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Title:

Development of a Handheld Electronic Travel Diary
for Monitoring Individual Tripmaking Behavior

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ABSTRACT

Electronic travel diaries can provide more and higher quality data for use in travel demand model development. By recording trip information on a programmable unit, keystrokes associated with a trip origin can be linked automatically to accurate estimates of trip start time. By replacing standard paper diaries with electronic units, the level of data associated with tripmaking can be increased without increasing the burden on the participant. For example, after trip types are recorded with a single button push, detailed activity codes can be input with a second keystroke from a scrollable list. Data entry and recording errors can also be significantly reduced using error-checking routines. The detailed data that are collected using electronic diaries can be used to develop enhanced 4-step travel demand models and to validate or calibrate existing travel demand models. This paper focuses on the capabilities of the handheld electronic travel diary developed for use in Atlanta as a component of the Atlanta Regional Commission's Year 2000 Atlanta Regional Household Travel Study. The goals of travel diary automation are outlined in the context of current travel survey methods. Then the electronic travel diary hardware and software developed for the study in Atlanta region is described.

KEY WORDS: Electronic Travel Diary, Personal Travel Surveys, Travel Demand Modeling, Travel Behavior

INTRODUCTION

The Comprehensive Electronic Travel Monitoring System (CETMS), currently being developed at the Georgia Institute of Technology in Atlanta, Georgia, is designed to simultaneously collect driver and trip characteristics, vehicle operating profiles, and engine operating conditions. To this end, a prototype instrumentation package has been assembled which includes a hand-held electronic travel diary (ETD), a global positioning system (GPS) receiver and antenna, an onboard diagnostics (OBD) engine monitoring system, and a rugged industrial computer (1,2,3,4). Traditional travel diary elements (e.g., driver and passenger identities, trip origins and destinations, and trip purposes) are collected on the handheld travel diary. The computer, OBD monitor, and GPS are installed as a single package in a personal vehicle. The vehicle equipment monitors second-by-second data for a multitude of vehicle and engine parameters (such vehicle location, speed, acceleration, engine rpm, manifold absolute pressure, throttle position, catalyst temperature, gear selection, air/fuel ratios, and coolant temperature).

The impetus for the overall monitoring system development arises from emissions modeling research needs. Motor vehicle emissions are related to the number of trips that are made. But the emissions from "clean vehicles" that normally pass standard smog checks are a strong function of the way that the vehicles are operated. Emissions are very high during the first few minutes of operation, so information on when how vehicles are operated after the engine start is critical to improving the emissions models. In addition, a small fraction of high acceleration activity or moderate acceleration activity at high speeds lead to combustion conditions ("enrichment") that increase emission rates by 10 to 1000 times for short periods of time (5,6). Some modern engine computers that control air/fuel ratios and subsequent emissions are also known to monitor the rate of change in throttle position in some vehicles. This means that driver interaction with the vehicle through the throttle can also lead to high emissions. Some driver and vehicle activities, such as high accelerations, tend to occur at certain locations within the transportation network. However, current emission models do not account for such factors.

The ultimate objective of the Georgia Tech travel diary project is to improve both the quantity and quality of travel data available for transportation planning analyses and mobile source emissions modeling. Traditional paper-and-pencil methods of travel surveys are subject to many biases, including: non-response, underreporting or mis-reporting of trips, and data entry errors. Yet, data collected from these surveys are used to forecast regional travel patterns such as the number of daily trips, trip purpose frequencies, trip origin and destination selection, trip duration distributions, and temporal distributions. In addition, travel routes are rarely collected as part of the travel survey. Instead, shortest path algorithms are used to model the flow of trips across a given network. These potentially biased forecasts are then used in transportation investment decisions. Automation of the travel diary process should provide more data and more accurate data for this planning process. Hence, model development should improve.

Although a prototype CETMS package has been developed, functional limitations of several components (temperature sensitivity and compatibility with some vehicles) have delayed field testing. Consequently, the first field tests of the entire package in five households will occur in December, with additional field testing in ten households to begin in March 1999. In addition, the scope of the handheld travel diary component has been expanded to include the capture of

non-vehicle trips, leading the research team to investigate options for a handheld diary with GPS capabilities (i.e., without the vehicle components).

This paper focuses on the capabilities of the handheld electronic travel diary component. The goals of travel diary automation are outlined in the context of current travel survey methods. Automated methods currently being investigated/implemented in the US and abroad are briefly summarized. The design objectives for the handheld unit are described. The capabilities of the hardware (Psion Workabout) and travel diary software for the Atlanta study are described. Advantages and disadvantages are discussed and recommendations for future testing are provided.

AUTOMATION OF THE TRAVEL DIARY PROCESS

Travel diary studies are one of the most common methods for collecting data for use in travel demand model development. In travel diary studies, or trip surveys, randomly selected survey participants from a metropolitan region are asked to manually record the characteristics of each trip that they make trips in a standard paper diary. These travel decisions are used to derive statistical representations of travel behavior throughout that region. The resulting statistical models become trip generation algorithms (trips per household per day by trip purpose) in traditional 4-step travel demand models. The models are then used to forecast travel patterns, such as the number of daily trips, trip purpose frequencies, trip origins and destination selection, trip duration distributions, and temporal distributions. The same detailed data are also used in developing the more complex tour-based models, which directly account for trip chaining behavior.

Automated capture of time and location data should produce great improvements in travel data accuracy compared to manual methods. Electronic diaries also provide the potential to expand recorded choices, making electronic diaries suitable for use in activity-based or tour-based travel demand modeling. Specifically, the electronic travel diary combined with GPS data collection is intended to overcome several problems related to manual travel diary studies:

- Paper survey participants may not keep accurate records (either accidentally or intentionally), which results in misreported or underreported travel, including the omission of entire trips (7). The screen flow of electronic travel diaries will prevent the omission of individual trip data elements and the GPS component can be used to detect the omission of entire trips. In addition, help screens can be coded to add clarification where necessary.
- Due to the time-intensive nature of manual travel diaries, participants often feel fatigued or hassled by the process, which makes it difficult to collect extended panels of data (most manual travel diary studies collect either one or three days of travel data per household). The electronic travel diary's nesting of screens can reduce the respondent's impression of the overall burden because the respondent sees only those screens necessary for the collection of data for the given trip.
- Actual route choice is rarely captured in travel diary studies due to the increased respondent burden. This burden is eliminated with passive GPS data collection. The ETD with GPS should be able to collect data for periods up to a week without imposing any additional requirements on the respondent.

Because manual travel surveys potentially suffer from these reporting biases and limitations, new methods for obtaining personal tripmaking behavior can help minimize or reduce the impact of these biases on the estimation of trip generation rates. Global positioning systems can also add a new spatial dimension to tripmaking, by tracking actual route choice.

DESIGN OBJECTIVES

The primary goal in developing the handheld electronic travel diary (ETD) is to automate the manual travel diary process, producing more data and more accurate data for use in transportation planning model development. The primary goal of the Comprehensive Electronic Travel Monitoring System (CETMS) project is to develop an instrumentation package (including the ETD) that will automate the capture and integration of travel activity (trip-level data) and vehicle and engine operating conditions. Emissions models can be improved once the relationships between driver behavior, vehicle operations, engine operations, and vehicle emissions are determined through studies that employ the new equipment.

It is difficult to justify the cost of automating the collection of traditional travel diary elements. There are certainly some accuracy gains, but the overall cost of switching from paper to an electronic device is probably not warranted without leveraging other automation opportunities. The capture of additional data elements, including exact trip origin and destination locations, precise trip start and finish times, and route choice (captured 'passively' by a GPS component) make electronic diaries attractive. In this case, additional highly accurate travel data is captured with no additional respondent burden. Consequently, few projects are investigating the automation of the traditional travel diary only.

Several recent travel diary projects are introducing an electronic travel diary with GPS capabilities to the general public. In the fall of 1996, FHWA sponsored a project in Lexington, Kentucky, which employed personal digital assistants (handheld computers) equipped with low-resolution GPS receivers. The handheld units were used to collect travel survey data for vehicle trips from 100 participants over a one-week period (8). A current study in the Netherlands has developed a portable activity diary that is also equipped with a GPS device to capture travel activity for all modes of travel (9). The Georgia Tech handheld ETD, described in this paper, employs hardware similar to that used in the Netherlands study. The Georgia Department of Transportation and Atlanta Regional Commission in the Year 2000 Atlanta Regional Household Travel Study will use the Georgia Tech ETD with GPS to collect data from approximately 400 of the 4000 Atlanta households to be surveyed.

All of the automated travel diaries used in current studies around the world have been designed to address the following:

- Collect all driver and passenger travel activities that would normally be captured using manual travel diary or telephone survey methods. For each trip, this information includes: vehicle (or other mode) identification, driver identification, passenger identification, driver and passenger trip purposes, trip start time, finish time (or duration), origin location, destination location, and distance traveled.

- Provide a portable, handheld device with independent data collection capabilities so that the unit can be employed for walking, cycling, and other trips made outside of the primary vehicle.
- Link route choice, travel speed, and functional classification of each link to the characteristics of each trip by linking trip data on the handheld diary to the GPS data collected simultaneously. A GIS provides the route matching routines that link trip origin/destination through the road network database.
- Provide the capability to store GPS data directly on the handheld device.
- Provide a user-friendly interface.

THE GEORGIA TECH HANDHELD TRAVEL DIARY

During the initial requirements definition and component evaluation phase of the CETMS project, it was decided to evaluate only those handheld devices which supported keypad data entry. This decision was based on two primary issues: 1) the sponsor expressed an interest in the evaluation of non-touch screen technologies; and 2) the data capture requirements included provision of alphanumeric data entry for the respondents. In addition, the expansion of scope to include non-vehicle trips dictated the need for a stand-alone device. As a result, the research team identified and obtained three handheld devices for testing: the Psion Workabout, the WPI Oyster Termiflex PT2000, and the Percon PT1000 (see Table 1). After programming all three devices with similar screen flows, the devices were examined by FHWA personnel in Atlanta. Ease of use was assessed for each device and the Psion Workabout was selected as the best option (4).

The Psion Workabout

The PSION Workabout (Table 1 and Figure 1) is a rugged handheld, programmable device with the ability to store up to 16 MB of data on internal flash memory. The unit has a 57-key alphanumeric layout and a 240-pixel by 100-pixel graphics display. Up to twelve lines of text (39 characters per line) can be displayed at a time. The display has a backlight and the contrast can be adjusted by the user. The unit can be programmed to provide an audible click for each key press and a beep on command. The Workabout weighs 325 grams (11.46 ounces) including batteries.

Power is provided through 2 internal AA batteries that can be recharged in a docking station (fast charge) or vehicle cradle (trickle charge). However, disposable batteries provide sufficient power for a week of travel data collection (trips only, no GPS data) without recharging. An RS232 port is available for communications. A Vehicle Interface Cradle (VIC) is available for the unit that provides a dashboard mount, one or three communications ports, and vehicle power conditioning. However, the current Georgia Tech project does not employ the in-vehicle cradle.

The baseline price for the Workabout is $900, with an additional $200 for a 2 MB flash disk (4MB $440, 8MB $900). Two flash disks can be used in the unit at one time. Software must also be purchased to program the unit.

The GT Travel Diary Program

The Georgia Tech ETD program was developed in OVAL, a proprietary programming language for the Psion Workabout handheld computer. The OVAL language is similar to and fairly compatible with Visual Basic, allowing the development of a graphical interface for data entry by the user. The program employs an input data file that is provided by the researchers after conducting a simple household telephone interview. The input file allows researchers to pre-load participant names and common locations so that user data entry is simplified. The program creates a comma delimited output file that contains such factors as trip time, date, driver and passengers, origin, destination, and activity.

The electronic travel diary can be configured to serve as a vehicle diary for motor vehicle emission rate studies (its original application) or as an personal travel diary. As a vehicle diary, the device is assigned to a vehicle, drivers are allowed to vary, and only the trips made in the vehicle are recorded in the diary. As a personal diary, the device is assigned to an individual household member and all trips made by the individual are recorded on the diary. The programming remains essentially the same, with an additional screen layer added for mode choice selection. In addition, a separate GPS component is added to the device for capture of non-vehicle trips.

Household Interview

Before the unit is used in the field, a household interview is conducted. Standard household demographic and socioeconomic data (number of household members by age and gender, number of wage earners, income, number and types of vehicles, etc.) are collected for later use in modeling work. The specific demographic and vehicle data used by the diary program are entered into an Excel spreadsheet. The spreadsheet is used to create a comma delimited household file (hhdata.csv) which is used as an input to the GT Travel Diary program. The specific data fields in the comma-delimited file are used to activate and populate the graphical menus in the travel diary program. For example, potential household drivers "Fred," "Wilma," "Barney," and "Betty" are entered in the spreadsheet, and driver buttons with the same names then appear in the GT Travel Diary program (empty screen buttons are automatically prevented from appearing on the screen). Similarly, potential passengers are identified at the outset of the study. If drivers other than those pre-programmed use the diary, their names can be entered through textboxes at appropriate points in the program. Once a new driver or passenger is entered, that individual becomes a permanent "member" of the household and appears on a selectable button for future trips.

The Excel spreadsheet used to develop the travel diary input is a matrix of 26 rows and 30 columns. The matrix format is square to make the file compatible with input format requirements. Blank data cells are populated with "*" values and are treated as empty cells when the program is running. The data contained in the matrix are described in Table 2. The Excel file is saved by the researcher in comma delimited format on the portable computer that is used to load the software onto the Psion Workabout flash disk. This file is automatically transferred to the handheld computer along with the compiled OVAL program code. The program also

allows researchers to manually enter all setup data directly through the Psion keyboard (including all household, vehicle, passenger, and trip origin/destination codes).

Data Entry

The program employs a graphical user interface. Command buttons are used for most data entry. The Enter key is commonly used to verify information presented on the screen. For most menus, the user selects items (such as drivers and passengers) by pressing the letter that is listed on the appropriate button. For example, on the driver selection screen, the first driver listed in the household data file would be selected by pressing the "A" key on the alphanumeric keyboard. See Figure 2 for example screens. When the program is running, the user can press the On/Esc key to return to the previous menu. For example, if the incorrect driver was entered, the user can return to the driver selection screen and enter the correct driver by pressing the On/Esc key.

When the unit is delivered to the user, the program file and household data file are contained on a 2MB SRAM card inside the Psion Workabout. To start the unit for the first time, the user simply presses On/Esc (the main Psion screen will be displayed) and then Enter to launch the travel diary batch file. The travel diary takes about 20 seconds to load initially, and then the main travel diary screen will be displayed. Once the program is started, the program will remain in operation even when the unit is powered down using the "Off" key. The only time the program will stop running is if the power to the unit is completely removed (i.e., the AA batteries and backup calculator battery are removed) or if the Shift+Psion+Enter keys are pushed. The unit automatically powers down after it is inactive for 5 minutes (the power conservation feature is programmable).

The flow of data entry in the electronic diary is very similar to standard paper diaries. Conventional travel diaries employ origin and destination selection first. However, the electronic travel diary employs mode choice and driver selection first, to facilitate the logical variable (and entry screen) flow for entering missed trips. The main travel diary screen displays the title "Georgia Tech Travel Diary." The user presses Enter to begin recording a trip. The following screens/steps are incorporated for data entry:

- User Confirmation – In personal diary mode, the unit queries the user to make sure they have the diary that belongs to them.
- Date and Time Confirmation – If more than 6 hours have elapsed since the last trip was made, the program will request that the user verify the current date and time (to ensure that no power loss occurred). If the time and date are incorrect, the program will record a time error code with all subsequent trips. Capabilities to correct the date and time proved difficult to program and will be added later.
- Mode Choice – The mode is selected for each recorded trip. Complex mode/access combinations are facilitated to provide enhanced data for mode choice modelers. For example, assume that an individual makes a trip from home to work by walking to a transit stop, taking the bus to the transit stop nearest to work, and then walking to work. The electronic diary allows the user to record three separate trips (home to transit stop by walk mode, transit stop to transit stop by bus mode, and transit stop to work by walk mode) or one

single trip (home to work by transit/walk mode, where transit is the primary mode and walk is the access mode). Experimental protocol and user instructions can state which data entry method is preferred. The following modes are currently included in the diary: Automobile (each household automobile is listed separately), Walk , Bicycle, Motorcycle, Bus/Auto, Bus/Walk, Bus/Bicycle, Bus/Motorcycle, Rail/Auto, Rail/Walk, Rail/Bicycle, Rail/Motorcycle, and Rail/Bus. Codes for multiple access modes (bicycle at transit access and walk at transit egress) can be included if desired. Up to 30 mode codes can be accommodated.

- Driver selection – The user selects their name from the list provided. Five name buttons on each screen correspond to letters A-E. By pressing R, the user can enter a new driver name that is not on the list.
- Trip Origin (First Trip Only) – For the first trip made by the user, the origin of the trip must be selected. The 10 trip types are contained on two screens. Trip types 1 to 5 are listed as A to E on the first screen. The second set of trip types can be accessed by pressing M (more). An "Other" classification is not usually allowed for this variable, but the program allows this feature to be included if the researchers select the appropriate toggle in the input file.
- Trip Origin (Subsequent Trips) – For each trip, the destination of the previous trip should serve as the origin for the subsequent trip. The previous destination is displayed and the user is asked to verify that this is origin of their current trip. If Y, the program moves to the trip destination screen. If N, the program allows missed trips to be entered.
- Trip Destination – As with trip origin, the user selects one of 10 trip destinations.
- Activity Type - Once the trip destination is logged, the user specifies the trip activity type. The screen allows the user to scroll through the list of appropriate trip activities for a give trip type using the left and right arrow keys. Once the correct activity is listed on the screen, the user presses Enter. See discussion below.
- Passenger Query – When the trip activity type is recorded, the program queries the user if there are any passengers on this trip. If N, the program goes to the validation screen. If Y, the program goes to the passenger selection screen.
- Passenger Selection – A passenger selection shortcut is first provided. The passengers from the last trip are listed on the screen and the user is asked if the passengers for this trip are the same. If Y, the passengers are automatically recorded. If N, the program turns to the passenger entry screens. Passengers are selected by pressing the appropriate letter corresponding to the passenger name. As each is selected, the button is deactivated so that the same passenger cannot be selected again. The driver is automatically deactivated as well. When passenger data entry is complete, the user presses Enter to reach the trip validation screen. If there is a problem during data entry, the user can press On/Esc and begin driver or passenger selection again. By retaining passenger records, auto occupancy estimates are also facilitated.
- Missed Trip Routine – When the trip origin is listed incorrectly, the previous trip destination is not the current trip origin. This means that the user forgot to log a trip. This missed trip can be entered through the missed trip routine. The previous trip details are provided on screen to refresh the user's memory. After reviewing the data, the user presses enter to begin

recording the trip that they missed. The destination is selected first. The user is asked if they were the driver (in vehicle diary mode). If Y, the driver name remains unchanged. If N, the user can manually enter the name of the driver of the missed trip. The program asks if the trip occurred today. If N, the user can specify the correct date. The hour of the trip is then requested in military format (0-24). The program then turns to the trip activity type and passenger selection forms as normal.

Trip Types and Activity Codes

In typical travel diary studies, participants provide a code for the origin and the destination of their trip. The most common origin and destination codes include: home, work, shopping, dining, recreation, school, and other. These codes are then used to define the trip type used in travel demand model development. Common trip types include: home-based work, home-based shopping, home-based other, etc. These paper diary studies usually limit the number of origin and destination codes for two reasons: 1) there are physical size limitations of the paper diary media that prevents presentation of numerous or tiered options, and 2) participants are more likely to become frustrated by their participation in the project if the data entry is onerous.

The programming capabilities of an electronic diary provide the opportunity to present multiple coded options for origin and destination without adding significantly to the time required to record data. With proper formatting and nesting in the data input program, driver frustration can also be minimized. The Georgia Tech electronic travel diary employs a nested trip destination / trip activity routine to facilitate data entry.

In the first menu, the driver selects one of 10 trip type codes that correspond to standard origin/destination codes: home, work location 1, work location 2, shopping, errands, dining, recreation, school, chauffeur, and miscellaneous. Most of the codes are self-explanatory. Two work destinations are provided for individuals employed at two locations (or for two separate workers if the unit is used as a vehicle diary rather than a personal diary). The chauffeur code is somewhat atypical, it indicates that the driver made a trip to ferry someone else to a specific location. "Shopping" and "other" codes are represented by shopping, errands, and miscellaneous. Shopping trips are essentially defined in the electronic diary as trips made for the purposes of purchasing items. Errands are defined as trips that are made to obtain services, to drop off items for service, or to pick up items that were previously purchased or serviced (such as dry cleaning).

In the second menu, the driver selects an appropriate code for the activity that is being undertaken at the destination. The codes scroll alphabetically. When the appropriate code appears, the user presses Enter. For example, for a shopping destination, the driver can select grocery store or hardware store to differentiate between the type of shopping activity being undertaken. The preliminary trip type and activity codes proposed for the Atlanta study are provided in Table 3. The ten trip type codes currently lead to a total of 98 activity codes. The coding system presented in Table 3 will be tested in five Atlanta households in December 1998. The codes will be refined and tested in at least ten households in the March 1999.

When sufficiently detailed trip purpose data are collected, activity codes can be used to separate sub-trip classifications for developing refined trip generation models. For example, shopping trips to the grocery store can be specifically identified in large data sets. If the tripmaking characteristics associated with this specific trip type are significantly different from other shopping trips and if sufficient data are available, trip generation algorithms can be developed for these types of trips. Such detailed data will likely prove useful in the new household trip simulation approaches being incorporated into models such as TRANSIMS.

Comma Delimited Output File

The output file is not opened until the first trip is recorded. Each subsequent trip that is recorded will open the output file (trips.csv) and append the latest trip data to the file. Even when power is lost by the unit, the SRAM card will remain unaffected. The program and the input and output data files remain in memory. All pertinent household trip-related variables are retained in each trip contained the output file.

CONCLUSIONS

The benefits of an electronic travel diary over standard travel diary approaches are mostly associated with increased detail and accuracy in the data collected while limiting respondent burden. All modes of travel can be captured, and the option of using a GPS component directly with the handheld device can provide an additional layer of information not collected using standard survey methods. By measuring and recording all tripmaking characteristics, along with the corresponding origins, destinations, routes, and times, the EDT makes available a host of new research opportunities to better understand human travel behavior and its impact on congestion and emissions. The detailed data can be used in both standard 4-step modeling approaches by retaining information only at the trip type level. The data can also be used in enhanced 4-step model development by reclassifying certain trip/activity combinations as entirely new trip types. Finally, the data can be used in enhanced tour based modeling approaches that account for trip chaining. It is also noteworthy that the same physical handheld travel diary can be used in pure human activity or time use studies. With reprogramming, the unit could be used in studies that examine specifically how individuals spend their time (from brushing their teeth to going to work). The data improvements come at the cost of the hardware and the in-house expertise required to process the data once they are collected. Field studies currently being conducted in Atlanta are designed to analyze these tradeoffs and quantify the benefits of electronic diaries.

REFERENCES

1) Guensler, Randall, Jean Wolf, Simon Washington, Wayne Sarasua, Chris Grant, Shauna Hallmark, Marcelo Oliveira, Robert Funk, Jeffrey Hsu (1998a). Development of a Comprehensive Vehicle Instrumentation Package for Monitoring Individual Tripmaking Behavior: The Electronic Travel Diary; Volume 1, Project Overview and Functional Specifications; Draft for Review and Comment; July 1998.

2) Wolf, Jean, Randall Guensler, Simon Washington, Wayne Sarasua, Chris Grant, Shauna Hallmark, Marcelo Oliveira, Robert Funk, Jeffrey Hsu (1998b). Development of a Comprehensive Vehicle Instrumentation Package for Monitoring Individual Tripmaking Behavior: The Electronic Travel Diary; Volume 2, Technical Specifications and Analysis; Draft for Review and Comment; July 1998.

3) Wolf, Jean, Randall Guensler, Simon Washington, Wayne Sarasua, Chris Grant, Shauna Hallmark, Marcelo Oliveira, Robert Funk, Jeffrey Hsu (1998c). Development of a Comprehensive Vehicle Instrumentation Package for Monitoring Individual Tripmaking Behavior: The Electronic Travel Diary; Volume 3, Literature Review; Draft for Review and Comment; July 1998.

4) Wolf, Jean, Randall Guensler, Simon Washington, Wayne Sarasua, Chris Grant, Shauna Hallmark, Marcelo Oliveira, Robert Funk, Maxim Koutsak (1998d). Development of a Comprehensive Vehicle Instrumentation Package for Monitoring Individual Tripmaking Behavior: The Electronic Travel Diary; Volume 4, Component and Systems Integration Test Plans and Results; Draft for Review and Comment; November 1998.

5) Kelly, Nelson A., and P. Groblicki. Real-World Emissions from a Modern Production Vehicle Driven in Los Angeles; General Motors Research; Publication GMR-7858 EV-403; December 1992.

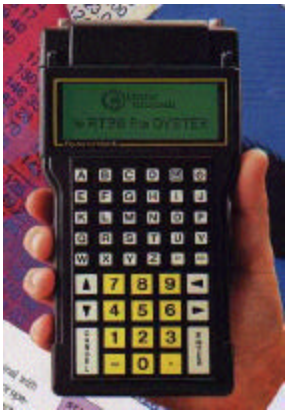
6) LeBlanc, David C., F. Michael Saunders, Michael D. Meyer, and Randall Guensler. Driving Pattern Variability and Potential Impacts on Vehicle CO Emissions; Transportation Research Record; Number 1472; pp. 45-52; Transportation Research Board; Washington, DC; 1995.

7) Richardson, A.J. and E.S. Ampt. Nonresponse Issues in Household Travel Surveys; In Conference Proceedings 10: Conference on Household Travel Surveys: New Concepts and Research Needs; Irvine CA 1995; National Academy Press; Washington, D.C., 1996.

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

9) Draijer, G., N. Kalfs, and J. Perdok. Possible Application of Global Positioning System (GPS) for Collecting Travel Data, Project Report; Transport Research Centre of the Ministry of Transport, Public Works, and Water Management; The Netherlands, 1998.

Table 1
The Three Handheld Devices Evaluated for ETD



WPI Oyster TermiFlex PT1000

The PT1000 is a programmable terminal with PCMCIA card capabilities. The display is 8 lines by 32 characters (with a 4x20 option) and has a 48-button keyboard with an internal RS232 port. The handheld is programmed in C or BASIC and has PC programming packages. Thirty-five hours of use is available between charges of NiCd batteries, and options include an in-vehicle cradle for charging (and communications) and easy RS232 connection. Price for the base unit is $700 with 32K RAM; for software, docking station, and accessories add $400.

Percon PT2000 (shown with docking station)

The PT2000 is a handheld portable data collection device with a 4-line by 16-character display. The keypad has 34 alphanumeric keys, including four programmable keys and 10 dual alpha/numeric keys that require the use of a shift button. Maximum storage on the unit is 1 Megabyte, with a specified operation range of 12 hours on internal batteries and a 10-day battery backup for data storage in memory. There is a PS/2 interface to allow for use as a keyboard wedge or connection via a RS232 port. A docking station can recharge the unit without having to remove batteries or make any connections. Prices for the PT2000 range from $600 with 128K memory to $1360 with 2 Mb memory. The docking station is $200 and software at $300 must be purchased to program the unit. An additional $350 is needed for accessories.

Psion Workabout (shown with Vehicle Interface Cradle)

The Workabout is a rugged handheld, programmable device with the ability to store up to 16 MB of data on flash memory installed in the machine. Two keypad options are available on the units, a 57 key alphanumeric layout (shown in unit in cradle) or a 35 numeric keypad layout which has larger keys. The display is 240x100 pixels, with the ability to display graphics on the LCD screen; 39 characters by 12 lines is the maximum text. A sound buzzer is included on the unit. Power is provided through internal batteries that can be recharged through a docking station (fast charge) or via a Vehicle Interface Cradle (trickle charge). An RS232 port is available for communications. The price of the unit is $1100 with 2MB RAM, the docking station is $400, the VIC is $275, software is $100, and accessories are $250.

Table 2
Description of Matrix Variables used as Input to the Travel Diary Program

Row	Data Type	Input Variables
1	Household Data	Traveler identification number, household identification number, household family name, address (2 fields), city, state, zip code, telephone (2 fields), and census tract identification. These data are linked to the demographic/socioeconomic data for this household.
2	Program Toggles	Reserved for turning on and off specific program sub-components that may or may not be needed for certain studies. For example, mode choice is not selected in vehicle trip log mode. Land use classification can be turned on and off.
3	Travel Modes	Specific household vehicles can be named. Mode choice and mode choice with access mode can be selected.
4	Potential Drivers	The names of the most likely drivers of the vehicle(s) involved in the study. Additional names can be entered later by the user using the alphanumeric keyboard.
5	Potential Passengers	The names of the most likely passengers of the vehicle(s) involved in the study. Additional names can be entered later by the user using the alphanumeric keyboard.
6	Origin/Destination Classifications	Ten general origin and destination classifications. These classes are based upon the literature review of travel diary studies across the US. See discussion below.
7-16	Destination Activity Type	For each destination classification, a variety of trip activities are provided. For example, the shopping category includes activity types for bookstore, grocery store, and hardware store. See discussion below.
17-26	Destination Land Use Classification	When the unit is toggled to provide land use classification capabilities, the user can select a general land use classification type for each destination classification. Current classifications include: regional mall, strip mall, isolated unit, park/open space, etc.

Table 3
GT Electronic Travel Diary Trip Types and Associated Activity Codes

Trip Type	Activity Code
Home	Just Going Home
Home	Home to Eat
Home	Quick Rest Stop
Home	Pick-Up Something
Home	Drop-Off Something
Home	Pick-Up Someone
Home	Drop-Off Someone
Work 1	Going to Work
Work 1	Stop-By and Visit
Work 1	Pick-Up Something
Work 1	Drop-Off Something
Work 1	Pick-Up Someone
Work 1	Drop-Off Someone
Shopping	Auto Supply Store
Shopping	Bookstore
Shopping	Clothing Store
Shopping	Computer Store
Shopping	Craft Supply Store
Shopping	Electronics Store
Shopping	Furniture Store
Shopping	Garden Supply/Nursery
Shopping	General Shopping
Shopping	Gift Shop
Shopping	Grocery Store
Shopping	Hardware Store
Shopping	House/Kitchen Store
Shopping	Jewelry Shop
Shopping	Music Tapes/CDs
Shopping	Music Supply
Shopping	Office Supply Store
Shopping	Pet Shop
Shopping	Pharmacy
Shopping	Sports Equipment
Shopping	Swap Meets
Shopping	Toy Store
Shopping	Window Shopping
Errands	ATM
Errands	Airport Run
Errands	Auto Repair/Smog Check/etc.
Errands	Banking
Errands	Charity/Volunteer Work
Errands	Copy Shop
Errands	Doctor/Dentist
Errands	Dry Cleaning
Errands	Flowers
Errands	Gas Station
Errands	Government Office
Errands	Professional/Legal
Errands	Personal Care (Hair, Nails, etc.)
Errands	Photomat

Trip Type	Activity Code
Errands	Post Office/Shipping
Errands	Travel Agency
Errands	Vet/Grooming/Training
Errands	Video Rental Store
Dining	Coffee Shop
Dining	Fast Food
Dining	Pub
Dining	Restaurant
Recreation	Art/Culture
Recreation	Camping
Recreation	Concerts
Recreation	Gambling
Recreation	Club/Organization
Recreation	Gym/Exercise
Recreation	Hobbies
Recreation	Hunting/Fishing
Recreation	Movies
Recreation	Sporting Event (Attend)
Recreation	Sporting Event (Participate)
Recreation	Vacation
Work 2	Going to Work
Work 2	Stop-By and Visit
Work 2	Pick-Up Something
Work 2	Drop-Off Something
Work 2	Pick-Up Someone
Work 2	Drop-Off Someone
School	Administrative
School	Bookstore
School	Classes
School	Library
School	Gym/Recreation Hall
School	Campus Event
School	Fraternity/Sorority
Chauffeur	Daycare Drop-Off
Chauffeur	Daycare Pick-Up
Chauffeur	Daycare Stop-By
Chauffeur	School Drop-Off
Chauffeur	School Pick-Up
Chauffeur	Kids to Practice
Chauffeur	Kids to Lessons
Chauffeur	Others to Shopping
Chauffeur	Other Chauffeuring Activity
Misc.	Church
Misc.	Family Visit
Misc.	Social Visit
Misc.	Sunday Driving
Misc.	Transit/Park-n-Ride Facility

Figure 1
Psion Workabout

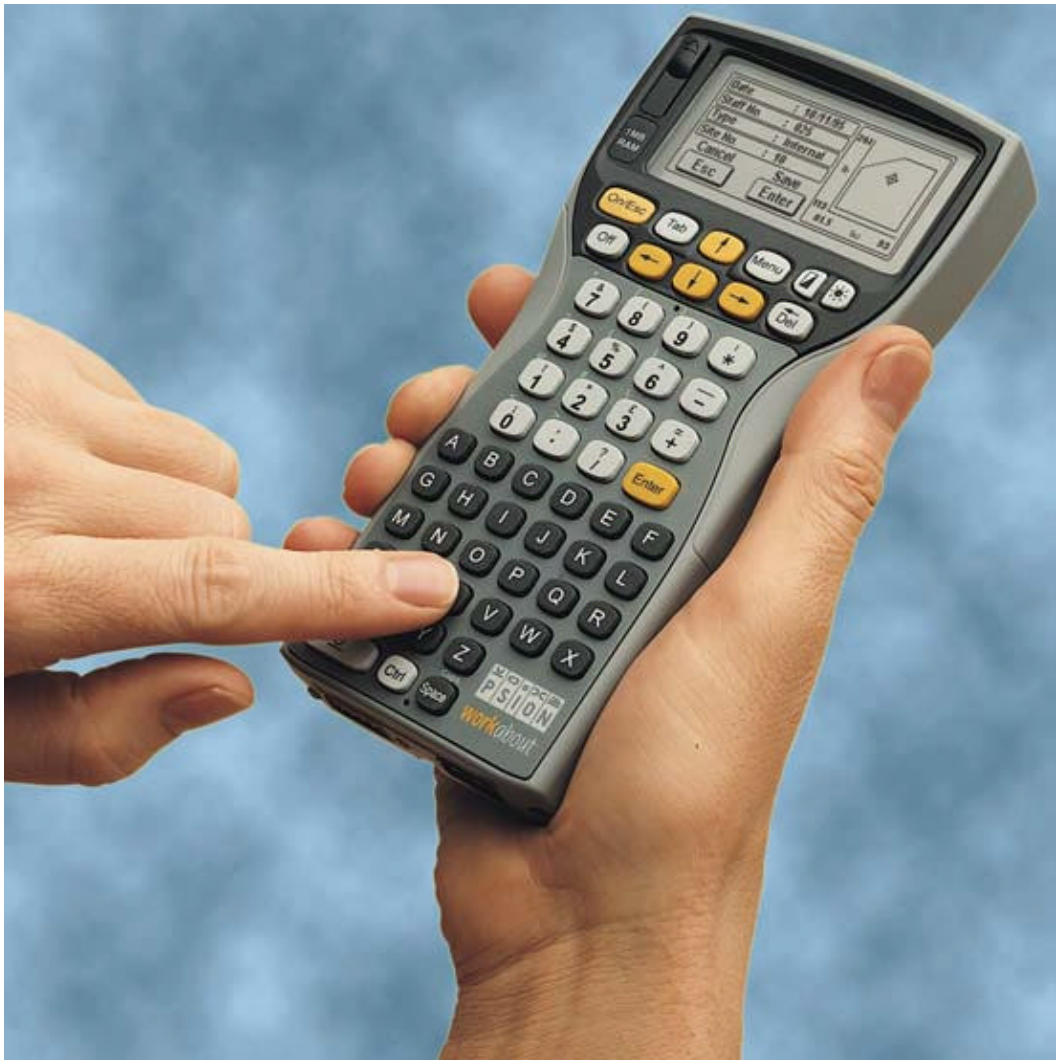


Figure 2
Psion Workabout Travel Diary Screens (Vehicle Mode)