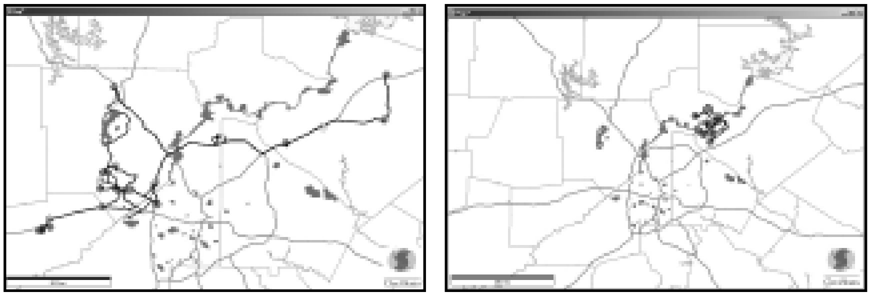
Spring 2004

TMIP Connection

The Travel Model Improvement Program Newsletter



These graphics show a week-long activity trace for two GPS study participants. The black lines represent GPS points collected during travel for each participant, with the circles representing trip ends of different durations. Note the difference in the activity spaces.

GPS Applications in Transportation Planning and Modeling

By Elaine Murakami, with assistance from Steve Taylor, Jean Wolf, Howard Slavin, and Bob Winick

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these satellites as reference points to calculate positions accurate to a matter of meters. In a sense, it's like giving every square meter on the planet a unique address.

Technological advances have now made formerly briefcase-sized GPS receivers available in the size of a postage stamp. In addition, due to the increasing use of GPS for vehicle navigation systems, and the incorporation of GPS into mobile telephone handsets to meet the FCC's E911 Phase II requirements, GPS technology costs are significantly reduced.

Now that GIS is an accepted component in transportation planning, it's important that we take the next step to integrate GPS into our travel demand forecasting processes. There are many opportunities for using GPS to improve your travel demand forecasting process in all four steps of the traditional 4-step model, and very likely, there are similar opportunities for applying GPS data in microsimulation. GPS measurements can be applied for improving network geography and geometry, capturing network speeds, and measuring the time spent in travel and other activities.

TRIP GENERATION

Travel behavior is far more complex than what can be accommodated by traditional data collection methods. The burden of keeping traditional diaries has resulted in declining response rates and respondents' omission of trips (item non-response). GPS can record the time and location of stationary activities and all movements that are made by a person or a vehicle for a day, a week, or even a year—with virtually no respondent burden. Thus GPS measurements are likely to greatly facilitate tour-based models and activity models.

Within the past three years, GPS-enhanced household travel surveys have been conducted in California (statewide survey), Southern California (SCAG), Ohio (statewide), Pittsburgh, Laredo, St. Louis, and Tyler / Longview (Texas). According to a paper presented by Johanna Zmud, however, in the California statewide study correlates for underreporting were identified. The variables trip duration, vehicle ownership, household income, and age of respondent were found to contribute significantly to trip underreporting. Using these results, weekday trip rate correction factors (or weights) were generated for the entire statewide sample based on values of the four significant variables.

Jean Wolf's research on the California statewide study has shown that the unreported trips are a combination of

- short stops made in a chain, e.g. stopping to pick up milk or dry-cleaning on the way home,
- complete round trips that would typically be reported as 2 one-way trips, and
- longer duration stops which were not part of a trip chain and were not 'on-the-way' from one destination to the next.

Analysis of the California GPS data by Zmud indicates that 71 % of the unreported trips captured by GPS were less than 10 minutes in duration. When all GPS-recorded trips are examined, the average trip length is significantly less than when only self-reported trips are counted. So if trip rates are adjusted upward to reflect the missed trips, friction factors used in trip distribution methods may need to be adjusted to account for this difference.

MODE SPLIT

GPS applications that can benefit the mode split step are beginning to show promise. There have been several efforts to use GPS to capture trips of all modes for household or personal travel surveys. For instance, a Dutch project headed by Geert Draijer for person-based GPS tracking and conducted in 1997, used equipment that weighed two kg. More recent work in Atlanta, as part of the SMARTRAQ project,

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U.S. Department of Transportation
Federal Highway Administration

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From the TMIP Review Panel

GPS Technology Improves Travel Time Data Collection

Tom Kane

Here at the Des Moines Area MPO, we recently enjoyed a boost in productivity in our most recent travel time survey thanks to the purchase of two sets of GPS data collection equipment. In previous surveys, we borrowed a GPS device from FHWA

Having two sets of specialized equipment gave our MPO several advantages over surveys taken in previous years. Most notably, my staff was able to survey twice as many routes in the same amount of time. The equipment improved our productivity by allowing us to cover more territory with the same number of people.

Our MPO purchased the hardware and specialized software from GeoStats[1]. The GeoStats equipment consists of a data storage unit (called a Data Logger), a GPS receiver/antenna, and a cord that connects the Data Logger to the receiver. GeoStats provided the "Download Utility" software

Download Utility allows us to import the collected data into a PC and to convert the data to a text format. The downloaded data, now text files, are input to ESRI's[2] ArcView GIS software. Once linked to the ArcView software, my MPO staff maps the travel time survey results and identifies control points (major cross streets along the selected travel time survey route). Then we use ArcView to create speed profile maps and maps comparing travel time results from previous years with the latest travel time data.

MPO Transportation Planner Kevin Gilchrist likes GPS technology, specifically its reliability and ease of use. Kevin says that because the GPS equipment was specifically designed for travel time data, there are fewer options that our employees have to set to make the equipment work. He also mentioned that with the old equipment, we could only get three or four satellites to plot our location and with this one, we are quite often getting nine or ten. ■

For more information, contact Tom Kane at tjkane@dmampo.org

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[1] GeoStats, 530 Means Street, NW Suite 310, Atlanta, Georgia 30318

[2] Environmental Systems Research Group (ESRI), 380 New York Street, Redlands, CA 92373-2853

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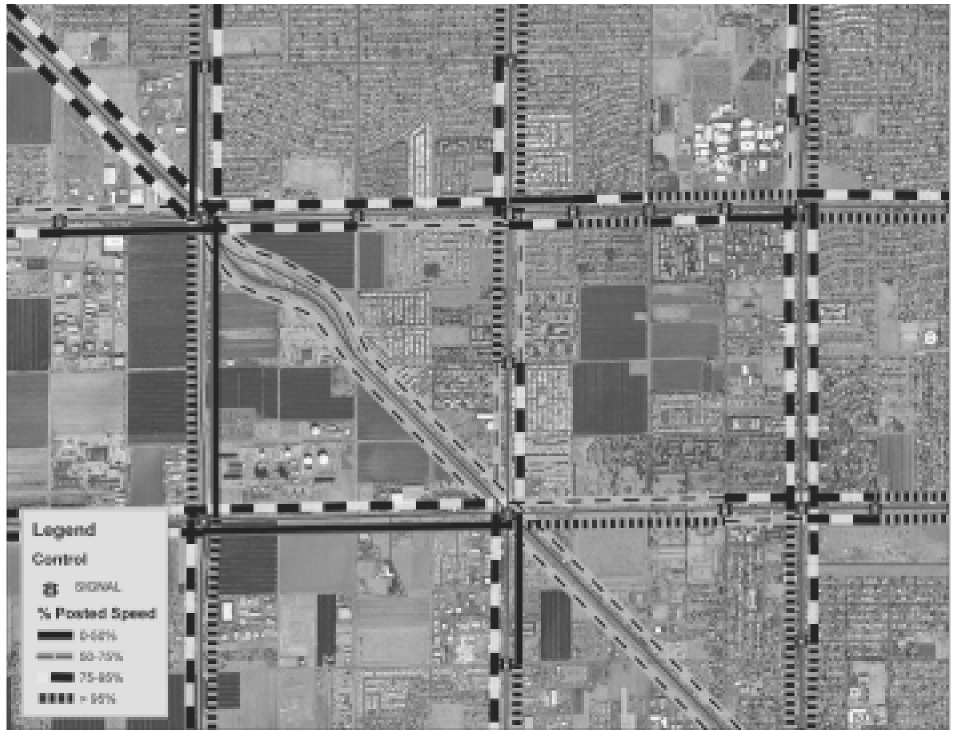

After applying the GPS point data to the LRS, the system then knows, based on the linear distance along the route, what the posted speed is within that area. You can then calcuate the reduction in speed (% of posted speed).

used a Palm Pilot PDA and a GPS weighing less than one kg. In 2002, a pilot study by Steer Davies Gleaves and GeoStats using wearable GPS data loggers for travel survey data collection was conducted as a follow-up to the London Area Travel Survey. In this study, participants were provided with a small wearable logger (also less than one kg) to carry with them for three days. Each participant recorded trips for the first two days and then reported their trips for the third day in a recall interview conducted on day four. This study proved to be a good test of the ability to capture and accurately recognize walk, bus, and train trips because Londoners, unlike most Americans, had many multi-modal trips. Findings of the study indicate that there is great potential for multi-modal activity capture using GPS technologies.

One opportunity for using GPS might be to get better information about walk trips. We often hear that people cannot walk due to lack of sidewalks and difficulty crossing busy streets without signals and crosswalks. We also hear, anecdotally, that many pedestrians fail to use crosswalks, resulting in accidents. As unit weight and cost continues to decline, capturing walk trips with differentially-corrected GPS, combined with satellite imagery (or aerial photography) for analysis of these trips, might be possible. The satellite imagery might be sufficient to determine presence or absence of sidewalks, crosswalks, and traffic signals.

TRIP DISTRIBUTION

Perhaps the best thing about GPS is that it captures location very well. If you have ever conducted a household travel survey, you know that asking respondents to report their destination addresses is the most difficult task. But this benefit to GPS comes with a cost! GPS data collection can result in so much more information than we have had historically, including route choice and speeds along links in the selected route with second-by-second accuracy. This incredible amount of data means that we need to have more data storage, and more computing capacity and user-friendly routines for analysis.

GPS data can be especially valuable in examining trip destinations relative to location of home and work. GPS data collected over a week or a month would be invaluable in capturing space-time prisms, especially when combined with analysis of "mandatory" vs. "discretionary" activities.

MODEL CALIBRATION

Travel demand models require information on roadway speeds for calibration and validation of base year models. Unfortunately, in many areas, speeds are never measured, leading to gross errors in modeling. GPS measurements in conjunction with traffic counts can be very useful in selecting among alternative volume-delay functions and in calibrating their parameters. For specific functional classes like major arterials, collection of speed information for specific facilities can greatly enhance the validity of a travel demand model.

At the 1999 conference, "Application of Transportation Planning Methods," Charles Baber of the Baltimore Metro Council (BMC), discussed GPS runs on limited number of corridors, with a limited number of miles. The audience was excited because labor costs could be reduced by

Atlanta's Comprehensive Travel Data Collection Effort

By Randall Guensler, *Georgia Institute of Technology*

GPS supplemented data provides a wealth of information for use in congestion monitoring and mitigation evaluation, travel demand modeling, traffic simulation, signal timing optimization, roadway and vehicle safety analysis, roadway design improvement, economic analysis, intelligent transportation system strategy evaluation, transit performance assessment, parking policy analysis, and even air quality impact assessment.

The Georgia Institute of Technology, School of Civil and Environmental Engineering is currently conducting the Commute Atlanta Study. Sponsored by the FHWA, Georgia DOT, and Georgia Tech, this study is currently collecting second-by-second travel data to provide better information on where, when, and under what conditions people drive in Atlanta.

More than 270 representative Atlanta households have been recruited to participate in this study. These volunteer households have allowed the research team to install a GT Trip Data Collector in their vehicles. There are currently 487 instrumented vehicles included in the study. Researchers remotely monitor the travel patterns of these vehicles, uploading vehicle speed, position, and engine operating data via a cell phone data connection. In the last six months, more than 350,000 vehicle-trips have been monitored, providing more than 76,000 vehicle-hours of onroad travel data. More than 2 million vehicle-seconds of data are collected every day.

Households were selected for participation through a random-stratified sampling process. The research team first established income, household size, and vehicle ownership groupings that reflect the distribution of households in the Atlanta region. Researchers were pleasantly surprised by the number of households that agreed to participate in the study, even though instrumentation had to be installed in their vehicles. Many participants have stated that they believe that such studies are very important and that they are glad that they can provide information that will help transportation planners make improvements to our congested system. Recruitment and retention in the upper income strata were much higher than originally expected.

Instrumented vehicle data are supplemented with travel diary survey data to better understand the types of trips made by these households (work, shopping, recreation, etc.). Approximately 50% of these households to date have participated in a two-day diary of their travel, recording the times and places visited and the activities undertaken. Travel diary data are retrieved through a computer-assisted telephone interview. General travel data, such as number of trips per household per day and selected travel routes, are used to evaluate transportation demand models currently used in Atlanta's transportation planning process. Analyses are currently underway to compare diary-reported trips against vehicle-reported trips and also to compare the vehicle activity for those households that completed their diaries against those households that elected not to complete their diaries.

The instrumented vehicle data provide planners with much needed information on the operational characteristics of our freeways and major arterials. Vehicle position and speed data are used to identify locations of recurrent traffic congestion. Nationwide congestion surveys typically rank Atlanta in the top 10 cities, with around 70 hours/person/year lost in congestion. The ongoing effort in Atlanta can help to prioritize system improvements to obtain the biggest congestion reductions, at the least cost, and as quickly as possible. Researchers have already identified specific areas where congestion might be mitigated through improved signal timing or other operational changes.

The onboard instrumentation and data transmission protocols employed in the Commute Atlanta study were developed by a partnership between Georgia Tech and the private sector. The instrumentation and software were designed to Georgia Tech specifications and provide a very robust data collection solution. The onboard equipment tracks second-by-second vehicle position, speed, acceleration, and up to ten engine and emissions-related parameters. Six additional data lines can allow researchers to collect information from on-off sensors (e.g. seatbelt use or windshield wiper status) and could be used to turn on or off additional onboard devices. Data are transmitted via a cellular connection, which opens the doors to a wide array of supplemental services. A communications port enables the onboard equipment to send and receive data to and from almost any additional computing or scientific device carried onboard the vehicle. To date, the researchers have demonstrated this capability by collecting and integrating data from a SEMTECH-D (by Sensors, Inc.) onboard emissions measurement system and have connected the equipment to monitor the engine computers on a MARTA bus. The researchers are developing a number of additional services likely to reach the commercial market this year.

The onboard instruments provide high-resolution travel data. The data are so accurate that if a participant's vehicle were stolen, the research could locate the vehicle using the equipment. Data can be transmitted in real time for use in a variety of intelligent transportation system (ITS) efforts. With enough instrumented vehicles on the roadway, travel time and route guidance information could be provided to participating vehicles through an in-vehicle interface. The units send and receive text e-mail messages and transmit large blocks of data via the cell phone connection.

The Commute Atlanta study is the largest instrumented vehicle travel behavior study ever conducted. Parallel data from instrumented vehicles, household travel diaries, surveys of regional employers, and detailed information on transportation costs and system performance provide the most detailed data set ever compiled for use in examining travel behavior. The first phase of the study alone will collect detailed information on more than one million trips. ■

For more information about Commute Atlanta call 404-385-2376 or email: commuteatlanta@ce.gatech.edu

half, since only one person was needed in the vehicle, compared to previous methods requiring a driver and a recorder with a stop-watch. Subsequent to BMC's early work with GPS, they now have retained Motion Maps to develop a GIS for organizing and analyzing the results of their extensive GPS travel speed data collection program. The results are included in their Congestion Management System report (www.baltometro.org/pdfs/GPS2003.pdf).

Mark Schlappi, for the Maricopa Association of Governments (MAG), initiated a major GPS and digital video project with Carter & Burgess, Inc. The first step in the project was to use the GPS equipment to build a linear reference file (LRS). The project included 1,800 centerline miles of arterial, freeway, and HOV lanes, covering AM, PM, and midday periods. Each vehicle was equipped with a differentially correctable GPS unit tied to a PDA with a custom program that could collect 1-second positional data-points. This effort produced a database of over 23 million data points, covering 75,000 miles of travel. In addition to travel speed data and digital video along the routes, many features such as traffic signals, stop signs, speed limits, school zones, jurisdictional boundaries, current construction activities, area type, functional classification were geocoded and integrated into the database. ■

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To subscribe to this free newsletter send an e-mail to TMIP@tamu.edu or contact Gary Thomas at (ph.) 979-458-3263, (fax) 979-845-6001, (mail) Gilchrist, Room 112, Texas Transportation Institute, Texas A&M University System, 3135 TAMU, College Station, TX 77843-3135

FHWA Evaluates GPS' Usefulness

By Douglas Laird, *Federal Highway Administration*

In the 1990's the FHWA began to evaluate the usefulness of GPS data in understanding travel activities and system performance. Efforts were primarily aimed at establishing the reliability and cost-effectiveness of gathering and processing GPS data.

Funding was recently obtained to complete the initial research efforts and provide a broader generic application framework. The goal is to make GPS data processing and GPS data queries a simple, user-friendly process. The following objectives apply to the research effort:

- develop an integrated data collection and data processing tool to collect GPS-based location and speed data and match that data to a GIS transportation network,
- provide ways of manipulating and displaying GPS data within GIS software packages,
- combine GPS data into performance statistics on a GIS-based transportation network,
- provide an easy-to-use interface to perform basic data processing tasks, and
- maintain the capability for more advanced data queries and data manipulation tasks.

To achieve the above objectives, FHWA will employ raw GPS data collection, data review, and integration into GIS; data smoothing, map matching, and analysis and generation of performance information.

FHWA developed one process for data collection and another for data manipulation.

The data collection software runs on handheld PCs. GPS data are collected on a second-by second basis and include location (latitude and longitude), time, and calculates travel speed and bearing (travel direction). An option is included for users to insert their own flags or codes to denote markers, events, or other factors. The software is designed to work with an array of GPS receiver protocols and tags individual records with other information (user name, trip number, and start time) for database management.

Data manipulation begins once the raw data have been gathered. The data can be read from the GPS records collected with the FHWA-based software or from other applications. The software is flexible enough to be adapted to a variety of other possible data sources. It provides menus to map data fields from other sources to identify location, speed and bearing data fields in the data record. Raw data can be exported to a shapefile for review.

GPS works on a line of sight between the receiver and the GPS satellites. GPS data are lost if the line of sight to satellites is obstructed (by tunnels, bridges, or dense tree cover) or become unreliable if other signal degradations (perhaps from multipathing in a downtown environment of tall buildings) occur. As a result, there are usually some holes in the user-collected data. The software smooths the data by interpolating between known data points and filling in the gaps. Smoothing attempts to account for acceleration, speed changes, bearing changes, and distances between the points. Smoothing parameters can be modified by the user to reflect local conditions.

The smoothed data are then matched to a base network, the crucial step in the process. A good basemap is critical to ensuring success with the match. The matching model uses such factors as changes in bearing, speed, distance, and street names to complete the match. The user can also modify the matching model parameters.

Matched data can then be queried to provide information on the quality of certain trips or on the quality of service provided by the transportation network. Some of the data automatically calculated include average speed, standard deviation, minimum and maximum speed, and the percent of time stopped. Summary data are available at a link level or can be summarized into link segments, facility types, or areas. Users can also define and save their own queries.

Results of the research are being implemented within commercially available and industry standard software development tools so that the public domain source code can be made available and utilized by others to build on the method's core functionality. Research products should be available in 2005. ■

For more information, contact Doug Laird at 202/366-5972 or e-mail at douglas.laird@fhwa.dot.gov

Upcoming Events

Conferences

NARC Annual Conference
Jun 25-29, 2004 - Chicago, IL
http://www.narc.org

North American Travel Monitoring Exhibition & Conference
Jun 27-30, 2004 - San Diego, CA
http://gulliver.trb.org/conferences/NATMEC/

Courses

Introduction to Urban Travel Demand Forecasting
May 3-7, 2004 - Sacramento, CA
Jul 19-23, 2004 - Atlanta, GA
Summer, 2004 (Dates TBA) - Memphis, TN
Contact: Penelope Weinberger
Phone: 202-366-4054 Cost: $530

Estimating Regional Mobile Source Emissions
Summer, 2004 (Dates TBA) - Knoxville, TN
Contact: Penelope Weinberger
Phone: 202-366-4054 Cost: $460

Seminars

Activity and Tour Based Forecasting Seminar
May 25, 2004 - St. Paul, MN
Aug 4, 2004 - Washington, DC
Contact: Penelope Weinberger
Phone: 202-366-4054
Cost: Free. Maximum of 30 participants.

Model Validation, Calibration and Reasonableness Checking Seminar
May 26, 2004 - St. Paul, MN
Aug 3, 2004 - Washington, DC
Contact: Penelope Weinberger
Phone: 202-366-4054
Cost: Free. Maximum of 30 participants.

Forecasting Land Use Activities Seminar
May 27, 2004 - St. Paul, MN
Aug 5, 2004 - Washington, DC
Contact: Penelope Weinberger
Phone: 202-366-4054
Cost: Free. Maximum of 30 participants.

Additional offerings may become available; consult the TMIP website http://tmip.fhwa.dot.gov/ for the latest training information.

FHWA-HEP-04-018

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