Assessing the Accuracy of the Sydney Household Travel Survey with GPS

Peter. Stopher[1], Min. Xu[2], Camden. Fitzgerald[1],
[1] Institute of Transport and Logistics Studies, University of Sydney, Sydney, NSW, Australia
[2] Transport and Population Data Centre, Department of Infrastructure, Planning and Natural Resources, Sydney, NSW, Australia

1 Introduction

A persistent and well known problem with household travel surveys is that respondents under-report their travel, and report travel time, distance, and locations of origins and destinations inaccurately. The most critical of these short-comings is the trip reporting. Self-administered diary-based surveys are likely to be the worst offenders, followed by CATI surveys. Wolf (2004) shows that from six household travel surveys conducted in the USA using CATI and GPS for comparisons between 2001 and 2004, the rate of missed trips ranged from 11 percent to 35 percent. Another reported 81 percent of trips missed. All of these are not adjusted for missing GPS trips, (something that has been done in this study), meaning that these rates should actually be higher. Face-to-face surveys, especially when conducted by experienced interviewers in a continuous survey do not experience these problems to the same level, although they definitely do experience them as is shown in this paper.

Wolf *et al.* (2003) reported that the main reasons for under-reporting of trips were the length of the survey, forgetfulness of respondents, or respondents considering the trips unimportant, and selective omission on the part of the respondent. Trips made by a non-motorised mode were also commonly missed.

The use of GPS data collection for a small sample in a household travel survey provides the opportunity to examine differences in reported and measured trip rates, the characteristics of trips that are not reported, start and end times, travel times and distance travelled. Forrest and Pearson (2005), reported that in a CATI household travel survey in Laredo, Texas only 44 percent of trips recorded by a GPS were able to be successfully matched with a trip reported by CATI. This is a significant shortfall considering that household travel surveys are used for transport modelling and planning.

This paper reports on a GPS survey that was conducted in conjunction with the Sydney 2003/2004 Household Travel Survey (HTS), and was commissioned by the NSW Roads and Traffic Authority (RTA). The objective of the study was to collect GPS data that can be used to provide information about under-reporting of travel activities in face-to-face household travel surveys. A small sample of households was obtained, and Population Data Centre (TPDC). Each year the survey covers approximately 5,000 households in Greater Metropolitan Sydney. The data gathered from these surveys is used to assist transport planners and has and is being used to re-estimate the Sydney Strategic Travel Model. Subjects are issued a one-day place-based travel diary and are aided by verbal activity recall in a face-to-face interview, (Battellino and Peachman, 2003).

2 Methodology

A sub-sample of households already taking part in the HTS was asked to take part in the GPS survey. By using the same households, we were able to ensure comparability between the two surveys. It minimised the potential for bias, respondent burden, and any other adverse effects the GPS survey might have on response rates for the HTS. The contact method for recruitment was face-to-face with no incentives being given. All the recruited GPS

households were those that had previously agreed to take part in the 2003/2004 HTS. Respondents were only eligible if over 15 years of age and had given consent to take part. Recruitment was restricted to households likely to travel on the Travel Day and to households whose Travel Day was at least three days from the recruitment day. It was not sensible to recruit the bed-ridden or house-bound. The three days to the Travel Day was used to permit time for delivery of the GPS devices and for households to get used to using them. Some preliminary data were obtained including key destination addresses.

Two types of GPS devices were used for the survey - an in-vehicle GPS devices and a wearable GPS. An in-vehicle GPS was provided for each car of each sampled household that agreed to participate in the survey. This device is plugged into the cigarette lighter/accessory socket, and requires no intervention by the driver of the vehicle. It records all travel undertaken by the car, so long as it remains plugged into the socket. Each eligible person in the household that did not use a car, or was more likely to use public transport, was asked to take and use a wearable GPS device for the same period. It is able to obtain data in buses and cars as well as when people are walking, cycling and any other modes of travel.

A prompted recall survey was conducted to confirm the trip information received by the GPS and to gather information not obtainable by GPS. This includes trip purpose, the number of passengers and the number of passengers that are household members. They were also used to determine who the driver was, whether any of the stops recorded were erroneous due to traffic delays or signal loss and if there were any stops that were not detected by the GPS processing algorithms. Information relating to fares and ticket type was also gathered for public transport users. These were conducted over the phone, via an internet survey, in a face-to-face interview, or were self-administered, depending on the choice of the respondent.

The field work of the study commenced in February 2004 with the last household completing their survey in early September 2004. Upon recruitment, GPS units were delivered the next business day via courier, ensuring respondents were in possession of and using the GPS devices for a minimum of two days prior to their assigned Travel Day for the Sydney HTS. Pick-up details for the GPS units were also obtained at recruitment. A courier was used to pick up the devices.

Once the GPS devices were retrieved and the data downloaded, a GIS software package was used to modify and illustrate the trip data. First, a program was run removing all bad data points and creating trip ends where the device was stationary for 120 seconds or more or where the heading changed by 180 degrees within 30 seconds. For the wearable data, additional manual interpretation was needed to identify trip ends. A second program was run that created route information. This includes origins, destinations, distance travelled, start time, end time, and travel time for each trip for each day of data recorded. Maps were produced that illustrate the routes taken and the trip ends. An example is given in Figure 1. From the output of the GIS programs, a summary table was produced, (see Figure 2). These were used as aids for respondents to report on their travel. They were distributed to the households with the prompted recall survey forms. For households that chose the internet as their method for doing the prompted recall survey, a Java CD was sent to the household with log-in details to the ITLS server. Respondents were asked to log into the server over the internet and complete the survey. Every trip on which questions were asked was shown in the form of an animated line moving over a map shown within the web browser (Collins and Stopher, 2004). All responses were stored directly in the database.

The GPS prompted recall surveys were always conducted after the HTS interview so that they could not influence responses to the HTS. The data from the HTS was sent by the HTS survey contractor to ITLS. This was then cleaned and edited for analysis with the GPS data.

Figure 1: Example of Route Map output from GIS

Summary of Travel Activity for John Citizen
Sunday, 29/2/2004

Location at Start of Day:	Street	Suburb
	DELANEY DR	BAULKHAM HILLS

STOP NUMBER	TIME OF ARRIVAL AT STOP	TIME SPENT TRAVELLING TO STOP (min)	DISTANCE TRAVELLED TO STOP (km)	LOCATION OF STOP		MAP	NOTES
				Street	Suburb		
1	9:01	4	1.7	ROUNDABOUT	BAULKHAM HILLS	MAP A	
2	11:40	6	3.5	CARRINGTON RD	CASTLE HILL	MAP A	
3	11:52	6	3.0	VICTORIA RD	CASTLE HILL	MAP A	
4	12:33	6	2.0	PRESIDENT RD	KELLYVILLE	MAP A	
5	12:43	6	4.0	DELANEY DR	BAULKHAM HILLS	MAP A	

Figure 2: Example of Summary Table

3 Response and Completion Rates

A total of 118 individuals from 70 households were recruited to take part in the GPS study. Table 1 shows the number of households recruited for each type of prompted recall method. The telephone was the method most widely chosen by respondents, followed by the internet. All prompted recall surveys were sent to respondents within two weeks of their travel day with the exception of one household. This was sent 16 days after the travel day. Households that elected the self administered method were generally slow in returning the completed forms and a number of phone calls had to be made to remind them to post them back to ITLS.

The total number of drop-outs is also given in Table 1. Drop-outs are households that returned no data from the GPS device. Reasons for this occurring include cigarette lighters being faulty, and respondents deciding not to use the devices. Respondents who chose the face-to-face option had the highest drop-out rate (43 percent) while those choosing the phone option had the lowest rate (21 percent). Overall, there were a total of 29 individuals from 19 households (27 percent) who dropped out leaving 51 valid households.

Table 1: Response and Completion Rates of GPS/Prompted Recall

	Method of Prompted Recall Survey Response				Total
	Phone	**Internet**	**Self-administered**	**Face-to-face**	
Households Recruited	33	17	13	7	**70**
Drop-outs (% of Households recruited)	7 (21%)	6* (35%)	3 (23%)	3 (43%)	**19 (27%)**
TOTAL VALID	**26**	**11**	**10**	**4**	**51**
Completes	18	5	5	2	**30**
No travel	2	1	2	1	**6**
Completes & no travel (% of total valid)	20 (77%)	6 (55%)	7 (70%)	3 (75%)	**36 (71%)**
Non-completes (% of total valid)	1 (4%)	3 (27%)	0 -	0 -	**4 (8%)**
Sub-Total (a) (% of total valid)	**21 (81%)**	**9 (82%)**	**7 (70%)**	**3 (75%)**	**40 (78%)**
Partial Drop-outs (% of recruited)	5 (15%)	2 (12%)	3 (23%)	1 (14%)	**11 (16%)**
Completes from partial drop-outs (% of total valid)	5 (19%)	-	3 (30%)	1 (25%)	**9 (18%)**
Partial completes from partial drop-outs (% of total valid)	0 -	1 (9%)	0 -	0 -	**1 (2%)**
Non-completes from partial drop-outs (% of total valid)	-	1 (9%)	-	-	**1 (2%)**
Completes & no travel + completes from partial drop-outs (% of total valid)	**25 (96%)**	**6 (55%)**	**10 (100%)**	**4 (100%)**	**45 (88%)**
Sub-Total (b) (% of total valid)	**5 (19%)**	**2 (18%)**	**3 (30%)**	**1 (25%)**	**11 (22%)**
Total (a) + (b)	**26 (100%)**	**11 (100%)**	**10 (100%)**	**4 (100%)**	**51 (100%)**

* one of these drop-outs was due to using it on the wrong day. We have data but not for comparison with Sydney HTS Travel Day

Partial drop-outs are also shown. Partial drop-outs are households where some, but not all, members of the household did not return any data from a GPS device. The partial drop-outs were made up of a total of 15 individuals from 11 households. A complete household is one that returned data from the devices and then also returned the prompted recall survey. A partial-complete household is a household from which data were obtained from all GPS devices, but one or more household members did not complete the prompted recall survey. A non-complete household is one that returned data from the devices but did not return the prompted recall survey. Households that returned no data from the GPS device but indicated that they did not travel on the Travel Day are also shown. These households are therefore considered as completing the survey.

Seventy-seven percent of valid respondents completed the telephone survey. The five households that were defined as partial drop-outs all completed the prompted recall survey. Therefore, 96 percent of valid respondents completed the survey (77% + 19%).

The internet option, while a reasonably new concept, was originally taken up by 19 households. There were two cases with the internet that encountered technical problems. They were therefore sent a mail-back version of the prompted recall and are counted in the self-administered column, bringing the total respondents using the internet for the survey down to 17. Only 55 percent of internet respondents completed the survey (including the one household with no travel on the Travel Day), and 12 percent partially completed it.

The self-administered option produced a 100 percent completion rate to the prompted recall survey, despite 23 percent of the recruited households partially dropping out before the survey was sent to them, (i.e., not all recruited household members used the devices). The face-to-face option was not taken up by many respondents. However, along with the mail-back method, it produced the highest completion rate (100 percent).

Overall, there was a 73 percent completion rate for using the GPS devices, (including households with no travel on the Travel Day), or, in other words, a 27 percent drop-out rate from recruited households. From the households that did participate, 88 percent completed the prompted recall (“completes and no travel” plus “completes from partial drop-outs”).

4 Analysis Methodology

Analysis was performed on a trip-level basis, comparing individual trip records from the HTS with the corresponding trip records from the GPS survey. A manual comparison of trips was performed to match trip records from each data file (GPS and HTS). Trip numbers were matched first, followed by checks on start and end times, travel times, trip purpose and distance. One individual was excluded from the analysis when trip records could not be matched. Another individual was excluded because there was no diary, despite there being GPS data.

GPS technology is not perfect, and there were some trips missed by this medium. The prompted recall survey is designed to detect such missed trips, but respondents do not always pick them up themselves. However, the majority of trips that were not captured by the GPS and prompted recall survey were missed for two reasons: respondents did not always take the device with them on their travels and respondents, who were given an in-vehicle device, could not have walking, passenger or public transport trips recorded. Trips that were missed by GPS are excluded from the comparisons and are hence irrelevant for assessing the accuracy of the HTS. Also excluded are all non-driver trips reported in the HTS for people that were provided with an in-vehicle device.

The number of reported trips was compared with the number that was recorded (after GIS processing and editing as a result of prompted recall surveys), illustrating the level of under-

or over-reporting. The characteristics of the trips that failed to be reported are examined, followed by an investigation into the differences in reported and recorded start and end times, travel times, and trip distances. A comparison of trip purpose stated in the HTS with what was reported in the prompted recall survey was also conducted.

5 Results

Table 2 presents summary statistics for the results using the GPS devices and prompted recall and for the results using the HTS. It should be noted that where no data were available, trips were excluded for that particular variable. A total of 68 persons from 49 households participating in the HTS, producing 407 trips were analysed. With the addition of the data received from the pilot survey, these figures increased to 81 persons from 59 households, generating 465 trips. All figures reported from here on include respondents from the pilot survey. After matching trip records from each data file, 86 percent of trips could be matched within 12.5 minutes of the starting times.

Table 2: Summary Statistics of Trips

Variable	GPS	HTS Diary
Average travel time/per trip	12.96 min	14.22 min
Average walking travel time/per trip	8.1 min	8.6 min
Average car passenger travel time/per trip	11.4 min	16.29 min
Average car driver travel time/per trip	12.29 min	14.69 min
Average VKT/per trip	8.07 km	8.85 km
Average VKT/per person/per day	42.40 km	42.77 km
Average vehicle occupancy	1.44	1.45

The average Vehicle Kilometres Travelled (VKT) recorded by the HTS was 8.85 km. per trip, while the average VKT recorded by the GPS was 8.07 km., indicating an average overestimation of 0.78 km. per trip by HTS respondents. Travel time per trip is also overestimated by one-and-a-half minutes by HTS respondents.

5.1 Missing trips analysis results

Table 3 is a summary of an analysis of the missing trips that were uncovered. From a total of 502 trips recorded, 37 were missed by the HTS. This is an under-reporting rate of 7.4 percent. Whilst seven percent would seem to indicate a lot of trips are being missed, this is very good in comparison to the CATI studies conducted in the USA with rates ranging from 11 to 81 percent. This demonstrates the strengths of using interviewers who are well trained and able to probe for answers and spot where a trip or trips may have been missed.

Table 3: Missed trips

Source	Total Trips	Total Trips in Sydney HTS	Missing trips by Sydney HTS	% of Total Trips	Total respondents processed
HTS	439	407	32	7.3	68
PILOT	63	58	5	7.9	13
TOTAL	502	465	37	7.4	81

In Table 3, “Total Trips” is the total number of trips that should have been reported in the HTS taking into account the trips missed by the HTS, but picked up by the GPS and prompted recall survey. Trips missed by the HTS refer to the difference between the “Total Trips” and the total number of trips reported by the HTS.

Table 4 summarises a more detailed analysis of the missed trips. First, we analysed the effect that the number of trips a household made in a day had on the under-reporting of trips. We hypothesised that a higher number of trips would result in a greater likelihood of failure to report all trips. The basis for this theory is that there is a higher burden on respondents and the probability of forgetting about a trip is higher.

Table 4: Characteristics of Trips Missed by HTS Diary

Characteristic	Range	Trips Missed	Total Trips in HTS	% of Total Trips (HTS + missed)	% of Missed Trips (Total of 37)
Travel Load	Light (≤ 5 trips)	5	172	2.8	13.5
	Medium (> 5 and < 10 trips)	15	147	9.3	35.1
	Heavy (≥ 10 trips)	17	146	10.4	51.4
Start Time	Before 9am	7	68	9.3	18.9
	12:01 pm to 4pm	10	123	7.5	27.0
	After 5pm	15	135	10.0	40.5
Travel Time	Less than or equal to 5 minutes	17	170	9.1	45.9
	More than 5 min up to 15 min	13	144	8.3	35.1
	More than 15 min	7	151	4.4	18.9
Distance	Less than or equal to 2 km	18	99	15.4	48.6
	More than 2km and less than 10km	14	130	9.7	37.8
	More than or equal to 10km	5	91	5.2	13.7
Activity Duration	Less than or equal to 10 min	18	145	11.0	48.6
	More than 10 min and up to 60 min	7	104	6.3	18.9
	More than 60 min	12	216	5.3	32.4
Trip purpose	Home	7	131	5.1	18.9
	Shopping	5	64	7.2	13.5
	Drop-off/Pick-up somebody	4	42	9.1	10.8
	Social Visits	3	20	13.0	8.1
	Work related business	3	77	3.8	8.1
	Other	5	131	3.7	13.5
	Not reported	10			27.0

Nine individuals had heavy travel, defined as ten or more trips for the travel day. These nine individuals travelled a total of 146 trips. However, only 129 trips were reported in the HTS, i.e., these individuals under-reported their trip rate by 10.4 percent. These seventeen missed trips represent 51.4 percent of the total trips missed by the HTS, supporting the notion that a greater number of trips leads to greater likelihood of failing to report a trip.

Twenty-one individuals had medium travel (six to nine trips), and made 147 trips, but reported 132 (under-reporting of 9.3 percent). These fifteen missed trips represent 35.1 percent of the total trips missed by the HTS.

Forty-six individuals had light travel, (five or less trips), made 172 trips, and reported 167 (under-reporting of 2.8 percent). These five missed trips represent 13.5 percent of the total trips missed by the HTS.

With the assumption that the first or last trips may be missed more than other trips, an analysis was completed on the trip numbers. However, no significant relationship was found between the trip number and missed trips. We also looked at the time of the day and what impact this had on the under-reporting of trips. As expected, evening trips were missed most

often. Ten percent of trips after five o'clock in the afternoon were not reported. This represents forty-one percent of all the trips missed by the HTS.

Further analysis of the trips that were not reported shows that most of them were short trips. Seventeen missed trips had a travel time of five minutes or less, (nine percent of all such trips and 46 percent of all missed trips). The significance of this is emphasised by the fact that 36 percent of all the trips with travel time reported (185 out of 502) were short trips. Eight percent of trips that lasted for more than five minutes and less than or equal to fifteen minutes were missed, (35 percent of all missed trips). As expected the longer trips (longer than 15 minutes) were relatively well recorded, with only four percent being missed (19 percent of the missed trips).

Distance was also a factor influencing the type of trip that was not reported by respondents. Eighteen out of 117 (15.4 percent) trips less than or equal to two kilometres long were missed, (49 percent of missed trips), whereas only five trips were missed that had a distance of ten kilometres or more. Thirty-one percent, (99 out of 320), of the trips with distance recorded were less than or equal to two kilometres.

The duration of the activity was also important in determining if a respondent reported it. Trips to an activity that lasted for up to ten minutes were missed by 11 percent. This is 49 percent of all missed trips. Thirty-two percent of missed trips had stays of more than one hour. This includes the last trip of the day back home, which was missed in nineteen percent of cases, although this is only 5.1 percent of all home trips.

5.2 Start and end time accuracy results

Comparison of data from the GPS and prompted recall survey with the HTS data resulted in forty trips from the total of 465 reported in the HTS being excluded from the following analysis because they could not be matched adequately.

The difference between the start times of trips reported by respondents to the HTS and that recorded by the GPS is presented in Table 5. The start time was not reported for ten trips. The figures in the table exclude these missing data, leaving 415 trips to be examined. Just over 50 percent of trips were reported within two minutes of the actual starting time recorded by the GPS. However, only 86 percent of respondents correctly reported their start time within 12.5 minutes. This indicates a significant level of inaccuracy in reporting travel time correctly. The start time of three trips was reported an hour or more earlier than the actual start time by two persons. All three trips had the same trip purpose reported as in the prompted recall surveys, but only one reported a similar distance. This trip's travel time was however, under-reported by 31 minutes. Seven trips from three respondents reported the start time as being an hour or more later than was the case. Travel time was similar for all of these trips, two had different trip purposes, five reported similar distances, one did not report distance and one over-reported distance by 23 kilometres.

Table 6 illustrates the differences between the reported and the GPS recorded trip-end times. There were eleven trips where it was not reported, and are excluded from the table, leaving 414 trips to be examined. Eighty-six percent of trip-ends were reported within 12.5 minutes. One respondent reported the time of ending a trip an hour or more earlier than the actual trip-end time. This respondent reported the same travel time and trip purpose as recorded by the GPS and the prompted recall survey. The same seven trips that were reported as starting an hour or more later than the actual start time were also reported as ending an hour or more later than the actual end time.

Table 5: Start Time Differences

GPS and HTS Difference (+ or -)	TRIPS	Percent
0 (exactly matched)	65	15.7
0 to 1 minute	152	36.6
0 to 2 minutes	213	51.3
0 to 5 minutes	294	70.8
0 to 12.5 minutes	355	85.5
0 to 30 minutes	392	94.5
0 minutes to 1 hour	409	98.6
All	415	100.0

Table 6: End Time Differences

GPS and HTS Difference (+ or -)	TRIPS	Percent of Total Trips
0 (exactly matched)	70	16.9
0 to 1 minute	166	40.1
0 to 2 minutes	218	52.7
0 to 5 minutes	295	71.3
0 to 12.5 minutes	356	86.0
0 to 30 minutes	392	94.7
0 minutes to 1 hour	407	98.3
0 minutes to more than 1 hour	414	100.0

5.3 Travel duration difference results

A total of 413 trips were analysed for travel duration with twelve having no reported travel duration in the diary. The reported travel duration was more accurate than the reported start and end times – 93 percent reporting within 12.5 minutes of the recorded travel time, (see Table 7). Seventy-eight percent reported within five minutes of the recorded travel time. The largest over-reporting of travel duration was 57 minutes while the largest under-reporting was 44 minutes. There were 89 cases (22 percent) of the exact same travel time reported as that recorded by GPS.

Table 7: Travel Duration Difference

GPS and HTS Difference (+ or -)	TRIPS	Percent of Total Trips
0 (exactly matched)	89	21.5
0 to 1 minute	173	41.9
0 to 2 minutes	236	57.1
0 to 5 minutes	323	78.2
0 to 12.5 minutes	385	93.2
0 to more than 12.5 minutes	413	100.0

Table 8 illustrates the level of over-reporting of travel time. Over half of the trips were over-reported, yet only six percent were over-reported by more than 12.5 minutes.

Table 8: Over-reporting of Travel Time by HTS

GPS minus HTS	TRIPS	Percent of Total Trips
-0.01 to -1 minute	46	11.1
-1.01 to -2 minutes	35	8.5
-2.01 to -5 minutes	63	15.3
-5.01 to -12.5 minutes	45	10.9
<-12.5 minutes	24	5.8
TOTAL	213	51.6

Table 9 illustrates the level of under-reporting in travel time. Twenty-seven percent of trips were under-reported. However, almost all (99 percent) of these were under-reported by 12.5 minutes or less. A total of 25 percent more trips were over-reported than were under-reported (51.6 percent to 26.9 percent).

Table 9: Under-reporting of Travel Time by HTS

GPS minus HTS	TRIPS	Percent of Total Trips
0.01 to 1 minute	38	9.2
1.01 to 2 minutes	28	6.8
2.01 to 5 minutes	24	5.8
5.01 to 12.5 minutes	17	4.1
>12.5 minutes	4	1.0
TOTAL	111	26.9

5.4 Trip distance difference results

TPDC has long been aware of the general inaccuracy of reported distance in the HTS and, though retaining the question at this stage, does not use the data for analysis. Instead, all distance analysis is based on GIS-calculated distance from the origin and destination of each trip. In the HTS, distance was only asked for private vehicle driver trips. Therefore, trips on public transport modes, walking, or bicycling could not be analysed despite having these data from the wearable devices. All 278 trips using the private vehicle mode had their distance reported by respondents for the HTS and if a trip was reported as 1 kilometre or less in distance it was recorded as 1km. Forty-eight trips (17.3 percent) were reported exactly the same as that recorded by the GPS. A total of 150 trips (54 percent) had distance over-reported. That is, respondents to the HTS reported longer distances than the GPS recorded. As can be seen from Table 10, 27.4 percent of trips had travel distance over-reported by more than one kilometre while 11.2 percent were over-reported by more than 2.5 kilometres.

Table 10: Over-reporting of Trip Distance HTS

GPS minus HTS	TRIPS	Percent of Total Trips
-0.01 to -0.1 km	9	3.2
-0.101 to -0.5 km	40	14.4
-0.501 to -1.0 km	25	9.0
-1.001 to -2.5 km	45	16.2
-2.501 to – 5 km	18	6.5
-5.001 to -10 km	6	2.2
< -10 km	7	2.5
Total	150	54.0

Eighty trips (28.8 percent) had distance under-reported. Table 11 shows that 15.1 percent of trips were under-reported by more than one kilometre, while 9 percent were under-reported by more than 2.5 kilometres.

Table 11: Under-reporting of Trip Distance HTS

GPS minus HTS	TRIPS	Percent of Total Trips
0.01 to 0.1 km	5	1.8
0.101 to 0.5 km	20	7.2
0.501 to 1.0 km	13	4.7
1.001 to 2.5 km	17	6.1
2.501 to 5 km	10	3.6
5.001 to 10 km	10	3.6
> 10 km	5	1.8
Total	80	28.8

Forty percent of trips were accurately reported within one kilometre of the distance recorded by the GPS. In total there were 25.2 percent more trips that had distance over-reported than under-reported which has led to an average over-estimation of 0.78 kilometres.

6 Conclusions

The various prompted recall methods met with a range of success in achieving a high response rate. The internet survey, while a popular choice for many respondents, had a high rate of drop-outs and non-completes. The face-to-face option was successful at getting all respondents to complete the survey, but was not chosen by many respondents. The phone recall method was chosen by most respondents and, despite problems encountered in contacting these respondents, almost all of them completed the survey. The self-administered option was also successful in getting all respondents to complete the survey.

Several inaccuracies have been noted. First, while the start, end, and travel surveys. The Sydney Household Travel time is clearly over-reported. Second, while trip distance was well reported (100 percent of private vehicle trips) the accuracy of reporting was not as good as for travel time. As for travel time, trip distance was over-reported. Similar rates of over- and under-reporting were evident for distance and travel time, however the level of this erroneous reporting was greater for distance. Third, the level of under-reporting of trips is a concern, with 7.4 percent of trips missed by the Sydney HTS. The characteristics of these missed trips is a defining factor with the majority of them being short trips (both in time and distance), trips starting after 5pm, trips with a short amount of time spent at the destination, and trips by respondents who have many trips in one day.

This study demonstrates that GPS can be used successfully to supplement travel diary surveys. When utilised in conjunction with household travel surveys, GPS technology can be used as a basis of comparison as well as a method to produce correction factors for such variables as trip rates, trip distance, and travel time. Future research may focus on the use of correction factors obtained from this technology to expand sample statistics to wider general populations. In this study we have found a high level of over-reporting of trip distance and trip duration suggesting the benefits of using GPS as a supplement to household travel surveys.

The GPS part of this study gathered more than one day's worth of data. Only one day was used for this study. However, if more were to be collected, this could used to test for variability across days.

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8 Acknowledgements

The authors would like to acknowledge the financial support of the New South Wales Roads and Traffic Authority for this research and the assistance of the Transport and Population Data Centre for the use of both their interviewers and data in undertaking this research. Any errors in this paper, however, are solely those of the authors.