HOME, HAVE EACH PERSON WORKING FILL OUT ONE FORM AND RETURN TO YOUR TEACHER, ON THURSDAY, MAY 21st. It is not necessary to sign this form.

Home Address Collingwood (do not use your rural mail route address)

Individual Workers Trip Record

- 1. What is the address of your place of work? Elm
2. What method of transportation did you use to get to work today? (Wednesday, May 20th)
Drove automobile, Taxi, Passenger in automobile, Walked, Street car, Other, Bus

If you drove to work today please answer the following questions:

- 3. What time did you leave home? 7:25 A.M.
4. What streets did you follow while driving to work? Give names of all streets in order of use. Collingwood - Bancroft - Elm

- 5. Where did you park your car? On the Street, Off the Street (Approximate street address)

- 6. What time did you arrive at your place of work? 7:45 A.M.
7. What time did you leave your place of work? 4:30 P.M.

Figure 3. Toledo, OH Home Interview Survey Form, 1942

In 1943, the Public Roads Administration (later named Bureau of Public Roads (BPR)) collaborated with the Bureau of the Census to develop sampling methods for capturing internal travel. The Bureau of the Census recommended the use of dwelling units as the basis of sampling. They recommended a 20% sample for cities with less than 100,000 population, 10% for 100,000-300,000 population and a decreasing sample size for populations larger than 300,000 (3). It was also noted that trucks and taxis would need to be surveyed separately to obtain a

complete analysis of internal traffic. Surveyors would interview respondents in their homes and obtain the trips completed the prior day using a form such as Figure 4. This method was called the "Lynch method," after I.T. Lynch, Chief, Planning Surveys, Bureau of Public Roads (3). These surveys were first conducted in Little Rock, Tulsa, and New Orleans in 1944. By 1947, HISs had been undertaken in fifty-five cities.

INTERNAL TRIP REPORT

SHEET OF

CARD 2 TRACT BLOCK SAMPLE No. SUBZONE DAY OF TRAVEL

1 OCCUPATION AND INDUSTRY	2 PROF. NO.	3 TRIP NO.	4 SEX AND AGE	5 Where Did This Trip Begin?	6 Where Did This Trip End?	7 Mode of Travel	8 Time of		9 Purpose of Trip		10 Type of Parking	11 Kind of Parking	12 Control Points
							Starting	Arrival	From	To			
		1				1 Auto Driver	A.M.	A.M.	1. Work..... 1	1	1 Street free	1 Memorial Bridge	
		2				2 Auto Pass.			2. Business..... 2	2	2 Street meter	2 Maine Avenue Viaduct	
		3				3 Street-car-Bus			3. Med.-Den..... 3	3	3 Lot free	3 Sixteenth Street Underpass	
		4				4 Taxi Pass.			4. School..... 4	4	4 Lot paid	4 None	
		5				5 Truck			5. Social, Rec..... 5	5	5 Garage free	5 None	
		6				6 Truck Pass.			6. Ch. travel mode 6	6	6 Garage paid	6 None	
									7. Eat meal..... 7	7	7 Service or repairs	7 None	
									8. Shopping..... 8	8	8 Res. property	8 None	
									9. Serve pass..... 9	9	9 Cruised	9 None	
									0. Home..... 0	0	0 Not parked	0 None	

Revised: August 1948

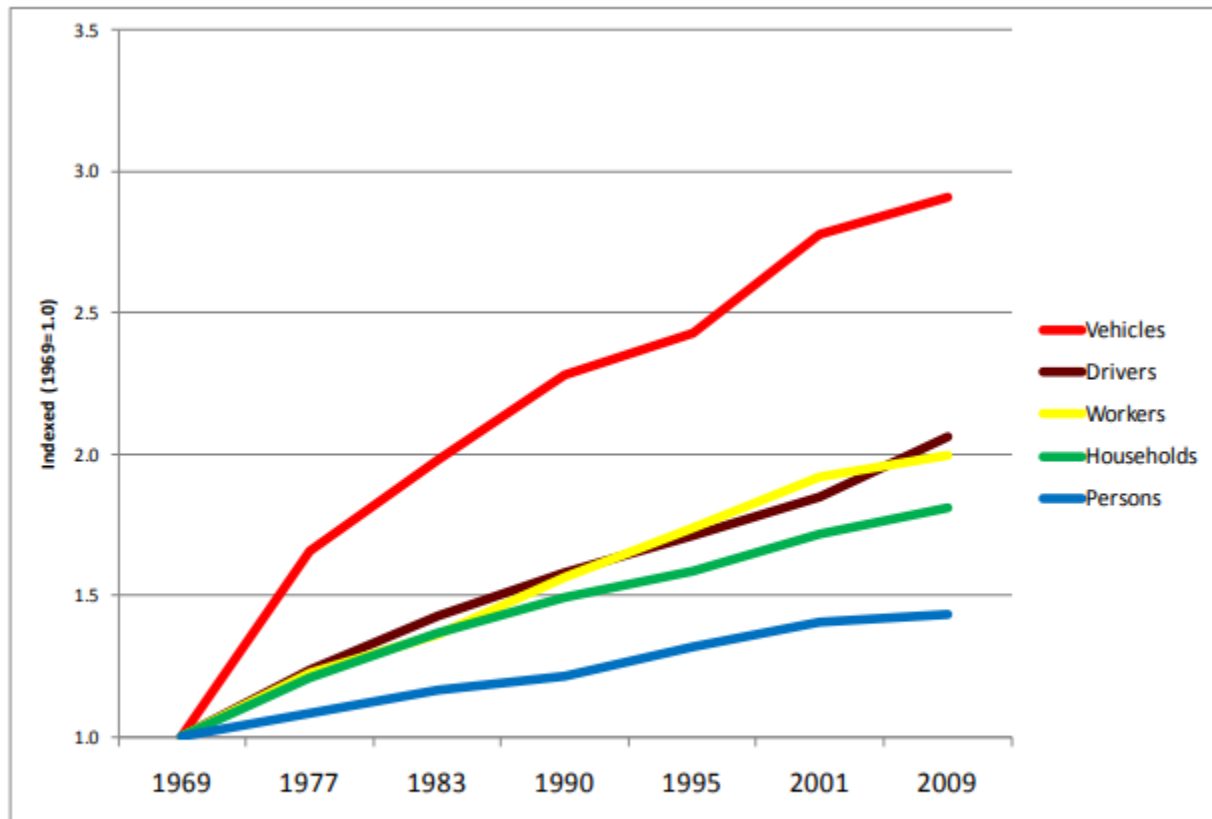
Figure 4. Home Interview Survey Form

Nationwide Personal Transportation Survey

In 1969, the Bureau of the Census conducted the first Nationwide Personal Transportation Survey (NPTS) for the Federal Highway Administration (FHWA) (previously BPR). The survey included 235 sample areas and represented every state. NPTSs were conducted again in 1977, 1983, 1990, and finally in 1995. Improvements were made to the survey method over these years to try to capture more travel. The 1995 report notes that the "changes that presumably caused the greatest impacts on trip reporting were the use of a written *travel diary* and *household rosters* of trips (17)."

In 2001, FHWA changed the national survey to better include all household travel and renamed the survey to the National Household Travel Survey (NHTS). Surveys were conducted

in 2001 and 2009. Figure 5 shows how various demographics have changed over the surveys (18).



Note:

- The 1969 NPTS did not include pick-up trucks as household vehicles, therefore the growth between 1969 and 1977 is exaggerated.

Figure 5. Changes in travel from the 1969 NPTS.

Sampling Methods

As noted above, the first HIS used dwelling units as the basis of the sample. Addresses were sampled and visited in person by surveyors. In the 1970 manual (14), address-based sampling was still recommended, with sample rates of 4 - 12.5% being recommended by BPR. As households more frequently obtained separate telephone lines, random digit dialing became popular as a recruitment method and the ability to link listed telephone numbers to selected addresses was heavily used to reduce costs due to in-person interviews. In 1999, Nancy McGuckin used the 1995 NPTS to analyze the potential bias in missing those households without telephone service as in-person interviews had become standard (24).

Transit Rider Surveys

Early surveys of transit riders were simply HISs with a large enough sample size to capture transit riders. These surveys could then be validated with results from an on-board survey. One of the first recorded on-board surveys was conducted in 1946 for a street car company in Washington, where riders were handed a postcard survey on predesignated routes. Only 10% of

the postcards were returned in a “usable condition,” but they showed good correlation with the earlier 3% HIS. (3, 11)

In 1946, the American Transit Association (ATA) published the *Manual of Traffic and Transit Studies*, which described the procedures to conduct twenty different studies on data collection (20). This and several other ATA reports maintained the status quo for transit studied until 1979, when the Urban Mass Transportation Administration (UMTA) (currently the Federal Transit Administration (FTA)), began the “Bus Transit Monitoring Study” which produced the 1981 *Bus Transit Monitoring Manual* (19), which was subsequently updated in 1985 (20). This manual provided detailed procedures and checks for six types of transit counts (on/off, boarding counts, load counts, fare box reading, revenue count and transfer counts) as well as two surveys (boarding to alighting and on-board surveys). A new manual was produced for NCHRP in 1997 with an emphasis on multi-modalism due to the 1990 Clean Air Act Amendments (CAAA) (25).

Travel Survey Methods Committee at the Transportation Research Board – Early Years

Travel Survey Methods was a purview of “Committee Number 4” of the Advisory Board on Highway Research, Division of Engineering, of the National Research Council. A report was given by the committee at the first Annual Meeting and was included in the Proceedings (12). Barkley notes that there are “seven subjects of research which come under the jurisdiction of the committee are listed, which brief discussions of the implications of each.” The first subject is the “purpose, methods, and cost of conducting traffic surveys, the significant data to be taken, and its useful applications.”

At the third Annual Meeting, the committee noted that “there is a differentiation made between the traffic census and the transport survey: the former gives information pertaining to the traffic using the system at the time the information is obtained; the transport survey determines the probable amount and character of the future traffic which will use a given highway during the lives of its several component parts.” Dr. J.G. McKay of the U.S. Bureau of Public Roads presented a paper on a Connecticut travel survey, at the end of which the committee’s chairman remarked that “this report opens up practically a new field in highway research. Such studies of transportation closely touch on the development of our highway systems.” (3, 13)

At the early Highway Research Board (HRB) Annual Meetings (AM), Dr. McKay presenting numerous papers, which were included in the Proceedings, but as research progressed, other researchers presented their methodologies and findings from a number of travel surveys in Pennsylvania, Tennessee, and Maryland. Enough progress had been made such that in 1927, Mr. G.E. Hamlin presented a synthesis of the “Principle Conclusions of the Committee Since Its Inception.”

Travel Survey Manuals

The first “Forms for Traffic Investigations” were printed in the HRB AM Proceedings in 1930. This can be thought of as the first travel survey manual produced by the Travel Survey Methods Committee (at that time the Committee on Highway Traffic Analysis) for TRB.

While many DOTs published their own manuals, the first full and nationally published manual, was in 1944 by the U.S. Bureau of Public Roads. A revised edition was published in 1946, and the second edition in 1954. Work started on the fourth edition by Thomas Humphrey in 1966 with “major contributions to the original work” by E.H. Holmes, S.T. Hitchcock, G.E.

Marple, G.A. Sharpe, D.H. O'Flarraty, J. Lynch, D.H. Trueblood and "many others in both State and Federal Government." (14)

A new manual was produced in 1976 by the Federal Highway Administration titled *Guidelines for Designing Travel Surveys for Statewide Transportation Planning*. This manual covered not only HISs, but also included sections on transit on-board surveys (and its applicability for air and rail passenger surveys) and roadside surveys. The manual also included sections on estimating sample sizes and biases for each type of survey (26).

Earlier that year, FHWA had also published a report regarding the sample sizes necessary for estimating travel demand models (23). This report concluded that the study "indicates that sample size, not sampling rate, is the critical factor in obtaining acceptable traffic assignment results." This was important as not only had the costs of travel surveys increased over the years, but population and housing units had also increased.

FHWA's manual was updated in 1996 in conjunction with the Travel Model Improvement Program by Cambridge Systematics (34) with chapters covering household and activity surveys, vehicle intercept and external station surveys, transit onboard surveys, commercial vehicle surveys, workplace and establishment surveys, visitor surveys, and parking surveys. This would be the basis for the 2008 update and the travel survey wiki.

In 1997, another manual was published by NCHRP as "Web Document 4" entitled *Multimodal Transportation Planning Data: Compendium of Data Collection Practices and Sources* (25). This document covered household travel surveys, workplaces surveys, stated preference surveys, longitudinal and panel surveys, transit on-board ridership surveys, commercial vehicle (truck) surveys, and external station surveys. This manual included a number of case studies where new technology was being used.

TRAVEL SURVEY METHODS – LAST 20 YEARS THROUGH TODAY

Technological developments, especially through GPS, have move faster than anyone could have imagined twenty years ago, and methodologies used in travel surveys have kept pace. GPS recording is now being used in almost every survey and new methods, such as virtual reality, are being fielded for stated response surveys.

Roadside Interview and External Travel Surveys

Throughout the 1990s and into the new millennia, roadside surveys continued to use the traditional personal interview and license capture methods, but the surveys were improved with enhancements in methods and the addition of technology. For roadways with low to moderate traffic levels, roadside interview surveys were conducted with increased attention safety with the use of carefully prepared traffic control plans. In many areas the use of pen and paper surveys, were replaced with computer tablets to facilitate data input and processing (Figure 6).



Figure 6. Roadside Interview Survey Using Computer Tablets

For external surveys on high volume roadways, the manual recording of license plates was replaced with the use audio or video recorders, high-speed cameras and automatic license plate recognition (ALPR) cameras (Figure 7). Video methods are also used to augment roadside interviews or postcard handouts especially near freeway entrance and exit ramps, weigh stations, rest areas, and truck stops.



Figure 7. Video License Capture Using Camcorder (left) and ALPR (right)

Advances in technology such as in-vehicle navigation, GPS commercial fleet tracking, and the near-ubiquitous use of mobile smart devices have resulted in momentous advances in external survey data collection. Traditional methods for collecting external OD data, have been - for the most part- replaced with passively collected data from Bluetooth, GPS, cellular, and location-based services (LBS) data. Numerous cities have used purchased datasets derived from cellular or LBS data to estimate external travel for both passenger and commercial vehicles. Figure 8 shows a comparison of traditional cordon survey flows (top left in blue) and three other purchased datasets for Lima, Ohio.

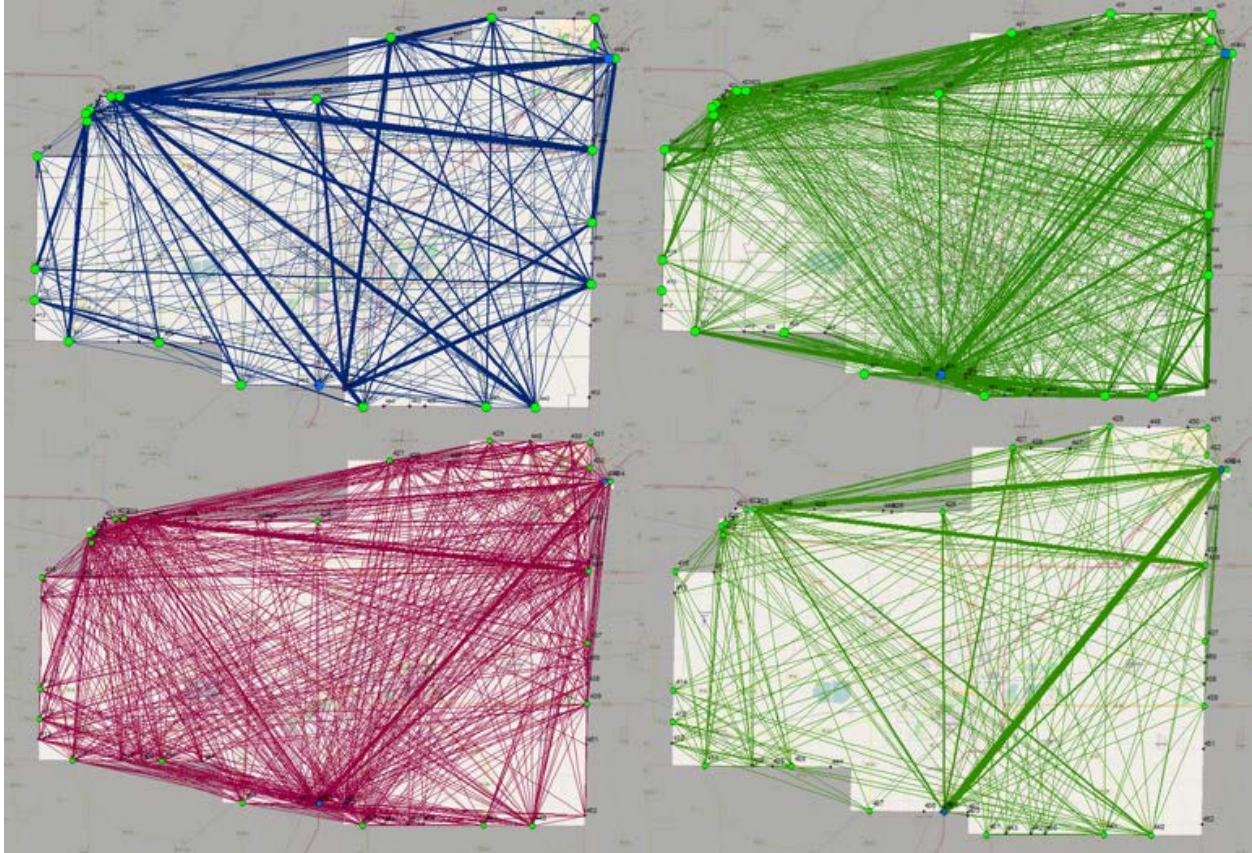


Figure 8. Comparison of traditional (top left) and three OD datasets derived from passive GPS data.

Improvements in external survey data continued to evolve with LBS data being the latest new technology source. Its location accuracy is better than that of cellular data, but not as good as GPS. Like cellular data, LBS data cannot discern the travel mode, but can provide estimates of basic trip purposes and whether travelers are residents of or visitors to a study area. LBS served as an alternative source to cellular data in its first several years of use, but has now effectively replaced cellular data in transportation studies due to its superior location accuracy.

Home Interview Surveys

In 2001, Oregon fielded the first household travel survey that included a GPS sub-sample in the United States. A GPS receiver was physically installed in respondents' cars and the resulting data were used to factor reported trips to total trips (to account for trip under-reporting). By the mid-2000s, GPS technology had advanced such that smaller, portable units could be carried by survey recipients. In surveys at this time, respondents aged 16 and over were sent a GPS device to be carried for several days (27).

There were a number of studies in the 2007-2013 timeframe where GPS was intended to be the primary method of data collection. A subset of the respondents was chosen to complete a prompted recall survey to select data items normally collected in a traditional survey, such as purpose, mode, and travel party members. This subsample was then used to estimate or train models that would impute those data items for the rest of the respondents.

Numerous papers were submitted to the Travel Survey Methods Committee regarding survey data imputation, and therefore a proposal to compare the different methods to advance the research was sent to the National Cooperative Highway Research Program (NCHRP), which published the findings under Report 775 (28). It was found that none of the methods was sufficient to replace the self-reported data.

Since 2010, the purchase and use of smartphones has skyrocketed, with penetration rates now above 75% (30). This has led to research on two main areas: the use of passive data to infer travel, as noted above, and the use of smart phones to collect travel survey data. By the time of the 100th Annual Meeting of the TRB, the use of smartphones to capture travel surveys will be considered state of the practice. The use of passive data to infer travel still requires additional research. The Travel Survey Methods Committee proposed a project to the NCHRP to better determine the potential of cellular point data to infer travel. The findings were published under Report 868 (29).

Sampling Methods

The landscape changed a second time with the advent of caller ID, the internet and particularly cellular phones. By 2008, responses to telephone surveys had declined due to the increase in unlisted telephone numbers and households screening their telephone calls with caller ID. NCHRP Report 571 noted that “after careful review, it is concluded that there are no standardized procedures that can be recommended regarding caller ID listings” (22, pg 27). In the late 2000s, HISs started to revert back to address-based samples, with postcards again being sent to households with a request for respondents to complete an on-line recruitment survey or to call a toll-free number to participate.

Transit Rider Surveys

As with the external surveys, technology has augmented the collection of transit on-board surveys, with most surveys being collected by surveyors on tablets. This mode has enabled virtually all collected locations to be mapped, as addresses are located using mapping software in real time, and results in lower item non-response as the surveyor can explain any questions and the tablet can be turned toward the respondent for answer confidentiality. The availability of automatic vehicle location (AVL), automatic passenger counters (APC) and automated fare card (AFC) on buses has allowed researchers to synthesize the datasets for better precision. Transit systems utilizing smartcards have the added ability to link passenger transactions, allowing for boarding-to-alighting (BA) movements to be estimated without the more expensive BA survey.

Travel Survey Methods Committee at the Transportation Research Board

Since 2000, the Travel Survey Methods Committee receives approximately forty research papers each year, documenting many new and varied research techniques. The advent of the technology highlighted above continues to be a mainstay of the committee’s focus. Over the last two years, the Stated Response Subcommittee has highlighted the use of virtual reality (VR) for new surveys and in 2019 held a workshop teaching researchers and practitioners to create their own VR surveys at the Annual Meeting. With the price of VR headsets coming down to under \$300, this new technology could become commonplace.

Travel Survey Manuals

Peter Stopher was the principle investigator for the travel survey manual published in 2008 as NCHRP Report 571 (22). This report covered previous methods of data collection and added guidance on all the challenges that researchers were facing at that time, including increasing respondent and item non-response, incentives, geocoding, weighting and expansion and required sample sizes. However, twenty percent of the report was dedicated to procedures and measures for further research, as it was obvious that the advent of technology could quickly change the field of travel surveys.

The Travel Survey Methods Committee quickly saw that technology could render the manual out-of-date fairly quickly and that same year began the effort to move the manual to an on-line wiki format. A conference call was held on August 19, 2008 to discuss the creation of the wiki's content and to assign roles to committee members. The wiki was finalized in January 2010, in time for the 89th Annual Meeting of the TRB.

The highlight of the Travel Survey Methods Committee came in 2014, when it awarded status as a Blue Ribbon Committee by the TRB Technical Activities Council for the creation of the Travel Survey Manual Wiki.

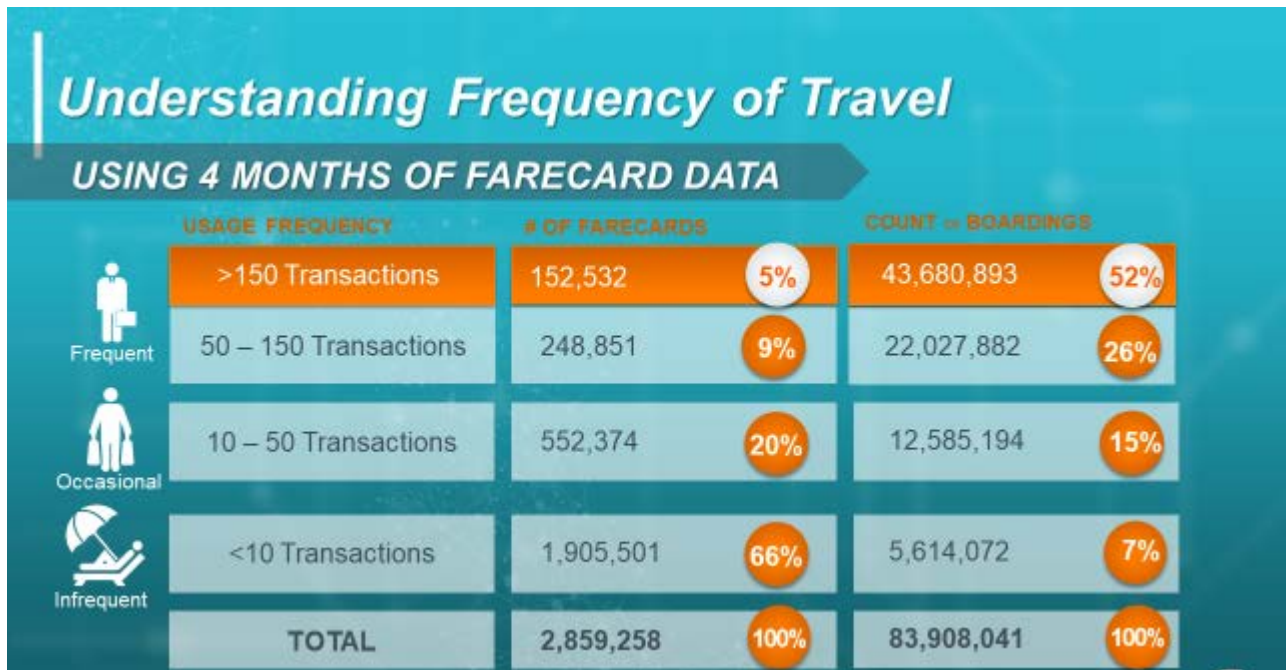
FUTURE OF TRAVEL SURVEY METHODS

Today, the community finds itself at a unique crossroads driven by two opposing forces – low response rates to traditional surveys offset partially by the increased amount of data available from passive datasets. This means that the problems facing this committee and practitioners will take on a slightly different flavor in the days and years to come. Three key themes have emerged:

Passive Data Will Continue to Grow

People increasingly plan their travel and choose their transportation modes with the touch of a smartphone. Ride-hailing transportation companies such as Uber and Lyft, Bird and Lime-Bikes did not exist a decade ago, but are well-known today – especially in urban areas. These same smartphones that are used to hail rides also leave behind a trace of rich spatio-temporal data which when parsed together, provide important and valuable passive datasets of user movements. There are several multimodal examples of these types of data:

- Transit agencies with electronic fare payment systems have the ability to conduct deep-dives into customer usage data to understand: who is using the system, how frequently are they using the system, boarding and alighting locations, what route combinations are most frequently used, and at what times the system experiences greatest usage (Figure 9).



Source: Summary of Electronic Farecard Data in the Los Angeles Metro System

Figure 9. Transit Rider Usage Profiles in Los Angeles

- Public bike-share systems (typically docked) are increasingly adopting an open data sharing approach about how the systems are being used to encourage research, ideation, and system planning.
- Similarly, anonymized geolocation and time-stamp traces obtained from mobile devices are providing cities with a vast swath of data that can help answer questions pertaining to mobility, congestion, and travel patterns (29).

Strong, unbiased research coupled with collaboration among practitioners, researchers, and the government sector is necessary to harvest these data effectively, while at the same time protecting individual user privacy.

Cost of Conducting Surveys Will Rise

The amount of data needed to build sophisticated models and answer challenging policy questions continues to rise and so does the burden on respondents. To encourage respondent participation, either creative outreach mechanisms or larger incentives will be necessary. As agencies continue to grapple with tight budgets, the challenge to conduct effective surveys will likely become an increasingly real problem. Data fusion techniques that combine data from traditional and new passive data sources will emerge as a means to maximize the value of data. Already, the next iteration of the National Household Travel Survey is slated to follow this path and will likely be the trailblazer for the next wave of data collection efforts (32).

Data Collection Cycles will be Shortened

A wave of socio-economic-technological changes are sweeping across the United States, particularly in urban areas – rising home and land values in desirable inner-city neighborhoods are displacing the most vulnerable of populations and forcing them to endure longer commutes,

new modes of transportation are appearing overnight, and policy questions are becoming nuanced (e.g., congestion pricing, limiting parking spaces). All of these changes mean that the policy of conducting comprehensive travel behavior and traffic inventory surveys once every decade is no longer enough. When combined with increasing survey costs, this means agencies must be mindful and plan far ahead so every dollar spent on data collection has a tangible and real impact on local, regional, and national transportation policy (33, 34).

The Travel Survey Methods Committee is tasked with tackling some of the same questions that were asked of us a few decades ago, but with an added technology flavor. It is important for the committee to remain true to our roots of developing statistically robust methods to collect traditional data, but also to be adept at providing guidance to support passive data collection, analysis, and research. Some of the key challenges in the travel behavior data efforts that the committee will likely have to address are discussed below:

Identifying Appropriate Data Collection Methodologies

Hybrid data collection efforts will become increasingly popular.

- For household survey efforts, this could mean that a portion of data are collected from truly random samples using smartphone-based GPS techniques, combined with data from targeted sub-samples (e.g. frequent e-scooter and car-share users) to address policy questions.
- For transit data collection, this could mean using fare-card analytics to develop trip tables needed for survey expansion.
- For external surveys, this could mean relying on anonymized data from mobile devices using GPS or Bluetooth to capture movements in, out, and through regions.

Trailblazers and early adopter agencies will implement these efforts, likely with mixed success. Documenting the findings so other agencies can adopt successful strategies and adapt not-so-successful ones will be very important. Key to this will be maintaining a repository of studies and findings.

Sample Sizes

As the data collection procedures evolve into episodic and repeated efforts, the sample sizes from each wave will likely shrink. For instance, the next generation NHTS is proposing a sample size of 5,000 – 7,500 households recruited for every wave of the data collection effort (three waves, each wave being implemented once every two years) compared to a sample size of approximately 25,000 households (not including the add-on sample) in the previous iteration. Smaller sizes coupled with more rigorous ways of analyzing the data to answer challenging policy questions will likely test the boundaries of analytical truth-telling. Research will be necessary to answer these questions in advance so agencies can plan effectively.

Influencing Big Data Analyses with Travel Behavior Values

NCHRP has already funded a highly relevant study (29) that provides practitioners with an understanding of how anonymized cell phone data can be used to support transportation planning and modeling. As part of this study, the researchers provided a list of do's and don'ts that practitioners will do well to heed. Similar studies may be required in the future to study new and emerging data sources such as the expected explosion of data from connected and autonomous vehicles (CAVs).

Practitioners and planners should also note that passive data often do not provide detailed information – rather much of the relevant information is often inferred. So, the more grounded the algorithms are in behavioral analyses, the more valuable is the information that can be gleaned from the data.

Identifying Bias and Developing Rigorous Expansion Techniques

Passive data tend to be massive in size, but the questions of bias still remain. For instance, lower income households may continue to use cash-fares so long as they are an available option on transit systems – meaning that their behavior and needs are not captured in passive data sets. Similarly, older generations that tend to have lower and slower adoption rates for smartphone technology may not be included in cellular data. Open discussions about the populations that are sampled at a lower rate in these data must be encouraged so that the community as a whole looks for solutions to overcome such biases.

Apart from these technical challenges, the committee also sees the community approaching a critical juncture where a few organizations could control and disseminate a vast amount of passive data to the transportation world. Such concentrations of data ownership are a cause of concern. To the extent possible, the committee must encourage and support the democratization of data by: promoting research that make analytical procedures more accessible to the community (to prevent black box solutions) and by developing clear dos and don'ts so new organizations looking to provide services know what the community is looking for and can tailor their services accordingly.

We also look towards the horizon and see a future where CAVs are likely to dominate the mobility landscape. Questions about equity, fair pricing, and new performance measures (e.g. deadhead miles) could all become relevant information that agencies are tasked to collect. This committee will remain nimble and collaborate with other committees to provide valid ways to collect such data including encouraging or enforcing public-private partnerships.

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