The Use of Electronic Travel Diaries and Vehicle Instrumentation Packages in the Year 2000 Atlanta Regional Household Travel Survey: Test Results, Package Configurations, and Deployment Plans

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1. INTRODUCTION

The Georgia Institute of Technology (Georgia Tech) has developed three instrumentation packages that will automate the capture of personal travel data for various sub-samples in the Year 2000 Atlanta Metropolitan Regional Travel Survey. These three packages include: 1) a passive in-vehicle GPS system, which has a GPS receiver, antenna and data logger to capture vehicle trips only; 2) a handheld electronic travel diary (ETD) with GPS capabilities to capture trip information for all modes of travel; and 3) a comprehensive electronic travel monitoring system (CETMS), which includes an ETD, a rugged laptop computer, a GPS receiver and antenna, and an onboard engine monitoring system, to capture all trip and vehicle performance information. All three systems have been designed to capture data for survey durations of three to four days.

The Year 2000 Atlanta Metropolitan Regional Travel Survey is a component of Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality (SMARTRAQ). This major research endeavor will collect and analyze sufficient data to develop an enhanced suite of travel demand models capable of addressing the land use, travel behavior, and air quality issues critical to the Atlanta metropolitan region. To support these data needs, a regional household travel survey will be administered to 8000 randomly selected households stratified by household income, land-use type and household size. In addition, automated data capture was identified as the primary method for gaining significantly greater detail and insight into the relationships between land-use, emissions, and travel behavior within the region. Three specific survey efforts were identified as needing automation support: the General Purpose Survey, the Physical Activity Study, and the Summer Ozone Study.

The General Purpose Survey will use the passive in-vehicle GPS system for a subset of the respondents employing traditional travel survey data collection methods. The GPS data will be used to compare actual versus reported trip data, allowing for the development of correction factors for trip under-reporting and mis-reporting, as well as providing detailed insight on trip making and trip chaining behaviors within the region. The Physical Activity Study entails an add-on survey for a subset of the General Purpose Survey participants and will use the electronic travel diary with GPS to more accurately capture all traditional travel survey elements (traveler and companion identities, trip purpose, modes, origin location, start time, destination location, finish time, and travel distance) as well as additional information on travel routes and speeds. These data will support the primary objective of the Physical Activity Study, which is to examine factors affecting the level of physical exercise that travelers obtain as a function of their trip-making patterns.

The third system, the CETMS, will support the Summer Ozone Study. It includes the ETD as described above and a comprehensive in-vehicle data collection system with both GPS technology and an engine-monitoring device. In addition to collecting all traditional travel data elements, as well as exact travel routes and second-by-second vehicle positions, the CETMS will also collect second-by-second vehicle and engine operating conditions from the vehicle's onboard engine computer monitor. Engine and vehicle data available for capture include such variables as speed, acceleration, engine rpm, manifold absolute pressure, throttle position, catalyst temperature, gear selection, air/fuel ratios, and engine coolant temperature.

This system will enable modelers, for the first time, to examine how network driving patterns (via speed and acceleration profiles and engine operation data) leads to increased emissions.

Implementation of the first two systems will coincide with the General Purpose Survey and Physical Activity Study, which will commence in the fall of 2000 and continue through the spring of 2001. Although funding for the Summer Ozone Study is not guaranteed at this time, plans for CETMS deployment include the spring and summer of 2001. Preliminary estimates on sample sizes for the instrumentation studies are 400 to 675 households with the passive in-vehicle GPS system, 510 respondents with the ETD and GPS device, and 160 vehicles with the CETMS.

The samples selected for the instrumentation packages will be controlled for the survey stratification variables, including household income, household size, and land use type, so that a direct comparison can be made of survey results between automated data collection methods and traditional manual methods. Key elements for evaluation include the number of trips made (reported and unreported), trip start and finish times, trip origins and destinations, trip lengths, and travel routes. GPS-captured route choice may also be used to probe for missing trip data and follow-up interviews may be conducted to explore real-world route choice decision-making processes.

Since this conference is scheduled immediately prior to the start of the Atlanta survey (September 2000), this paper will focus on the test results and configurations of the three packages, along with the deployment / implementation plans. It should be noted that the April version of this paper does not contain complete details for each section; however, the final version presented at the conference will include all plans and results to date.

2. BACKGROUND: SMARTRAQ AND INSTRUMENTATION

The primary objective of SMARTRAQ is to provide a framework for assessing which combinations of land use and transportation investment policies have the greatest potential to reduce the level of auto dependence while promoting the economic and environmental health of the Atlanta Metropolitan Region. To support this objective, research goals have been defined to collect and analyze sufficient data to develop an enhanced suite of travel demand models capable of addressing the land use, travel behavior, and air quality issues critical to the Atlanta metropolitan region. These future models will be used in regional transportation and air quality planning activities and, as such, must be capable of answering important policy questions related to transportation investment decisions. This project is supported through a partnership between transportation interests including the Federal Highway Administration (FHWA), the Atlanta Regional Commission (ARC), and the Georgia Department of Transportation (GDOT); environmental interests including Environmental Protection Agency (EPA), the Turner Foundation, and the Georgia Conservancy; public health interests including the Center for Disease Control (CDC); and land / economic development interests such as the Urban Land Institute and the Atlanta Chamber of Commerce.

Georgia Tech was contracted to develop comprehensive survey instruments, sampling plans, and the approach for the Atlanta 2000 Travel Survey. Georgia Tech will also oversee the recruitment and completion of the survey by the selected consultant. The travel survey will be administered to 8000 randomly selected households stratified by household income, land-use type and household size. This survey will be quite unique in its ability to attain a wide variety of information including physical activity levels, air quality, housing choice, and mobility constraints due to the many funding partnerships.

The SMARTRAQ sampling framework consists of a General Purpose Survey and four sub-surveys (see Figure 1). Each major study employs a stratified sampling plan designed to ensure that representative household populations (household size, income, etc.) and representative household land use configurations are selected for participation. As a result, the studies should provide insight into how land use as well as traditional household demographic and socioeconomic data influence trip-making patterns, mode choice, vehicle emissions, and air quality. To provide the detailed information necessary to gain insight into the relationships between land-use, emissions, and travel behavior, the General Purpose Survey, the Physical Activity sub-survey and the Summer Ozone sub-survey (identified in bold in Figure 1) will involve the deployment of specialized data collection instruments.

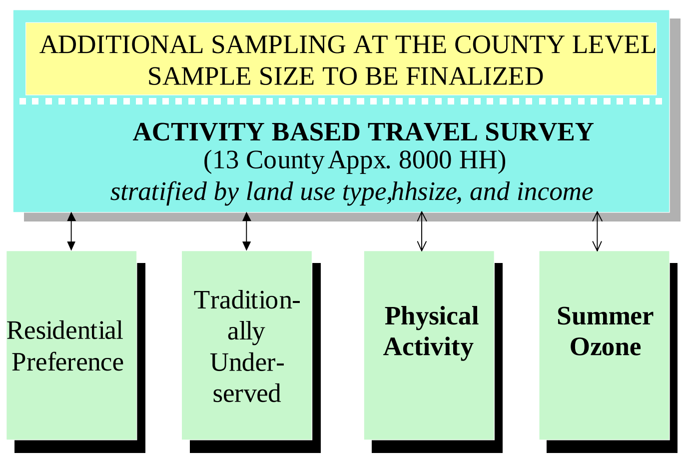

Figure 1: SMARTRAQ Sampling Framework

The objectives of these three surveys are:

- The General Purpose Survey will collect activity-oriented travel data using state-of-the practice activity-based travel diaries and computer-assisted telephone interview (CATI) retrieval methods. The activity diary data will be used to develop the region’s travel demand models and to provide general understanding of the relationships between travel behavior, land use, and emissions.
- The Physical Activity Study is designed to examine the factors that affect the level of physical exercise that travelers obtain as a function of their trip-making patterns.
- The Summer Ozone Study provides insight into the effectiveness of current and future transportation control measure strategies (such as parking pricing and employer based trip reduction strategies) as well as provide insight into driver-vehicle interactions which impact vehicle emissions. This study will result in data that will help improve air quality models.

The instrumentation packages developed for the Atlanta studies are the means to answer specific research questions. That is, the equipment will provide improved or supplemental data to traditional data streams. Hence, different packages have been developed to address the functional and informational requirements of each study. For example, in the General Purpose Survey, trip activity type, trip start and end times, origin and destination land use locations and types, mode choice, and other relevant data needed to build state-of-the-practice travel demand models will be collected. The passive in-vehicle GPS system will support this survey effort by: 1) providing a means to confirm trip occurrence, travel times and distances, and trip origin and destination locations so that under-reporting of trips and accuracy of diary-reported data can be assessed for the light-duty vehicle mode; and 2) capturing actual route choice and travel speeds, travel elements typically considered infeasible to capture through manual methods, so that route choice algorithms can be evaluated and traffic levels / transportation system performance can be assessed.

Because the main goal of the Physical Activity Study is to examine factors that affect the level of physical exercise that travelers obtain as a function of their trip-making patterns, a significant number of households that use alternative travel modes will be sampled. The team will administer an add-on physical activity questionnaire in a subset of households located in each land use pattern (upon which the larger activity-based survey is stratified). This add-on survey will be designed to capture the level of health and activity of the household members. The target sample size for the add-on questionnaire within each land use pattern will be between 2000-2500 households or 400-500 households per land use pattern. Collecting accurate information on the mode characteristics that influence mode selection and physical activity calls for an enhanced travel diary instrument. The goals of the activity survey instrumentation activities are: 1) to provide an electronic travel diary instrument that is capable of collecting more detailed activity and trip stage data across all modes of travel than are typically collected in standard computer-assisted recall methods; 2) to provide a system capable of confirming trip occurrence, travel times and distances, and trip origin and destination locations so that under-reporting of trips and accuracy of diary-reported data can be assessed for all vehicle modes (i.e. portability is required); and 3) to provide information on the level of individual physical activity (i.e. the amount of exercise achieved). In addition, the uncorrected GPS data collected should be accurate enough to recover most travel routes, especially in areas with low-density street networks.

Finally, the proposed Summer Ozone Study involves a follow-up survey with a subset of the General Purpose Survey to collect more detailed information on the changes in travel patterns between the fall / spring seasons and the summer. Follow-up surveys of households and employers are planned to determine what demand management strategies (parking pricing, transit incentives, etc.) are implemented at the workplace. Because this survey will collect travel activity patterns during the peak ozone season, researchers will be able to better predict how the implementation of transportation control measures can affect motor vehicle emissions and ozone formation. This component is tentatively scheduled for the summer of 2001. The goals of the summer ozone survey instrumentation activities are: 1) to provide a system capable of confirming trip occurrence, travel times and distances, and trip origin and destination locations so that under-reporting of trips and accuracy of diary-reported data can be assessed for the light-duty vehicle mode; and 2) to capture actual route choice and travel speeds -- travel elements typically considered infeasible to capture through manual methods -- so that route choice algorithms can be evaluated and traffic levels / transportation system performance can be assessed (to evaluate information-related TCM strategies); and 3) to provide a system that, for the first time, allows modelers to look at how network driving patterns (via speed and acceleration profiles and engine operation data) and driver behavior leads to increased emissions.

3. COMPONENT TEST RESULTS

An FHWA-sponsored pilot study was completed at Georgia Tech in the spring of 1999 that developed the prototypes for the CETMS and ETD. Since then, researchers have continued evaluating a variety of GPS equipment, rugged laptops, handheld PC's, and batteries for possible use in the SMARTRAQ instrumentation packages. Given the intent of this paper to present final equipment configurations and deployment plans, only the key findings from the component tests will be covered in this section. Readers are encouraged to reference several papers and reports by Wolf, J. *et al* (1999a, 1999b, 1999c, 1999d, 2000) for detailed test results.

For each of the following equipment categories, key observations and findings were as such:

GPS / differential GPS (DGPS)

- To obtain accurate origin location, destination location, and route choice data, differential correction of GPS data should be included. Data accuracy errors associated with Selective Availability – the U.S. government's intentional degradation of signal accuracy – and from atmospheric delays can range from 40 to 140 meters. Both the Lexington and Austin GPS-enhanced travel surveys (Wagner, 1997 and Pearson, 1999), which collected raw GPS data, spent an unexpected amount of time processing this uncorrected GPS data. Even with various map matching software applications, there is a need for extensive quality control of the routes if the data are not differentially corrected.
- Vehicle speeds are estimated through a GPS phase differential calculation (change in signal phase with time) and vendors stipulate that this calculation is affected by Selective Availability; hence, differential GPS should be employed in any passive GPS system requiring collection of accurate speed and acceleration data.
- Post-processing differential correction of GPS signals involves setting up two GPS receivers with portable computers to record all pertinent satellite information at the base station and field unit. The field data are then post-processed to correct the x, y, and velocity readings using the assumption that the known base station location was stationary. Real-time differential GPS involves the real-time transmission of a correction signal from a broadcast station or satellite to a DGPS receiver connected to the GPS receiver in the field.
- To avoid the data storage and labor costs, as well as the potential for base station data losses associated with post processing differential correction methods, real-time differential GPS should be employed in any passive GPS systems requiring route choice data. For example, satellite signals collected and processed by the GPS carry a great deal of data associated with satellite and signal performance. Approximately 1 megabyte per hour of raw data needs to be logged to a data logger if post-processing DGPS is used.

Using real-time differential correction methods, however, will reduce the data storage requirements for second-by-second storage of 10 GPS data elements to approximately 80 kilobytes.

- Two feasible real-time DGPS solutions are available in the Atlanta metropolitan area – an FM sub-carrier based commercial transmission and the radio beacon signal transmitted free-of-charge by the U.S. Coast Guard. Analysis of the FM-based differential signal revealed that coverage and reliability are a serious concern for the 13-county metropolitan area.
- Evaluation of radio beacon signal reception, coverage, and reliability in the Atlanta region will be conducted in the spring of 2000 using the radio beacon broadcast from the Macon, Georgia station, which came online March 20. Reports from radio beacon signal users in other areas covered by the U.S. Nationwide DGPS program or within range of a U.S. Coast Guard beacon station indicate that this signal should be satisfactory for the Atlanta metropolitan area.

Other GPS-specific Findings

- GPS satellite signals are often lost when a vehicle passes beneath a tree canopy or under an overpass. The response of the individual GPS system to these conditions (which can only be determined through field-testing because manufacturer specifications are typically for 'optimal' conditions) affects the amount and accuracy of the data collected. A GPS system resistant to loss-of-lock under tree canopies is critical for Atlanta and other urban areas with heavy forestation.
- When the GPS system loses satellite lock, it is important for the system to reacquire signals as quickly as possible. Most systems have an extended cold start delay when acquiring from a power-off or loss-of-signal condition for more than several hours. To ensure data capture for accurate origin data during this emissions-sensitive period, initial GPS positions should be determined within a maximum of 45 seconds after a cold start. Reacquisition time after an intermittent loss of satellite lock should be no more than 2 seconds. The system employed in the Atlanta studies will not power down, but data recording will cease by design when the vehicle is stationary for longer then a pre-set interval.
- Equipment located in the trunk or cabin of a vehicle must be capable of withstanding sustained temperatures of 150^{o}F. Even with high-efficiency insulated packaging, the equipment must be capable of operating at the average daily temperature. Low temperatures below freezing are also a major issue in the winter months. Most GPS devices without displays are designed to withstand such temperature extremes.

Handheld and portable computers

- Handheld and portable computers typically cannot withstand high or low temperatures, since both the screen and the CPU will lock up at such extremes. Therefore, rugged handheld and laptop solutions for the passive in-vehicle GPS system and CETMS system are needed since these systems that will remain in the vehicle throughout the survey period.
- The Palm IIIx handheld organizer cannot withstand extreme trunk temperatures. However, the electronic travel dairy will be carried with the traveler as opposed to being left in the

vehicle, so temperature extremes should not be an issue with the use of the Palm IIIx in the ETD.

Power Supply

- For liability and installation cost reasons, it was initially decided that all systems would be powered by their own power supply (i.e., there would be no connection made to the vehicle's power system). Therefore, power draw of system components has a significant concern for extended (3-7 day) studies. All systems must be self-powered for the entire period or capable of running off of a 12V marine battery placed in the trunk of the vehicle. (Note: this requirement has been removed for the new passive in-vehicle GPS system; see next chapter for details.)

Overall, technology in the GPS field and the handheld / portable computer field is changing rapidly, as functionality improves while size is reduced and costs continue to fall. Of particular promise is the trend towards more integrated packages as manufacturers compete in this technology-hungry marketplace. To finalize the equipment components with adequate time left for system testing, however, only equipment in production by March 2000 were considered for the final SMARTRAQ system configurations presented in the next chapter.

4. INSTRUMENTATION PACKAGES

The overall goals of the SMARTRAQ survey and sub-surveys, as well as the automation goals for these studies, led the Georgia Tech research team to develop three different instrumentation packages. Each package is tailored to provide the flexibilities and data capture needs for its particular application.

4.1 Passive In-Vehicle GPS system

The first system is a passive in-vehicle GPS system, which will be used in conjunction with the General Purpose Survey. A subset of households that are given traditional paper diaries will also be given passive in-vehicle GPS systems that record the actual use of household vehicles. The system is passive in that it requires no driver interaction. The purpose of this system in the General Purpose Survey is to develop missed trip correction factors for paper diary participants. When combined with the paper diary data, it will also provide accurate trip origins, destinations, trip start and finish times, travel distances, and travel routes for the sub-sample.

Although the research team has been working on several prototypes of this package, a completely new package will be used for this application as the result of a recent National Highway Transportation Safety Administration (NHTSA) project award given to Georgia Tech. The objective of this project is to investigate and ultimately quantify the relationship between vehicle speeds and crash risk under various environmental and physical conditions. Numerous studies of crash data, including those conducted by Solomon (1964), Cirillo (1968) and West and Dunn (1971), suggest that speed deviation from prevailing speeds is a contributor to crash risk. Speed behavior is a complex function of dynamic variables including the driver, vehicle, and environment. To fully quantify the speed/crash risk relationship, a better understanding of the interactions between driver speed behavior, vehicle performance and environmental conditions that are most commonly associated with crashes is needed. By determining these high crash risk combinations, NHTSA can efficiently direct programs to control speeding in situations where the risks of crashing are greatest.

The intent of this project is to utilize advanced crash detection and vehicle positioning technologies to enable accurate profiling of driver speed behavior under crash and non-crash situations. Equipment packages will be deployed in 600 to 1,000 vehicles in the Atlanta area for a study period of two years. (The reason for the range in deployment numbers is that a split site scenario is currently under evaluation.) The equipment package consists of a telematics platform with a combination GPS receiver, processing unit, and digital communications transceiver; a crash detection module with a tri-axial accelerometer; and a differential GPS receiver.

The functionality of this equipment package will be fully automated and thus transparent to the survey participant. The package powers up with the ignition on and automatically turns off with the ignition off allowing the use of the vehicle battery as the power supply. Accurate latitude, longitude, and velocity data collected at one to five second intervals will be transmitted periodically from the vehicles to a central server at Georgia Tech via digital wireless communications.

The target sample size for instrumentation ranges from 400 to 675 households, subject to the final quantity of packages obtained and the number of vehicles per household (up to two vehicles per household will be instrumented). Because this package is designed for semi-permanent deployment on light-duty private vehicles, it is not applicable the for the Physical Activity Study, which must capture multi-modal and non-motorized travel patterns.

4.2 Electronic Travel Diary with GPS

The second system is a portable electronic travel diary with GPS for use in the Physical Activity Study. The target sample size for the instrumentation component is 510 respondents and is subject to the final quantities of packages obtained. Equipment deployment will focus on households located in the most ‘walkable’ and/or ‘bikable’ locations of the region. A secondary target group might include those who use travel modes other than personal vehicle (i.e., transit); however, GPS reception will be subject to some outages in both train and bus. This package is not applicable for those General Purpose Survey participants who use a personal vehicle for 100% of their trips.

The system consists of a handheld electronic travel diary (programmed in Palm OS for the Palm IIIx handheld connected organizer), a small Garmin GPS receiver (see Figure 2) with an integrated antenna, and batteries to operate the system for up to three days. The Palm IIIx and Garmin GPS 35LP can be seen in Figure 2. The batteries and Palm are carried in a small camera bag (7” by 5” by 3”), the GPS receiver is attached to the top of the shoulder strap, and the package has a total weight of 2.25 pounds (approximately 1 kg). Respondents will interact with the diary application using the Palm’s stylus to record all of the traditional data collected in the standard paper diaries, plus additional activity details. The system is actually designed to decrease overall respondent burden through the electronic interface, as users will see only those screens that are applicable to their trip activity and mode.

Figure 2: Palm IIIx Handheld Organizer and Garmin 35LP GPS Receiver

The GPS component is being used to confirm trip times, distances, and origin and destination locations. Integration of differential corrections equipment into this package would require deployment of a much heavier and larger system since most DGPS technology improvements are currently focused on vehicle and marine applications. A pilot travel diary study conducted in the Netherlands last year used an electronic travel diary with GPS and DGPS components. The total system weighed approximately 4.5 pounds (2 kilograms) and 41% of the participants reported negative feedback on the size and weight of the system (Draijer, 2000). In fact, size and weight were found to play an important role for non-use of the system in trips made by bicycle, walking, and public transport, and for trip purposes such as shopping and visits. Consequently, the research team has decided to recommend not using differential GPS for this package, at least until there are smaller, integrated solutions available.

4.3 Comprehensive Electronic Travel Monitoring System

The third system is the Comprehensive Electronic Travel Monitoring System (CETMS), which includes an electronic travel diary, a passive in-vehicle differentially-corrected GPS system, a rugged laptop computer, and an engine onboard diagnostics (OBD) system monitor. The OBD monitor allows researchers to accurately record the engine and vehicle operating conditions that lead to high emissions events. The enhanced data stream will be used to examine influences of driver behavior on emissions generation and potential impacts on ozone formation. As mentioned previously, funding for the Summer Ozone Study is not guarenteed. In addition, the cost of the CETMS is relatively high compared to the other systems. Therefore, only a small subset of the Summer Ozone Study participants will receive the full CETMS.

5. INSTRUMENTATION DEPLOYMENT PLAN

The final configurations of the equipment packages will be field tested for four weeks in the summer of 2000. This will include testing the equipment functionality, usability, and durability for the 3-day survey period, as well as testing the mailout / mailback deployment plan for the ETD with GPS. These field tests will require the recruitment of additional households for the pre-test phase. Once all testing is complete, multiple units of each will be developed / assembled and initialized for SMARTRAQ deployment.

The SMARTRAQ General Purpose Survey is scheduled in two phases – beginning with an 8-week period in the fall of 2000 and continuing with a 12-week period in the spring of 2001. The Physical Activity Study will be conducted simultaneously with the General Purpose Survey. Finally, the Summer Ozone Study will begin during the second phase of General Purpose Survey (12 weeks in the spring 2001) and will conclude with a 12-week data collection period during the summer of 2001.

5.1 Deployment Plans

Each instrumentation package will have its own deployment plan due to unique characteristics of each. First, the passive in-vehicle GPS system will be deployed as defined in the NHTSA study implementation plan; all installations will be done by trained professionals and the data will be collected automatically via the weekly cellular data transfer. Next, the electronic travel diary with GPS will be deployed using a standard shipping service in the Atlanta metropolitan region for unit distribution and collection. Finally, the CETMS would be installed by research associates at either the home or work location of the participant. Details of each plan are provided in the following sections.

5.1.1 Passive In-Vehicle GPS System

A total of 600 to 1000 vehicles in Atlanta will be instrumented for the NHTSA study; these installations will occur at a rate of 150 per month beginning in September 2000 and will continue until all units are deployed. The current goal is to equip up to two vehicles per household, which will yield a SMARTRAQ household sample size ranging from 400 to 675, depending on the final number of instrumented vehicles. Trained professionals will install these systems given the technical nature of the components. The aggressive deployment schedule enables the SMARTRAQ survey administrators to send the paper travel diaries to these same respondents for participation in the General Purpose Survey at a staggered schedule throughout the 20-week data collection period. The data from the instrumentation packages will be collected automatically through the weekly cellular data transfer from each unit back to a central server located at Georgia Tech as contracted under the NHTSA project. The travel diary data will be collected as part of the overall General Purpose Survey.

5.1.2 Electronic Travel Dairy with GPS

The Electronic Travel Diary with GPS will be shipped to each respondent's home and will be shipped back to Georgia Tech on the day after the survey period is complete. With standard next day shipping service available for the Atlanta metropolitan area, this would create the following 8-day rotation schedule:

Monday:	Ship unit to respondent
Tuesday:	Respondent receives unit, confirmation phone call occurs
Wednesday:	Day 1 of travel survey
Thursday:	Day 2 of travel survey
Friday:	Day 3 of travel survey
Saturday:	NA
Sunday:	NA
Monday:	Respondent ships unit
Tuesday:	Unit is received, data is uploaded, and unit is shipped to next respondent

Given an 8-week deployment period in the fall, this would allow seven waves of equipment deployment with a few extra days built in for shipping delays. And, the 12-week deployment period in the spring would provide ten waves of deployment, for a total of 17 waves. Therefore, the total number of respondents sampled in the Physical Activity Study with the ETD/GPS will depend directly on the number of units acquired. Thirty units should provide a total sample size of 510 respondents.

5.1.3 Comprehensive Electronic Travel Monitoring System

Deployment for the CETMS is proposed to begin in the spring of 2001 and to continue through the 12-week Summer Ozone Study. The higher costs associated with the components of this system have restricted the total number of systems proposed to five. To ensure that these packages are installed and used to their fullest extent, graduate associates would be dispatched to install and uninstall all CETMSs at the work or home location of each respondent. With only five packages and a five-day deployment cycle, it is feasible that one installation could occur on every day of the survey period (with the exception of the last week). For each 12-week survey period, this would yield approximately 80 vehicles samples, and a combined sample size of 160 vehicles.

5.2 Estimated Sample Sizes

In Table 1, total deployment estimates are provided for each instrumentation package in each deployment period. The first number in each total represents the total possible sample size with all equipment deployed and the second number represents to sample size with a 10% equipment failure / survey drop-out rate. For the passive in-vehicle GPS system, the lower NHTSA deployment number (600 versus 1000) is used. It is also important to note that these 400 households will also be providing GPS travel data throughout the summer of 2001 and could therefore possibly be used to supplement the CETMS data collected for the Summer Ozone Study.

Survey Equipment Package	General Purpose In-Vehicle GPS	Physical Activity ETD	Summer Ozone CETMS
Fall 2000 (8 weeks)	160 / 144	210 / 189	NA
Spring 2001 (12 weeks)	240 / 216	300 / 270	80 / 72
Summer 2001 (12 weeks)	NA	NA	80 / 72
Instrumentation Total	400 / 360	510 / 459	160 / 144
Survey Target	8000	1020 (~1 in 8)	NA
Percent to Total Instrumented	5%	50%	NA

Table 1: Estimated Sample Sizes for Each Equipment Package and for Overall Surveys

6. CONCLUSIONS

The use of automated data capture tools, such as GPS technologies and handheld computers, in household travel surveys offers great promise with respect to improved data accuracy and the collection of additional relevant data. These data enhancements will improve travel demand models and subsequent air quality analyses by integrating stated and measured travel behavior.

Travel studies that have used these technologies to date, including travel diary studies in Lexington, Kentucky; Austin, Texas; and the Netherlands, have experienced both the benefits and challenges presented by their use. Three different equipment packages will be deployed in the Year 2000 Atlanta Metropolitan Household Travel Survey to meet a variety of data needs for overall trip reporting, respondent physical activity levels, and summer travel behavior. As these technologies continue to improve in performance, as they continue to decrease in size and cost, they will likely become common travel data collection tools used by metropolitan planning organizations.

REFERENCES

Cirillo, J.A. (1968) Interstate System Accident Research Study II**. U.S. Bureau of Public Roads Interim Report II, Vol. 35, No. 3**, 71-75.

Draijer, G., Kalfs, N., and Perdok, J. GPS as a Data Collection Method for Travel Research: The use of GPS for data collection for all modes of travel (00-1176). **Presentation at the79th Annual Meeting of the Transportation Research Board**, Washington DC, 9-13, January, 2000.

Pearson, D. (1999) 1997-98 Austin Household Survey. **Presentation at the Transportation Research Board Data Committees Mid-Year Meeting**. Washington, D.C., June 1999.

Solomon, D. (1964) Accidents on Main Rural Highways Related to Speed, Driver, and Vehicle. **Bureau of Public Roads**, July.

Wagner, D. Battelle. (1997) **Report: Lexington Area Travel Data Collection Test: GPS for Personal Travel Surveys**. Final Report for OHIM, OTA, and FHWA.

West, L.B. and Dunn, J.W. (1971) Accidents, speed deviation, and speed limits**. Traffic Engineering 1971/07**, 52-55.

Wolf, J., Guensler, R., Washington, S. and Frank, L. (1999a) The Use of Electronic Travel Diaries and Vehicle Instrumentation Packages in the Year 2000 Atlanta Regional Household Travel Survey. **Proceedings of the TRB Conference on Personal Travel: The Long and Short of It**, Washington DC, June 1999.

Wolf, J., Guensler, R., Washington, S., Sarasua, W., Grant, C., Hallmark, S., Oliveira, M., Koutsak, M., Thittai, R., Funk, R., Hsu, J. (1999b). **Development of a Comprehensive Vehicle Instrumentation Package for Monitoring Individual Tripmaking Behavior - Test Plans and Results (GTI - R - 99004)**. Georgia Transportation Institute; Atlanta, Georgia.

Wolf, J., Guensler, R., Washington, S., Sarasua, W., Grant, C., Hallmark, S., Oliveira, M., Koutsak, M., Thittai, R., Funk, R., Hsu, J. (1999c). **Development of a Comprehensive Vehicle Instrumentation Package for Monitoring Individual Tripmaking Behavior – Final Report (GTI - R - 99005)**. Georgia Transportation Institute; Atlanta, Georgia.

Wolf, J., Hallmark, S., Oliveira, M., Guensler, R., and Sarasua, W. (1999d). Accuracy Issues with Route Choice Data Collection Using GPS. **Transportation Research Record, Number 1660**; pp.66-74; Transportation Research Board; Washington, D.C.

Wolf, J. and Thittai. R. (2000) Real-Time Differential Correction Options for GPS Route Choice Data Collection. **Paper 00-1034, Proceedings of the 79th Annual Meeting of the Transportation Research Board**, Washington, D.C., January 2000.