THE FUTURE OF TRANSPORTATION STUDIES:
A COMPARATIVE REVIEW

New Technologies Offer Affordable, Effective Options for Augmenting and Replacing Traditional Traffic Data Collection Methods

EXECUTIVE SUMMARY

The traditional "gold standards" in compiling origin-destination data—household travel surveys, vehicle intercept surveys and license plate surveys—are being supplanted by new technologies.

Those new technologies, using information from Bluetooth® technology or data from cellular devices, including cell phones, tablet computers and laptops, have shown many advantages over traditional traffic study methods. Cellular, in particular, can be a low-cost alternative or adjunct to traditional surveys, providing data in a fraction of the time and cost.

Two factors are driving interest in new technologies: research/study budgets are constrained, and new technology can deliver larger, more accurate data samples much faster, making the data more current than most other methods. Increasingly, public agencies and commercial clients are studying and using new strategies, especially cellular data, to supplement or replace traditional traffic study methods.

With public budgets constrained, public agencies and commercial clients are studying and using new technologies.

The pros and cons of household travel and vehicle intercept surveys are well documented. Both generate detailed traffic and demographic data. However, they are costly, limited in the geographic area that can be surveyed, and can require months—or even a year or more—and significant personnel and other resources to complete. Because of the time and costs, many jurisdictions only have the resources to update their travel demand models using traditional methods every five to 10 years, or even less frequently.

Bluetooth and license plate surveys eliminate some of the drawbacks of traditional survey methods. Both can cost less and be completed more quickly than household and vehicle intercept surveys. However, because both require expensive equipment, they share the same restriction of covering only a limited geographic area.

Cellular technology eliminates many of the drawbacks of traditional surveys, Bluetooth technology and license plate surveys. The technology is relatively low cost, data can be collected and analyzed in just weeks, and the size and scope of a cellular traffic study are virtually unlimited.

The bottom line: Based on preliminary findings, a household travel survey augmented by a cellular survey provides the richest pool of data, but the length of time to complete the study is long and costs (due to the household survey) are high. Cellular surveys, which provide unprecedented amounts of current and historical data at a relatively low cost, offer an effective and affordable alternative for regions of any size.

TRANSPORTATION STUDY TECHNOLOGIES: AN OVERVIEW

This brief overview of the leading traditional and newer traffic monitoring technologies outlines how each technology works and how each is typically used. The five technologies are:

- Bluetooth
- Cellular Data
- License Plate Surveys
- Vehicle Intercept Surveys
- Household Travel Surveys

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Bluetooth Technology

Bluetooth uses roadside sensors to detect Bluetooth devices, such as cell phones, tablets and some navigation systems. Those sensors use Anonymous Wireless Address Matching (AWAM) by detecting the unique Median Access Control (MAC) address assigned by the manufacturer. If a given device passes more than one sensor, the system has a usable pair, defined by a researcher at the University of Wisconsin-Milwaukee (in *Use of Bluetooth Technology in Traffic Data Collection & Management*) as the "total number of pairs that pass reasonable travel time filters (filtering out people that stopped and got back on)."

The usable pairs are then evaluated by filtering software to screen out data that indicates unreasonable travel times, and is therefore inaccurate. The amount of bad data can be significant: in a study of traffic flow in the Tomah and Portage areas of southern Wisconsin, for instance, false positives reported by Bluetooth sensors ranged as high as 10%.

A recent study by the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization (DCHC MPO) of traffic in a small North Carolina community (population 15,000) demonstrated a typical use of Bluetooth technology. To learn how many vehicles were passing through downtown and how many were coming to the area to participate in an activity, DCHC MPO set up Bluetooth stations to measure traffic in the five corridors leading into/out of downtown for 48 hours. The study's conclusion: the technology answered the question relatively quickly and at a lower cost than household travel surveys or vehicle intercepts. However, the study also concluded that the technology would be much less effective on a larger scale. A similar study in Raleigh, for example, would require 50 sensors—at a cost between $485,000 and $610,000—and monitoring for seven days.

Cellular Technology

Cellular technology forgoes sensors and detects data from mobile devices, such as cell phones and tablets, as each one contacts its cellular network. When users make or receive calls, send or receive texts, browse the Internet, or send or receive email, the device communicates with the network. The data available from cellular companies is anonymous, eliminating privacy concerns.

Unlike Bluetooth, the geographic area covered by a cellular technology survey is virtually unlimited, since no sensors or personnel are needed. The technology can be widely used to provide traffic data in every city in the nation, as well as information on intercity and long-distance travel.

Two recent studies, both completed in 2012, show the benefits of cellular technology.

- *Understanding Individual Mobility Patterns from Urban Sensing Data: A Mobile Phone Trace Example*, a University of Singapore working paper analyzing a study in Massachusetts, demonstrated the scope of a cellular survey. In this study, anonymous location estimates from approximately one million mobile phones generated 829 million data points. By overlaying that data with census maps, researchers were able to determine traffic mobility patterns over a wide area encompassing eight counties.
- Researchers concluded that, compared to data gathered from household travel surveys, cellular technology provided researchers with information about individual mobility with a lower collection cost, larger sample size, higher update frequency, and broader spatial and temporal coverage. They also found that cellular technology collected mobility data of millions of people across the metropolitan area over a longer time period, compared to a few thousand households' movements within one to two days usually collected through travel surveys. Cellular data sets are updated on a real-time basis, which could lead to more reliable and verifiable urban performance indicators and support more prompt policy responses to emerging urban issues.
- A joint project by researchers at IBM and MIT, *Predicting Personal Mobility with Individual and Group Travel Histories*, concluded that fine-grained, extensive data from mobile phone networks "is providing us with a more comprehensive view of activity and mobility at the urban scale than travel diaries can possibly do on their own. It also enables us to shed light on hitherto invisible intra-personal variation in travel activity."

Mobile phone trace data provides researchers new opportunities to examine individual mobility from an alternative perspective.

License Plate and Vehicle Intercept Surveys

By using high-speed cameras or Automated License Plate Readers (ALPRs), license plate surveys attempt to recognize license plate numbers and then compare those numbers to state motor vehicle registration databases to identify the vehicles. Some jurisdictions mail brief surveys to in-state drivers once vehicle owners have been identified.

To ensure accuracy, license plate captures must be manually processed. However, according to a recent study by the American Association of Motor Vehicle Administrators (AAMVA), 20% of license plates are misread by ALPRs due to visibility problems and the lack of uniform design standards among states.

Vehicle intercept surveys are typically conducted by questioning drivers when their vehicles are stopped. Surveys take place at locations such as rest areas and service stations, at commercial weigh stations, or at mandatory stops (where troopers or officers pull drivers over). Surveyors normally use a short survey to discover the origin, destination and purpose of a trip, as well as to capture demographic information.

Household Travel Surveys

Highly valued for the amount of behavioral data generated, household travel surveys involve sending surveys, often including logbooks or similar manual diaries, to carefully selected households. Participants are typically asked to log the day, time, duration, mode and purpose of every trip for a few days. Households are also asked to supply socio-economic and demographic information, such as household size, structure and income. Household travel surveys can also be conducted by telephone or submitted online. The data is then manually processed for analysis. Because of the cost, time and resources needed to complete a major household travel survey in a metropolitan area, most jurisdictions only undertake major surveys once per decade.

THE PROS AND CONS OF EACH TECHNOLOGY

Each technology has advantages and disadvantages when it comes to speed, accuracy, cost, depth of data, and other critical factors. In a nutshell, here are the pros and cons of each.

Bluetooth: Pros and Cons

Because Bluetooth sensors capture Bluetooth data automatically, personnel needs are limited: install, maintain and remove the equipment. Data is available quickly, and costs are lower than household, vehicle intercept and license plate surveys.

However, the scope of a Bluetooth survey is constrained by the required equipment, making this method of data capture more suitable for smaller studies. In addition, as highlighted by the Ohio-Kentucky-Indiana Regional Council of Governments, the technology faces a significant challenge: Bluetooth devices only emit a Bluetooth signal when placed in "discoverable" mode. Because Bluetooth drains batteries faster, a percentage of users turn off Bluetooth, lowering the number of vehicles that can be monitored with this technology.

License Plate Surveys: Pros and Cons

Like Bluetooth, license plate surveys can capture a large amount of data, but personnel must go beyond installing, maintaining and removing equipment. As noted previously, additional personnel are required to review data manually to ensure accurate capture of license plate information.

In *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation*, the United States Department of Transportation - Federal Highway Administration pointed out other drawbacks of license plate surveys.

These shortcomings include the following:

- The primary limitation is that these surveys provide information about the performance at a single location, and that location may not accurately represent the performance of the rest of the roadway segment being studied.
- In addition, video detection from beside the roadway can suffer from "occlusion," which degrades the accuracy of traffic volume counts. Cameras placed above roadways generally have fewer problems with occlusion, but because of safety rules, they often require lane closures during installation and repair or maintenance.

According to the Texas Department of Transportation in *Evaluation of External Station Survey Methodologies for High Volume Locations*, performing follow-up surveys poses additional issues:

- Only 9-17% of surveys are returned, which may not represent an accurate demographic profile of the region being studied.
- When capturing rear license plates (19 states do not require front license plates), the license plate on commercial traffic—such as tractor-trailers—is tied to the trailer (which is often leased from out of state), not the cab. In one study, 28% of all traffic fell into this category.

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Vehicle Intercept Surveys: Pros and Cons

According to a study by traffic consultants Fehr & Peers, vehicle intercept surveys can provide a wide range of data, such as the number of vehicles that travel through a region, their origins and destinations, the purposes of their trips, and some demographic data.

The cons, according to the firm, include:

- The time and expense to complete a survey project,
- The potential for underreporting and survey bias due to reliance on the survey taker to accurately record vehicle trip information, and
- The difficulty of implementing a survey of sufficient size to be statistically valid.

The experiences of the Ohio Department of Transportation highlight the resources required for vehicle intercept surveys. A three-year origin-destination survey at 700 locations by the agency cost $7 million. Prior to this survey period, the department had a staff of several hundred people conduct hundreds of travel studies each year. The agency is currently conducting a cellular origin-destination study to determine whether cellular data can replace vehicle intercept surveys and license plate surveys.

In addition, some states have outlawed vehicle intercept surveys because of safety concerns.

Household Travel Surveys: Pros and Cons

Household travel surveys provide detailed trip information, such as trip generation rates, trip purpose, occupancy, origin-destination, and class of vehicle. Valuable demographic and behavioral data can also be collected.

At the same time, household travel surveys also have significant limitations:

- There is an extreme potential for underreporting of trips and survey bias due to reliance on survey taker for all trip information.
- Surveys do not isolate intra- and interregional travel or target visitors within the region.
- The process is very labor intensive.
- The time to design, implement and complete a survey can be six to 12 months.
- The survey data is typically collected over a small number of days and may be limited in its ability to incorporate seasonality effects or to capture infrequent trips, such as medical appointments, long-distance shopping trips, or airport trips.
- GPS-based household surveys often rely on data inferences to derive trip purposes.
- Development and implementation of a survey sample size large enough to be statistically valid can be costly.

To illustrate the costs of household travel surveys, a recent household travel survey conducted by the Atlanta Regional Commission cost $2 million, which was an average of $200 per completed survey. A household travel survey by the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization required a similar budget: surveying 1,200 households cost $250,000, or $208 per completed survey. And a massive household survey currently underway in California has generated 42,348 completed surveys from a population of 38 million at a cost of $10,016,443, or $236 per completed survey.

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Cellular Data: Pros and Cons

Because cellular technology captures signals from all mobile devices in real-time, the scope of population movement insights can be unlimited, and results are available quickly—typically within weeks. Sample sizes are virtually unlimited, and no equipment is needed. In addition, cellular technology captures both resident and visitor population movement.

Cell phones are virtually universal. According to CTIA-The Wireless Association®, more than 91% of people in the United States own a cell phone.

Cellular surveys have several other benefits:

- Data is provided in a format more suitable for comparison and easy integration with travel demand models.
- Data is available for all devices in use. Unlike Bluetooth, users do not have to have their devices in a particular mode for location information to be collected.
- Data can be queried, aggregated and disaggregated to match desired level of analysis.
- Data collection does not require setup time or human transcription of observed field data, which reduces errors.
- Costs are relatively low: a recent study by the town of Sierra Vista, Arizona, measured travel across 80 districts, covering 16,000 square miles for 12 weekdays, and collected data on more than six million trips for $10,000.

Cellular surveys can be used in conjunction with household travel surveys to extend and validate the collected data.

One other key benefit is that cellular surveys can be used in conjunction with household travel surveys to extend and validate the data collected from households. Sierra Vista, for example, wanted to supplement household survey data to capture commuting patterns outside of Sierra Vista so that they would have a bigger picture of the data and be able to validate their travel survey data. Typically, capturing regional data between Tucson and Sierra Vista would require an expensive long-distance travel survey.

Cellular data has its own shortcomings:

- Although cellular data does inherently detect unique devices, it cannot always distinguish a user's mode of travel. For example, an iPad user in a cab stuck in heavy traffic and an adjacent walker moving at the same speed while using a cell phone would appear alike. Also, cellular technology cannot distinguish between type of vehicle (*e.g.*, car, light truck or heavy truck).
- Cellular data does not provide the rich demographic information available from household travel surveys.

TRANSPORTATION STUDY TECHNOLOGIES: COMPARISON CHART

Technology	Typical Costs	Time to Results	Accuracy/Coverage	Ease of Method
Household Travel Surveys	$100,000-$1+ million	Months to a year or more	Accuracy depends on survey respondents, in-depth data available, limited coverage area	**Difficult:** time consuming and expensive
Vehicle Intercept Surveys	$5,000/site*	Months	Accuracy depends on survey respondents, in-depth data available, limited coverage area	**Difficult:** time consuming and expensive
License Plate Surveys	$48,000/mile**	Months	Fairly accurate, coverage area limited by cost	**Difficult:** time consuming and expensive
Bluetooth	$20,000/mile**	Weeks	Accuracy depends on number of Bluetooth devices in discoverable mode, coverage area limited by cost	**Medium:** timely, equipment and installation required
Cellular Data	$10,000+	Weeks	High accuracy, largest sample size and coverage available	**Easy:** timely, no equipment needed

** Estimate based on a 24-hour survey, although costs are variable*

*** Cambridge Systematics*

Cellular data offers high accuracy, as well as the largest sample size and coverage available.

CONCLUSION

Household travel surveys, because of the rich data they provide, are still an extremely valuable travel survey tool. Because of associated limitations, however, the most comprehensive study strategy pairs a household survey with a cellular survey to give a more complete and far-ranging picture. In addition, frequent cellular data updates provide more current information. The result is rich demographic and trip purpose data, along with updated, in-depth traffic volume and origin-destination information. Cellular data is also well suited to building activity-based models that can be used to predict future travel, an integral component of emissions, air quality and other studies.

With increasing budget pressures and the need to have information available for analysis as quickly as possible, cellular surveys offer the best combination of trade-offs, including cost savings, geographic coverage, and speed of data collection. This new method of data collection also provides an affordable and effective alternative for areas that do not have the resources for household travel surveys. With the ability to deliver billions of data points per day, an amount that far exceeds what other methods can provide, cellular data represents an emerging technology that holds great promise for the future of traffic modeling and research.

The most comprehensive study strategy pairs a household survey with a cellular survey.

About AirSage

AirSage™—a pioneer in population analytics—is the largest provider of consumer locations and population movement intelligence in the United States. Each day, AirSage uses patented technology to capture and analyze more than 15 billion anonymous, real-time, cellular-signal data points to identify travel patterns and transportation trends.

Partnerships with the nation's largest wireless carriers give AirSage exclusive access to data from more than 100 million mobile devices. Analyzed and aggregated, AirSage data provides actionable insights into where and when people travel and is transforming the transportation industry, commercial enterprises and a diverse range of industries.

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