Advances in the Application of GPS to Household Travel Surveys

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ABSTRACT

This paper presents the state-of-the-art in the application and integration of GPS technology in a regional household travel survey. The Kansas City Regional Household Travel Survey is the ninth such study in the past eight years to include a GPS component. In addition to having the lowest recorded trip underreporting rate (10 percent) compared to these other studies, this project also included a small follow-up prompted recall survey. The prompted recall survey was invaluable in providing insight into what trip purposes are underreported and began to provide explanations for why trip underreporting occurs. The methods and results used in this study are summarized in this paper to provide information and guidance for designing a GPS component for the next nationwide household travel survey.

INTRODUCTION

The 2004 Kansas City Regional Household Travel Survey was a comprehensive study of the demographic and trip-making characteristics of regional households. Sponsored by the Mid-America Regional Council (MARC), and the Kansas and Missouri Departments of Transportation, the primary objective of the study was to obtain data in order to update the regional transportation model. This regional travel behavior study included a concurrent technology supplement that involved equipping a subsample of household vehicles with Global Positioning System (GPS) equipment to achieve three objectives:

(1) to provide an independent data stream of vehicular travel in order to measure the level of accuracy of the vehicle trips reported over the telephone
(2) to obtain details about those trips that were captured by GPS but not reported over the telephone to ultimately derive trip rate correction factors. (The method used to develop the trip rate correction factors for this project follows that developed by Zmud and Wolf, 2003).
(3) To conduct a prompted recall follow-up survey focusing on trip purposes and reasons that some trips were unreported.

The use of GPS equipment to supplement telephone-based data collection in the United States began in 1996 with a proof-of-concept study in Lexington, Kentucky. This FHWA-sponsored study was designed to help transportation planners understand the extent to which self-reported travel data was incomplete due to respondent error - not understanding travel survey diary instructions, not considering short stops made as part of a larger trip chain to be relevant to the study, or simply not wanting to provide the details required in the study.

The success of that 1996 study in documenting differences between self-reported travel and GPS recorded travel, as well as stimulating subsequent discussions of the potential for using GPS technology more in household travel surveys, has led to GPS deployment as part of nine household travel surveys in the United States. This includes two statewide studies (California and Ohio) and seven regional studies (Austin, Los Angeles, Pittsburgh, Laredo, St, Louis, Tyler/Longview TX, and Kansas City). With each study, the understanding of self-reported "missed trips" has increased. In addition, the underlying methodology for developing trip rate correction factors has steadily been refined.

This study, which is the most recent, contributes to the state-of-knowledge concerning trip under-reporting in four ways. First, the number of "missed trips" was the lowest ever documented across all the US studies. This suggests that the lessons learned from prior GPS studies (that were incorporated into the survey materials for the Kansas City study) made a difference in obtaining more complete travel data from the self-reported method. Second, this study included a prompted recall survey, in which follow-up surveys were mailed to a selected sample of GPS participants whose self-reported trips (reported via computer-aided telephone interviewing or CATI) did not include stops identified through the GPS data. The survey presented the differences in travel and asked the respondents for more details about the GPS-identified stops. This information from 27 respondents provides insight into why the under-reporting takes place from a respondent perspective, which will lead to more precise survey method improvements. Third, the development of the trip correction factor builds on those developed over the past eight studies and incorporates the most recent thinking in terms of how the factor should be created and applied to the data. Finally, it adds to the growing documentation of missed trips across studies, which is starting to suggest that geography and culture may affect the accuracy of trip reporting, given that this study, St. Louis, and the Ohio study showed the lowest levels of trip under-reporting.

The purpose of this paper is to summarize the study results, both in terms of the prompted recall survey as well as the development of trip rate correction factors. The purpose for doing so is to provide insights into how GPS technology might benefit the next national household travel survey, both in terms of methods as well as application of results. The next section of the paper provides background information on the GPS study and prompted recall survey, and the following sections will present the development of trip rate correction factors for this study along with recommendations for incorporating this technology into the next national survey.

BACKGROUND

The GPS supplement to the Kansas City Regional Travel Survey was conducted concurrently with the main study, using a subsample of households that had already agreed to participate in the regular study. As documented in the Final Report, the study was conducted over a ten-month period, from October 2003 through May 2004 using the GPS logging equipment shown in Appendix A. This section summarizes the demographic characteristics of households that participated in the GPS study, presents the details and methods used to conduct the prompted recall survey, and discusses the results of the prompted recall survey.

GPS Study Participants

All households that agreed to participate in the household travel survey were eligible for inclusion in the GPS study, provided three criteria were met: (1) the household owned at least one vehicle, (2) all household vehicles had a functioning cigarette lighter or 12-volt power adapter (to the best of the owner's knowledge), and (3) the household indicated an interest in participating. Of the 3,049 households that participated in the regional household survey, a total of 228 households with 426 vehicles participated in the GPS study. The demographic characteristics of the GPS households compared to all households participating in the study are shown in Table 1. As indicated, the GPS households were larger than the general survey population households, owned more vehicles (by definition since 0-vehicle households were excluded), and had higher incomes, on average.

TABLE 1: CHARACTERISTICS OF GPS STUDY HOUSEHOLDS

CHARACTERISTIC	GPS HOUSEHOLDS	ALL HOUSEHOLDS	CENSUS DATA
Household Size			
1	16.8%	27.5%	27.4%
2	39.7%	32.9%	32.9%
3	22.0%	16.2%	16.2%
4+	21.5%	23.5%	23.5%
Household Vehicles			
0	0.0%	7.4%	7.4%
1	30.3%	33.9%	33.9%
2	56.1%	41.7%	41.7%
3+	13.6%	17.0%	17.0%
Geography			
Urban	12.9%	20.6%	20.6%
Suburban 1st Ring	19.8%	26.0%	26.0%
Remainder	67.3%	53.4%	53.4%
County			
Johnson County, KS	27.4%	26.4%	26.6%
Leavenworth County, KS	5.3%	3.1%	3.5%
Wyandotte County, KS	9.6%	8.5%	9.1%
Cass County, MO	3.4%	4.8%	4.6%
Clay County, MO	9.5%	12.3%	11.1%
Jackson County, MO	40.6%	40.4%	40.6%
Platte County, MO	4.2%	4.5%	4.5%
Household Income			
< $15k	3.7%	9.6%	12.2%
$15k - < $25k	4.9%	9.7%	11.3%
$25k- < $50k	27.9%	29.8%	30.1%
$50k - < $100k	46.1%	36.1%	33.6%
$100k +	34.2%	13.7%	12.8%
Income refusals	3.1%	5.5%	--
Hispanic Origin			
Yes	2.2%	3.4%	5.5%
No	97.8%	96.6%	94.5%

Source: Kansas City Regional Household Travel Survey, weighted and Census 2000. Includes those 228 households that participated in the GPS study and the 3,049 regional households that completed the general travel survey.

The GPS households were also different in terms of recorded travel. A comparison of the vehicle driver trip rates for the drivers in the GPS-equipped vehicles against those for drivers in all other participating households from the general survey is shown in Table 2. As indicated therein, the GPS households (which were larger, owned more vehicles, and reported higher incomes) had higher trip rates than the general households. The GPS trip rates were statistically higher, except for the largest household size category. There were only 19 GPS households in the largest category (5+ persons), which may have influenced this result. The corresponding person trip rates for the GPS households were higher as well: 5.15 average daily person trips compared to 4.18 average daily person trips for non-GPS household members.

TABLE 2: HOUSEHOLD VEHICLE DRIVER TRIP RATE COMPARISON

HOUSEHOLD SIZE	GPS HOUSEHOLDS	NON-GPS HOUSEHOLDS	ALL HOUSEHOLDS
1	5.31	4.61	4.65
2	8.63	6.89	7.05
3	11.24	8.43	8.72
4	11.65	10.38	10.46
5+	12.22	10.44	10.58
Total	9.26	7.38	7.53

A general analysis of the GPS households shows that they had good geographic dispersion throughout the study area, were larger, and had more vehicles as compared to the non-GPS households. They also reported higher annual incomes. These three factors (household size, vehicles, and income) are known to contribute to higher trip-making, and thus it was not surprising to see that the GPS households reported three more trips, on average, than the non-GPS households in the general survey effort. Further research into the question of whether participation in a GPS study enhances the self-reported information in the travel diary is needed to add to the rigor of the trip rate correction methodology. Without this research, one could also argue that participation in the GPS may decrease the accuracy of self-reported information for some participants assuming that these participants realize that similar data is being recorded by the GPS device.

Prompted Recall Survey

In the second part of the Regional Household Travel Survey GPS Supplement, a follow-up survey was conducted with a small sample of GPS households for whom the GPS data identified trips but there were not corresponding matches in the CATI data. A short questionnaire (included in Appendix B) was sent to those households. It listed the reported travel for a particular household vehicle and included a map of the unmatched / GPS acquired trips. The participants were then asked to identify the unreported stops, the driver of the vehicle, how many household members were with them at the time, the trip purpose, and the reason for not reporting the missing stops/trips in the travel log. Surveys were mailed to 32 GPS households, with 27 responding and providing information about 47 "missed stops." The survey sample was small, reflecting limited budget resources. However, the results provide valuable insights into why trip underreporting takes place in household travel surveys.

As part of the prompted recall survey, the respondent was asked to indicate, for each missed stop/trip, why that stop/trip was not reported during the CATI retrieval interview. Of the 47 trips identified in the GPS data but not found in the CATI data, some were not stops/trips as defined by the study. They included work-related travel by someone who drove for a living (respondents were specifically instructed to NOT record these trips in their travel logs), movement of vehicles within the same parking lot (since the address stayed the same, these were considered loop trips and also not collected from the respondents), or traffic delays/driver error.

However, 28 trips were true trips that should have been reported. The explanations provided by respondents for these "missed" trips were mainly that the respondent didn't think the stop was important enough to record in the travel log or report over the telephone. As shown in Table 3, this included 7 stops to drop off or pick up someone, 7 stops to "grab some food," 4 stops to refuel, 4 shopping stops (ran in and bought one item), and 3 stops to mail a letter.

TABLE 3: GPS PROMPTED RECALL MISSED TRIP EXPLANATIONS

REASON FOR NOT REPORTING THE STOP	# STOPS	PERCENTAGE
I forgot	10	21.3%
I didn't know about this stop	2	4.2%
I didn't think this stop was important	14	29.8%
I ran out of room in the travel log	2	4.2%
This stop was a work-related stop (e.g., recorded by arealtor who was showing homes to clients).	10	21.3%
This was not a stop - it was a traffic delay, wrong turn, or moving car to another parking space at same location	9	19.1%
Total	47	100.0%

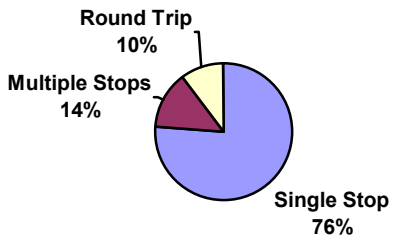
The average duration for these forgotten/"not important" trips was 5.7 minutes. The average length by stop type is shown in Table 4. Due to the small sample sizes, this information is for qualitative consideration only. As shown in Table 4, stopping to put a letter in the mailbox took less than one minute, while dropping off or picking up someone took a little over a minute. The shopping and getting food trips took more than 10 minutes, on average.

TABLE 4: AVERAGE STOP DURATION FOR MISSED TRIPS

MISSED TRIP PURPOSE	N	AVG. LENGTH
Drop-off/Pick-up Someone	7	1.2 min.
Get Food	7	12.8 min.
Refuel	4	4.8 min.
Shopping	4	10.9 min.
Mail Letter	3	0.4 min.
Other	3	1.8 min.
Total	28	5.7 min.

Each missed trip was categorized in relation to the other travel reported by the respondent. Three types of trips were identified: single stop in a chain, multiple stops in a chain, or all links in a roundtrip. As shown in Figure 1, most trips (76%) were a single stop among a series of trips in a chain (with all other trip chain stops reported). Fourteen percent of the missed trips were part of multiple stops in a trip chain not reported, while 10 percent were entire round trips not reported.

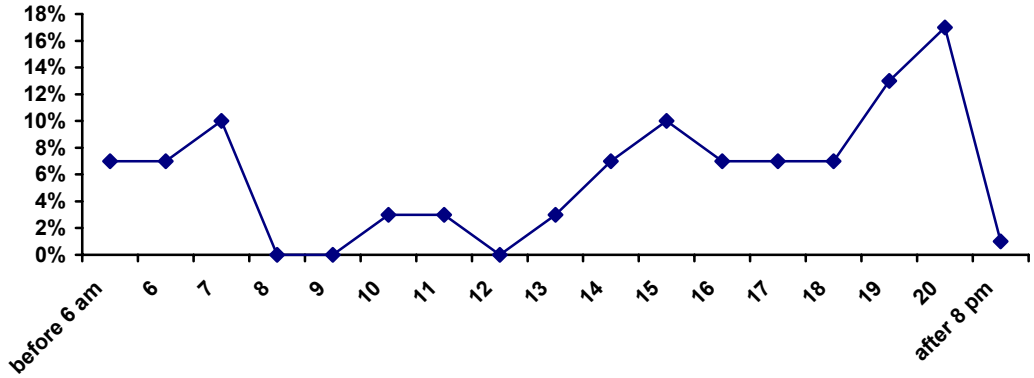
FIGURE 1: TYPE OF MISSED VEHICLE DRIVER TRIP



Base: All vehicle driver trips captured through GPS but not reported in CATI for prompted recall participants.

The findings from earlier GPS studies suggested that most missed trips took place later in the day, when the respondent was at home and made a trip at the end of the travel day. A review of the times these missed trips took place confirms this finding, as most missed trips were reported after 6 pm.

FIGURE 2: TIME MISSED TRIPS TOOK PLACE



Base: All vehicle driver trips captured through GPS but not reported in CATI for prompted recall participants.

The prompted recall survey is an important part of understanding travel behavior and establishing confidence in the trip reports obtained through CATI retrieval. The following conclusions can be drawn from the Kansas City Prompted Recall Survey:

1. Not all "missed trips" should have been recorded. Respondents were instructed to record all travel within the seven-county region. Those respondents who drove outside the 7-county region or for a living were asked to not report that travel. Thus the GPS data reflected vehicular travel of a realtor showing homes to buyers, which was correctly not recorded in the travel logs. This accounted for 21 percent of the "missed" trips identified through the GPS matching process.
2. Most true missed trips take place at the end of the travel day. This suggests that it is important to ask all respondents specifically whether they ran out to pick-up someone or something at the

store on their way home from work or after they were settled in for the evening, similar to probing for a lunch trip when a worker reports being at the office all day.

3. Most true missed trips were short stops on the way to another destination. Interviewers typically probe for these during retrieval, asking "did you make any stops along the way?" However, as shown in this small survey effort, 76 percent of the true missed trips were a short stop on the way to another location. This suggests the importance of that probe question, as well as the need to fine-tune the wording to be more specific – any stops to get fuel or food, or drop off / pick up someone / something. It is also important to note that these stops along the way may or may not have been along a straight-line travel path – and this may help explain why reported trip lengths or durations take longer that modeled travel distances or times. This was explored in more detail for the California Statewide Household Travel Survey GPS Study by Wolf et al (2003).

Finally, given the wealth of information about trip purpose gleaned through this small effort, the supporting evidence for the need to ensure that the GPS and CATI data comparison both focus only on relevant trips, and the simple yet revealing respondent insights into why the trips were not reported through the CATI retrieval interview suggest the need for future GPS studies to include a more extensive prompted recall component. These details are critical to more accurately measuring and reporting on the level of "missed trips" actually occurring in the travel survey data sets.

TRIP RATE CORRECTION FACTOR DEVELOPMENT

One of the main objectives for conducting the GPS augment to the Regional Household Travel Survey was to identify the level of trip under-reporting when respondents self-reported their travel over the telephone. The development of trip rate correction factors relied heavily on methodology developed by NuStats and GeoStats for previous GPS studies and refined through continued research as documented in "*Identifying the Correlates of Trip Misreporting*" written by Zmud and Wolf for the 2003 International Conference on Travel Behavior Research. The purpose of this section is to document the assumptions and procedure for developing trip correction factors for the vehicle driver trips in the Kansas City Regional Travel Survey data. This includes adjusting the GPS/CATI trip comparisons to exclude the falsely identified GPS missed trips (as documented in the previous section), reviewing characteristics of GPS households that did not report all their travel, developing trip correction factors, and re-estimating trip rates to account for the misreporting.

The first step in the development of trip rate correction factors was to compare the number of trips detected by the GPS units versus those reported over the telephone by the respondent, after both data files were adjusted to remove trips that were outside the area, flagged as business (rather than personal) travel, or otherwise inconsistent with the study objectives. This comparison is shown in Table 5. The 228 GPS households reported 2,083 trips over the telephone while the GPS unit detected 2,292 trips, for a trip under-reporting rate of 10%.

TABLE 5: CORRECTED TRIP REPORTING COMPARISONS

COUNTY	# HH	# VEH	GPS TRIPS	CATI TRIPS	MISSED TRIPS	% MISSED TRIPS
Johnson County, KS	63	118	609	569	40	7.0%
Leavenworth County, KS	12	26	138	126	12	9.5%
Wyandotte County, KS	21	36	216	191	25	13.1%
Cass County, MO	8	16	87	71	16	22.5%
Clay County, MO	21	35	217	210	7	3.3%
Jackson County, MO	93	176	917	811	106	12.7%
Platte County, MO	10	19	108	105	3	2.9%
Total	228	426	2,292	2,083	209	10.0%

In reviewing the data shown in Table 5, three important issues should be noted.

(1) One factor should not be calculated and applied to the entire data set. The proportion of missed trips in the last column of Table 5 varied from 3 percent to 23 percent across the seven counties in the study area.
(2) Not all households need adjustment. More than half of all GPS households had accurately conveyed their travel over the telephone and that travel matched the GPS data exactly.
(3) Finally, the proportion of misreporting varies across households, with most households only missing one or two trips, if any, and 3% of the households being the biggest offenders in misreporting a large number of trips.

These facts argue against the application of a constant trip rate correction factor for all vehicle driver trips. In order to identify the households that would benefit from a trip rate correction factor, an analysis of several demographic and travel behavior characteristics was conducted, focusing on variables found to be significant in prior studies. This included trip duration, household size, number of vehicles, household income, age of main respondent, number of household workers, number of students in the household, and the presence of children under the age of 18 in the household. Table 6 shows the distribution of missed trips by household and vehicle driver trips.[1] The general findings in terms of what types of households contributed more of the missed trips agrees with common expectations. The 2-person, 2-vehicle, 2-worker households earning mid-level incomes were most likely to not report all of their travel.

TABLE 6: CHARACTERISTICS OF HOUSEHOLDS THAT MISSED TRIPS

CHARACTERISTIC	# GPS HHLDS	% GPS HHLDS MISSED TRIPS	# MISSED VEHICLE DRIVER TRIPS	% OF MISSED VEHICLE DRIVER TRIPS
OVERALL	228	44.3%	297	14.3%
Household Size				
1	40	37.5%	34	11.4%
2	94	38.3%	97	32.7%
3	49	63.3%	86	29.0%
4+	45	42.2%	80	26.9%
Household Vehicles				
1	63	31.7%	46	15.5%
2	132	43.2%	153	51.2%
3+	33	72.7%	98	32.3%
Household Income				
< $25k	19	36.8%	17	5.7%
$25k- < $50k	60	38.3%	59	19.9%
$50k - < $100k	102	44.1%	154	51.9%
$100k +	40	62.5%	66	22.2%
Income refusals	7	14.3%	1	0.3%
Main Respondent Age				
Less than 25 years	2	50.0%	2	0.7%
25 to 34 years	37	43.2%	71	23.9%
35 to 44 years	61	37.7%	74	24.9%
45 to 54 years	45	53.3%	61	20.5%
55 years or older	83	44.6%	89	30.0%

[1] The total number of missed trips as shown in Table 5 is 209 trips. This represents the number of underreported trips in the CATI data and is calculated as 2,292 GPS trips minus the 2,083 CATI reported trips. When integrated into the general trip framework, the actual number vehicle trips increases from 209 to 297, which reflects both the missed trips as well as new origin/destination pairs created when old origin-destination pairs are broken apart to include the missed trips.

Household Workers				
0 workers	30	40.0%	34	11.4%
1 worker	87	37.9%	99	33.3%
2+ workers	111	49.0%	164	50.2%
Household Students				
0 students	129	39.5%	133	44.8%
1 student	47	55.3%	57	19.2%
2+ students	52	43.2%	107	23.9%
Presence of Children (<18)				
Children Present	140	43.6%	159	53.5%
No Children Present	88	45.5%	138	46.5%

Source: Kansas City Regional Household Travel Survey GPS households (N=228).

A logistic regression was used to determine the characteristics that were statistically different between those that misreported and those that did not. When applied, this correction factor is designed to improve vehicle trip rate estimates to account for the misreporting, without artificially over-inflating the data. The regression analysis was conducted on the database of vehicle driver trips for all GPS households (n=2,292). In this model, y_i is an indicator (dummy variable) that was set to 1 if the vehicle driver trip record was missing from the CATI data and 0 if the vehicle driver trip record was present in the CATI data file. The model also includes x_i, which is a vector of associated characteristics that influence whether a trip will be "reported" via CATI or not. The objective of the analysis is to estimate the conditional distribution of y_i given x_i, $\Pr[y_{i,}, x_i]$. A logistic regression was used to determine which variables had the most impact on trip underreporting. Those considered included household size, household vehicles, household workers, household students, presence of children, income, age, trip duration, and trip departure time.

TABLE 7: RESULTS OF LOGISTIC REGRESSION

VARIABLE	S.E.	SIG.	EXP(B)	95.0% C.I.FOR EXP(B)	
				Lower	Upper
Household Size	.114	.000	.641	.513	.802
Household Vehicles	.075	.000	1.636	1.413	1.895
Household Students	.115	.000	1.505	1.202	1.884
Household Workers	.097	.001	.721	.597	.872
Trip Departure Time	.015	.347	1.014	.985	1.045
Respondent Age	.092	.384	.923	.772	1.105
Trip Duration	13.500	.589	1464.808	.000	.000
Presence of Children	.226	.793	.942	.605	1.469

As indicated above, the regression analysis identified four variables as being significantly associated with trip under-reporting (household size, household vehicles, household workers, and household students). Interestingly, these variables are often used to describe the life cycle status of the household. The remaining six variables were not found to be significant. Based on these results, a 22-cell matrix representing the 4-way cross tab of the four significant variables was created, which was then used to derive the adjustment factor for specific household types. Within each of the cells, the total sample count was divided by the number found by GPS to give an adjustment factor (GPSWT). Table 8 shows the cells and the corresponding factors. This assumed the following variable groups:

- Household Size: 1, 2, and 3+ person households
- Household Vehicles: 1, 2, and 3+ vehicles
- Household Workers: 0 or 1+ workers
- Household Students: 0 or 1+ students

The adjustment factors range from a low of 1.00 for 3 cells (2-person, 1 vehicle, 0 worker, 0 student households; 2 person, 1 vehicle, 1+ worker, and 0 students; and 2 person, 2 vehicle, 0 workers, 0 students) to a high of 1.67 for households that are characterized as 1 person, 1 worker, 3+ vehicles. The lower the factor, the more accurate the trip reporting by those households.

TABLE 8: MISREPORTING ADJUSTMENT FACTORS

HH SIZE	HH VEHICLES	HH WORKER	HH STUDENTS	HH TRIPS	GPS TRIPS	GPSWT
2	1	0	1+	11	11	1.00
2	1	1+	0	44	44	1.00
2	2	0	1+	8	8	1.00
3+	2	1+	0	164	171	1.04
2	3+	1+	1+	21	22	1.05
3+	2	1+	1+	1075	1141	1.06
2	1	1+	1+	98	104	1.06
3+	1	1+	0	42	45	1.07
2	1	0	0	44	47	1.07
1	1	1+	1+	13	14	1.08
3+	1	1+	1+	121	132	1.09
1	1	1+	0	124	135	1.09
2	2	1+	0	428	468	1.09
2	2	0	0	173	193	1.12
2	2	1+	1+	76	87	1.14
3+	3+	1+	0	78	90	1.15
2	3+	1+	0	82	98	1.20
3+	3+	1+	1+	309	376	1.22
1	1	0	0	42	52	1.24
1	1	0	1+	4	5	1.25
1	2	1+	0	33	42	1.27
1	3+	1+	0	3	5	1.67
Total				2993	3290	1.10

In the final step, the trip rate correction factors were applied to all households in the general household travel survey data set (not just the GPS households). Table 9 shows the effect of the trip adjustment factor on the original vehicle driver trip rate, and the adjust vehicle driver trip rates with the trip rate correction factors applied to the vehicle driver trips only.

TABLE 9: EFFECT OF TRIP ADJUSTMENT FACTORS ON VEHICLE DRIVER TRIP RATES

HOUSEHOLD COUNTY	HH VEH DRIVER TRIPS		
	# HHs	Unadjusted	Adjusted
Johnson County, KS	805	8.30	8.31
Leavenworth County, KS	96	7.13	7.14
Wyandotte County, KS	260	6.65	6.64
Cass County, MO	146	7.25	7.31
Clay County, MO	375	7.49	7.51
Jackson County, MO	1231	7.14	7.16
Platte County, MO	137	8.35	8.40
TOTAL	3049	7.54	7.56

CONCLUSIONS

The GPS augment to the Kansas City Regional Household Travel Survey was successful in many respects. It provided an audit data stream to confirm the reliability of the CATI reported vehicle driver trips, it furthered the state-of-the-knowledge of GPS studies through the inclusion of a prompted recall follow-up survey, and it also advanced the research regarding the development of trip rate correction factors to help take the GPS findings and apply them to the travel survey data. In doing so, it provides useful insights in methods and applicability to the next nationwide household travel survey and supports the argument for increased federal funding of travel surveys to include larger GPS-based prompted recall surveys.

In addition to solidifying the usefulness of this approach, the Kansas City study identified several areas where additional research regarding the application of GPS technology is warranted. In particular, the small degree to which trips were underreported in this study raises the question of whether the presence of the GPS device in itself increases trip reporting accuracy, or whether there may be regional effects of the dedication of respondents to successfully completing the task requested of them (e.g., do mid-western respondents more thoroughly report their travel in general or was their high level of trip reporting a result of having the GPS unit in the vehicle?)

A second question is how to integrate the details learned from the prompted recall survey into the data collection process itself. How does an interviewer best probe for late evening trips? Are there reminders or examples that can be presented to the respondents with the travel survey materials to help remind them to record quick trips to the post office, gas station, or convenience stores? Are all GPS data comparison studies comparing apples to apples? If people who drive for a living were told to not record their trips, is the current GPS trip underreporting process "penalizing" or mislabeling these trips as missed rather than screening them out from the survey? If so, how can the proper screening be implemented? These questions, in particular, are critical for developing a true missed trip rate.

Finally, the Kansas City project resulted in refinement to the existing method for developing trip rate correction factors. Is the household level the appropriate unit for weight development, or should these factors be person-based? Do particular types of households underreport or specific types of persons? A careful review of the findings of the nine US GPS studies is warranted to help advise FHWA of the implications for the next nationwide household travel survey.

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APPENDIX A - GPS EQUIPMENT

GeoStats led the Kansas City Regional Travel Survey GPS data collection effort, using its GPS data collection device, the GeoLogger. This is a rugged yet simple GPS data-logging device developed specifically for use in household travel surveys and travel time studies throughout the world. As shown in Figure 1, the GeoLogger consists of three components: the data collection device, an antenna that mounts to the windshield using a suction cup, and the power cord, which plugs into the cigarette lighter or an auxiliary 12-volt power outlet in the vehicle. Installation was very simple, and required only plugging the unit into the power source and affixing the suction-cup mount to the windshield. This device was totally passive; once the unit was installed, no further action (or interaction) with the unit was required.

FIGURE 1: THE GEOSTATS GEOLOGGER

Source: GeoStats

APPENDIX B – PROMPTED RECALL SURVEY MATERIALS

Transportation Outlook Study

Dear XXXX XXXXXXX:

Thank you for participating in the Transportation Outlook Study, sponsored by the Mid-America Regional Council. We appreciate the time your household took in recording your travel information on February 24, 2004 as well as agreeing to use the GPS equipment provided. As indicated to you earlier, all of your responses will be kept confidential and your responses will only be used in combination with the 3,000 other households participating in the region.

We have one final step for which we'd like to ask your help. In processing the travel information you reported over the telephone with the information obtained through the GPS equipment, we noticed that there was one trip missing from your telephone information. We were hoping that you'd be able to give us some details about this trip so that we can complete your travel record.

To help with this, we've created summary tables and maps that show the travel information reported for Honda Accord in which differences were found. You can provide the needed information to us by filling in the missing information in the following pages and mailing these pages back to us in the enclosed postage-paid envelope or by calling Miriam Thompson at 1-866-GEOSTATS.

Thank you for your time!

Todd Ashby at MARC (tashby@marc.org or 1-816-474-4240)

Miriam Thompson at GeoStats (mthompson@geostats.com or 1-800-GEOSTATS)

Stacey Bricka at NuStats (sbricka@Nustats.com or 1-800-447-8287, ext 2240)

Vehicle: 1999 Honda Accord

Table 1 lists the trips made in your Honda Accord as reported by your household members during the telephone interview. A trip is travel from a starting place to an ending place. Table 2 lists the trips that were captured by the GPS equipment that was placed in the Honda Accord.

Table 1: Reported from the Travel Diary information.

Trip Number	Start Place	End Place	Departure Time	Arrival Time	Number of People	Driver
1	HOME	JC PENNY LOGISITIC CENTER	10:58 AM	11:20 AM	1	XXXX
2	JC PENNY LOGISITIC CENTER	KINKO'S	2:08 PM	2:15 PM	1	XXXX
3	KINKO'S	QUICK TRIP	2:25 PM	2:32 PM	1	XXXX
4	QUICK TRIP	JC PENNY LOGISITIC CENTER	2:39 PM	2:45 PM	1	XXXX
5	JC PENNY LOGISITIC CENTER	RESIDENTS	12:46 AM	1:08 AM	1	XXXX
6	RESIDENTS	HOME	1:09 AM	1:14 AM	1	XXXX

Table 2: Captured in GPS data

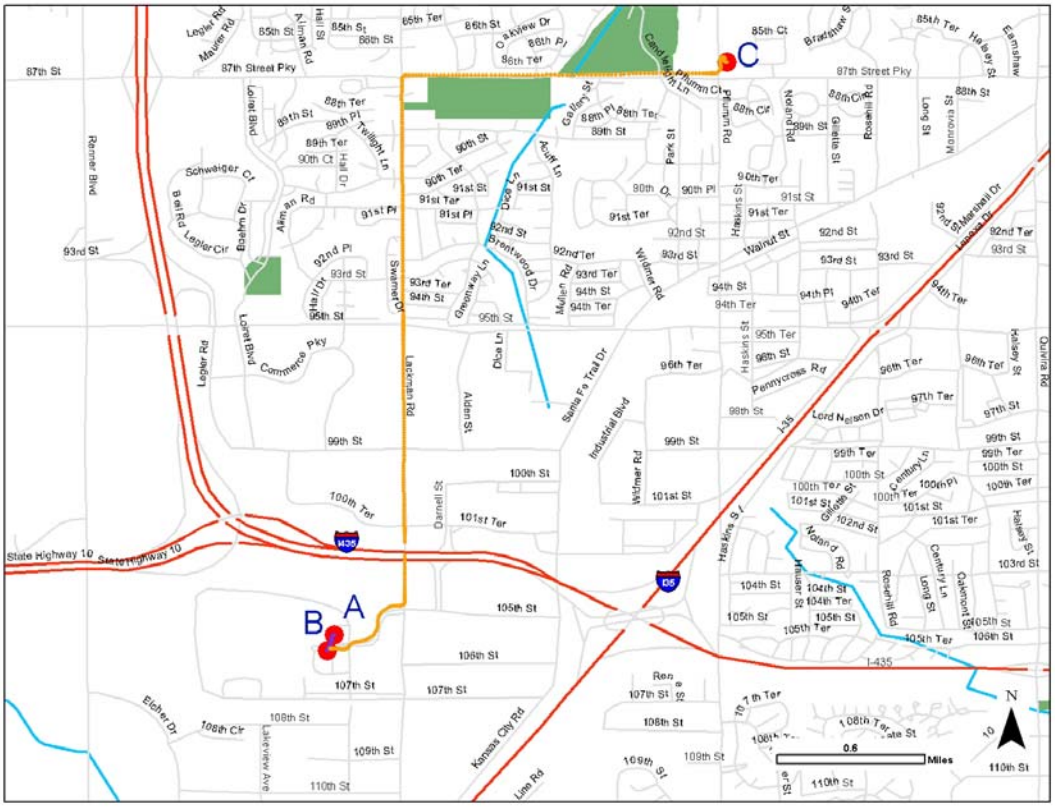
Trip Number	Start Place	End Place	Departure Time	Arrival Time	Number of People	Driver
1	HOME	JC PENNY LOGISITIC CENTER	10:59 AM	11:17 AM	1	XXXX
2	JC PENNY LOGISITIC CENTER	Captured by GPS	1:48 PM	1:49 PM		
3	Captured by GPS	KINKO'S	2:09 PM	2:17 PM		
4	KINKO'S	QUICK TRIP	2:24 PM	2:30 PM	1	XXXX
5	QUICK TRIP	JC PENNY LOGISITIC CENTER	2:38 PM	2:43 PM	1	XXXX
6	JC PENNY LOGISITIC CENTER	RESIDENTS	12:25 AM	12:26 AM	1	XXXX
7	RESIDENTS	HOME	12:43 AM	1:11 AM	1	XXXX

There is a slight discrepancy between these two tables. We'd like to confirm with you whether each stop found by the GPS but not report during the telephone interview was an actual missed "trip" or just some type of traffic delay and not an actual ending place). We'd like you to help us confirm our GPS findings by filling in the information below. To help you, we've included maps of the "missing trips" on the following pages.

Vehicle: 1999 Honda Accord

The map below shows two trips captured for this vehicle. The vehicle left **JC PENNY LOGISITIC CENTER (A)** at 1:48 PM and traveled to **Location B**, arriving at 1:49 PM. The vehicle left **Location B** at 2:09 PM and traveled to **KINKO'S (C)**, arriving at 2:17 PM. Can you tell us what Location B was (if it was an ending place) and what you did there?

GPS TRIPS 2 AND 3



INFORMATION NEEDED

Please help us to fill in the missing details about **Location B**.

What is **Location B**? (Please provide place name or type of place)	
What was the reason you made a stop at **Location B**? (e.g. Drop off children at school)	
How many people from your household were in the vehicle between **JC PENNY LOGISITIC CENTER (A)** and **Location B?**	
The stop at **Location B** was not reported because: A) I forgot B) I didn't know about this stop C) I didn't think this stop was important D) This was not a stop – it was a traffic delay. E) Other (please give details)	
How many people from your household were in the vehicle between **Location B** and **KINKO'S (C)**?	