Results of an Evaluation of TravelSmart in South Australia

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Abstract

Beginning in 2005, an evaluation was undertaken of a TravelSmart project in South Australia. The evaluation was undertaken using a panel of households, members of which were asked to carry GPS devices with them for a number of days. The panel comprised 200 households, and only household members over the age of 14 were asked to carry the GPS devices. This paper reports on the three waves of panel measurement that took place in 2005-2007. It documents the successes and failures of the panel survey, and describes the results, which indicate a substantial decrease in car use and some potential decrease in car ownership among households that participated in TravelSmart, compared to those that did not.

Introduction and Background

During 2005 and 2006, the South Australian Department of Transport, Energy and Infrastructure (SA DTEI[1]) commenced implementation of a Voluntary Travel Behaviour Change (VTBC) program in Western Adelaide (see Figure 1). Although approaches to VTBC have differed across Australia, VTBC programs have consistently been branded under the *TravelSmart* banner (Red3, 2005) and this TravelSmart project was called *TravelSmart Households In the West* (referred to in this paper as TravelSmart).

TravelSmart engaged residents in a targeted area using a model for behaviour change that had two components: a community development approach and an individual conversation-based approach (Government of SA, 2009). 22,101 households had a guided conversation to assist individuals to reduce their car use. Tools were provided to address their specific needs rather than given en masse as with a general marketing approach (Tideman et al., 2006). To evaluate this project independently, SA DTEI contracted the Institute of Transport and Logistics Studies (ITLS). The evaluation focussed on the revealed change in household travel behaviour measured in vehicle kilometres travelled (VKT), and the number and type of trips made by persons and households. This was achieved through the use of two independent longitudinal panel surveys of households;

[1] Formerly the South Australian Department for Transport and Urban Planning (SA DTUP)

the first panel reporting the odometer readings of all household vehicles every four months, described elsewhere (Stopher et al., 2007a) and the second using personal passive Global Positioning System (GPS) devices to record travel for a period of one week annually. This paper reviews the GPS results and reports on the changes in trip-making by mode and by purpose between wave 1, wave 2, and wave 3.

Evaluation of VTBCP initiatives has consistently been identified as somewhat problematic (Ker, 2002; Taylor and Ampt, 2003; Ampt, 2001). The challenge for evaluators is to identify the occurrence of travel behaviour change, quantify it and describe its character. GPS surveys have been recommended (Stopher *et al.,* 2005) as a potentially valuable tool for fulfilling these requirements. To our knowledge, this is the first such full-scale evaluation of TravelSmart to be conducted with GPS technology.

METHODOLOGY

This TravelSmart project was rolled out in Adelaide beginning in late 2005 and continued to the end of 2006. The evaluation surveys began in advance of TravelSmart implementation to establish baseline measures for travel behaviour, and finished at the end of 2007, a year after implementation of TravelSmart was completed. The GPS survey involved all household members over the age of 14 carrying a personal passive GPS data logger for a period of one week (or 15 days for a small sub-sample) to record all their travel and repeating this once each year for three years. In addition to carrying the GPS devices, household members were asked to charge the device overnight every night and whenever else possible and to wait for the device to indicate that it had obtained a GPS signal before beginning a trip, whenever possible. By analysing the data collected on the GPS devices in conjunction with extensive Geographic Information System (GIS) data for Adelaide, the number of trips made, their duration, and length can be identified, and the mode of transport can be inferred. Compared to using traditional travel diaries, for collecting seven or more days of data, GPS is a much more accurate and much lower burden alternative (Swann 2006). The GPS logger used for this study was developed by a South Australian firm in conjunction with ITLS and is shown in Figure 2.

Households that agreed to take part in the study were asked to complete a number of survey forms in addition to their use of the GPS devices. These forms collected household and vehicle information with an important addition – the two grocery stores they visit most often and, if applicable, the addresses of each person’s primary place of work and study. These are used in the map editing process for the GPS data. The completed household and vehicle information forms and the GPS data loggers were returned at the end of the data collection period and the data were downloaded and processed.

After a household completed the forms once, they were provided with pre-printed forms that displayed their most recently reported data. The respondent was asked to check

for any errors or for anything that had changed in the twelve months since they last did the survey and note down any changes. An additional survey form (see

Figure 3) was used in waves 2 and 3, which was designed to determine whether days with no data were legitimate no-travel days, the result of the respondent leaving the device behind, or a result of the device failing to record because of exhausted battery or other problems.

Figure 1: The TravelSmart Households in the West Target area and Evaluation Zone

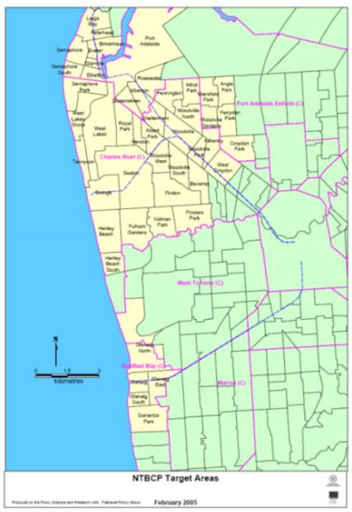
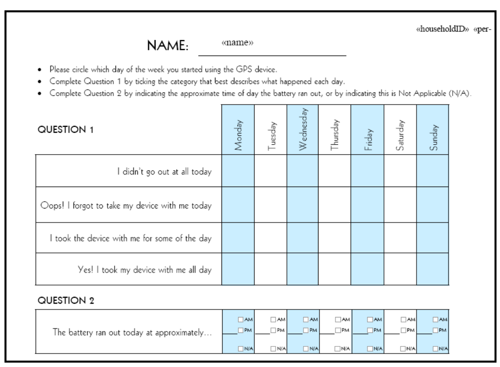


Figure 2: The Neve GPS Device in Comparison to a Standard Nokia Mobile Phone

Figure 3: The GPS Form for Collecting Device Usage Data



«householdID» «per-

NAME: «name»

- Please circle which day of the week you started using the GPS device.
- Complete Question 1 by ticking the category that best describes what happened each day.
- Complete Question 2 by indicating the approximate time of day the battery ran out, or by indicating this is Not Applicable (N/A).

QUESTION 1	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
I didn't go out at all today							
Oops! I forgot to take my device with me today							
I took the device with me for some of the day							
Yes! I took my device with me all day							

QUESTION 2

The battery ran out today at approximately…	☐AM ☐PM ☐N/A	☐AM ☐PM ☐N/A	☐AM ☐PM ☐N/A	☐AM ☐PM ☐N/A	☐AM ☐PM ☐N/A	☐AM ☐PM ☐N/A	☐AM ☐PM ☐N/A

RECRUITMENT STRATEGY AND PROCESS

The sample for the GPS survey was drawn from a GIS layer of land parcels supplied by the SA DTEI and was limited to suburbs in the evaluation zone. The sample was drawn randomly from all the residentially-zoned land parcels in the evaluation zone. There was concern that, because a proportion of households do not have landline telephones or have unlisted numbers, telephone recruitment would lead to coverage error. Because of this, when the study first went into the field for the first wave of the Pilot Survey, the first recruitment drive was conducted by post. This method was slow and unproductive and was replaced by telephone recruitment in which sampling was conducted by residential address and phone numbers were matched to the sample. To provide households without a matched telephone number with an opportunity to participate, all households in the sample frame were sent a pre-notification letter signed by an SA DTEI official together with other survey materials.

When non-matched households returned this information, they were contacted by telephone to arrange for the courier delivery of the GPS devices. The GPS package contained a GPS device for every household member over 14 years of age in a protective plastic case with a belt clip (as with mobile phone cases) and labelled for each user to avoid mixing the devices between household members. In addition, each package contained a charger for each GPS device and instructions on how to use the GPS device. Matched households were asked to return the completed forms with the returned GPS devices. At the end of the data collection period, households were re-contacted and arrangements made for the courier pick-up of devices from households. In subsequent waves, households were recontacted to confirm their willingness to continue participating, to confirm details of persons over 14[2] currently living in the household and to confirm their residence address. Households that had moved, but were still within the evaluation zone were invited to continue participating, but households that had moved outside the evaluation zone were thanked and discontinued from the sample.

During 2005 and 2006, ITLS conducted a parallel GPS survey for the National Travel Behaviour Change Project (NTBCP). For this study, there were 50 additional households in western Adelaide using the GPS devices for one month at six monthly intervals. When the NTBCP project was completed, these households were invited to continue to take part in the studies being conducted for the SA DTEI. These households were much more valuable as replacement sample than new recruits because they had a history of data that could be used in measuring changes in behaviour. These households then participated in wave 2 of the main study which occurred 6 months after their previous participation in the NTBCP survey, but were requested to use their GPS devices for 15 days rather than seven.

MAINTAINING THE PANEL

As with any panel, the GPS panel survey faced significant problems with attrition, especially with a frequency of survey of once per year. To make up for households that dropped out of the sample or could not be contacted, replacement recruitment was conducted in wave 2 to supplement the sample. The second method of recruitment (telephone) was used for all replacement recruitment. Replacement recruitment was conducted only in wave 2 both to replace households lost to attrition and to ensure target levels of recruitment in wave 3 would be reached without further replacements, because a household needs to return GPS data in at least two waves to provide information on

[2] If a child turned 14 between waves, then this child would be included in subsequent waves of the survey.

changes in travel behaviour. Newsletters were produced for participants in the GPS study and were distributed shortly before field work was initiated for both waves 2 and 3. The newsletter acted as a pre-notification letter as well as providing important information about the study, the research's progress, and answers to frequently asked questions about the devices.

METHOD OF ANALYSIS

Data Processing

ITLS has developed software specifically for the purpose of processing the information recorded by the GPS devices (Stopher, 2008). First, the data for each person are downloaded. A procedure known as 'Trip Identification' is applied to each person's data. This procedure breaks the data up into individual trips, by looking for periods of non-movement of 120 seconds or more. Such a period is assumed to mark a stop at the end of a trip, with the next trip beginning when movement is once again detected. It also checks for a change in the speed profile in the trip, as would appear for example if someone were to park their car and immediately go for a walk. While very effective, this technique is not 100 percent accurate, and some manual editing of the resulting trips must therefore be carried out. One problem often encountered with GPS devices is the 'cold start'. This is a period of no data collection when the device is turned on. It is caused by the device trying to get a lock on satellites which have moved since its last position reading, and usually lasts 1 or 2 minutes. Cold starts and other causes of signal loss mean that gaps will appear in the trip data. The ITLS software is able to fill in these gaps using a process called 'Trip Linking'. This looks at the distance between the gaps, and also the speed profiles of trips before and after the gap, to automatically generate trip information.

The trip identification procedure also records the distance travelled, the duration, the start and end times of the trip, and the maximum and average speed during the trip. The process also automatically generates a map for each day's data, overlaid onto a street map (Figure 4). Each individual trip is colour coded. After the trip identification process is complete, a visual check is carried out of all the trips generated. This looks for errors in the trips, such as inaccurate trip linking, trip ends incorrectly defined, or just corrupted data. The generated maps serve as a necessary visual aid for this process.

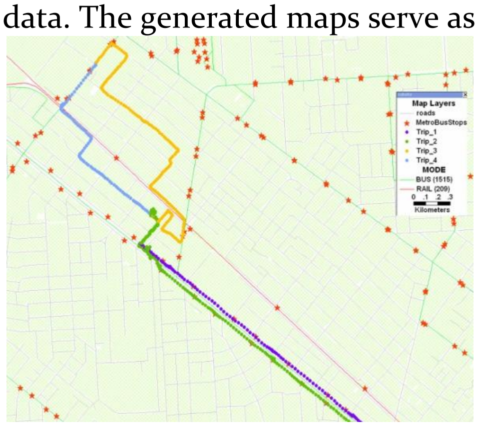


Figure 4: A Typical Map of a Day's Travel as Produced by Our Software

Unfortunately, GPS data do not provide any information directly on the mode of transport used. However, this can be deduced with high accuracy from the trip information recorded by the GPS device, provided there are adequate GIS databases for the urban area and adequate demographic information about the GPS user (Clifford, Zhang, and Stopher, 2007). In this project, five different modes of transport were considered: walk, bicycle, private car, public bus or tram, and rail. For mode identification, the GIS information required comprises the street network, all public transport routes, and all bus stops and station locations.

The identification of travel mode is a hierarchical process, using heuristics based on speed and route of travel, as well as some demographic information. The easiest mode to identify is walk, because of the consistently low speeds for the entire trip segment. Rail trips are identified next, because the trip route will coincide with rail lines which are not on the street network. The next mode to be identified is bus. This is based on maximum (85^{th} percentile) and average speed, and on the trip segment beginning and ending close to a bus stop. The trip should be along a bus route for its entirety, and should also show deceleration near at least two bus stops along the trip. Bicycle trips are identified next. The demographic information is examined to see if the person has a bicycle in their household. If not, then no trip segments are assumed to be by bicycle. If at least one is owned, then the bicycle trips are identified by examining the maximum speed, average speed and acceleration. All remaining trips should then be trips by car. However, a further check is made of maximum speed and acceleration, and also that the trip segment remains on the road network. If these are correct, then the trip segment is identified as being by car. As yet, we cannot determine whether the trip is by a car driver or a car passenger, which is a significant failing for the GPS method of measurement at this point, given that TravelSmart is hoped to encourage carpooling. However, it is expected that future refinements to the software will allow this to be detected.

Once all the trip information is processed, the data are checked for survey days that have no travel recorded. For waves two and three, information was requested from each person regarding whether days with no recorded data were legitimate no-travel days, or if the person just forgot to carry around their device. Generally, if a person had no data for four or more days in a week, and was either employed or a student, they were considered not to have completed the survey, and their data were removed before the final analysis was carried out. Homemakers and the retired or unemployed were permitted up to five days a week with no travel data. If a person indicated that they had limited mobility, or gave information to indicate that they had actually not travelled on the days in question, their data were not deleted.

RESULTS

RESPONSE RATES AND ATTRITION

Initially, a two-wave pilot survey was conducted. The first pilot wave was conducted in May-June 2005 and the second wave in September 2005. The second wave coincided with the first wave of the main survey and the households completing the second wave of the pilot were added into the first wave of the main survey, because the pilot survey did not indicate the need for any significant changes to the survey procedure. The first wave of the GPS study commenced with a prenotification mail-out in July 2005. The response rates for this wave are shown in Table 1. A sample of 1000 households was randomly drawn and posted a pre-notification letter; of these, 699 households were contacted. The data collection period for the 167 recruited households was August-November 2005. This wave of the survey was completed by 151 households. The final data set for wave 1 also included data from 51 households who had completed the pilot study. The data collection period for these participants was June-September 2005. Data collection took place for wave 2 from August to October, 2006, and for wave 3 from September to November, 2007. The recruitment and continuation rates for waves 2 and 3 are shown in Table 2.

Table 1: Sample Disposition for the Initial GPS Recruitment Panel for Wave 1

Disposition	*Pilot Wave 1*	*Pilot Wave 2*	*Main Wave 1*	*Main Wave 1 Plus Pilot Wave 2*
Sample	280		1000	1280
Attempted to contact	280	54	699	979
Known Refusing Households	94 (34%)	0	323 (46%)	417 (43%)
Total ineligible	63 (23%)	0	209 (30%)	272 (28%)
Households Recruited	55 (25%)†	54 (100%)	167 (34%)†	221(31%)†
Households failing to comply	1 (2%)*	3 (6%)*	16 (10%)*	19 (9%)*
Households complete wave 1	54 (98%)*	51 (94%)*	151 (90%)*	202 (91%)*

† Percent of Eligible Households
** Percent of Recruited Households*

Table 2: Sample Disposition for Waves 2 and 3 of the GPS Panel

Disposition	*Main Wave 1*	*15-day Households*	*New Recruits*	*Final Total Wave 2*	*Main Wave 2*	*15-day Households*	*Final Total Wave 3*
Sample			550				
Approached	200	44	338		246	33	279
Ineligible	25 (13%)	3 (7%)	21 (6%)		9 (3.7%)	1 (3%)	10 (3.6%)
Refused	26 (13%)	4 (9%)	165 (49%)		38 (15.4%)	4 (12.1%)	42 (15.1%)
Continuing/Recruited	149 (75%)	37 (84%)	152 (45%)	338	199 (80.9%)	28 (84.8%)	227 (81.4%)
Did not comply	11 (7%)*	1(3%)*	18 (12%)*	30 (9%)	21 (11%)†	9 (32%)†	30 (13%)†
Completed	138 (93%)*	36 (97%)*	134 (88%)*	308 (91%)	178 (89%)†	19 (68%)†	197 (87%)†

**Percent of Recruited Households*
†Percent of Continuing Households

ANALYSIS OF THE DATA

Households were being recruited actively to TravelSmart during the second wave period. About two-thirds of the panel members in the second wave were TravelSmart participants. Of most importance are the differences between waves by households that were measured in two or more waves. For this analysis, the GPS data from the three waves were merged and aggregated to households. Differences between each pair of waves were calculated, i.e., waves 1 and 2, waves 2 and 3, and waves 1 and 3. The results were analysed for all modes, but only the results from total travel and car are reported in detail in this paper. The decision to restrict the analysis to these modes is based partly on the fact that there is little difference apparent in the overall statistics in bus, bicycle, rail, and walk.

Table 3 shows the changes in numbers of trips, travel distance, and travel time per day at the household level for all modes of travel, for each of three groups of respondents and for three groupings of days of the week. The 95 percent confidence limit is shown in brackets under each difference. If the value in brackets is smaller than the value above it, then the difference is statistically significant at 95 percent confidence. The statistically significant results are marked with asterisks.

Table 3: Differences Between Waves for Total Travel per Household

Group	Days	Difference (95% Confidence Limit)								
		Number of Trips per Day			*Travel Distance per Day*			*Travel Time per Day*		
		Waves 1 to 2	*Waves 2 to 3*	*Waves 1 to 3*	*Waves 1 to 2*	*Waves 2 to 3*	*Waves 1 to 3*	*Waves 1 to 2*	*Waves 2 to 3*	*Waves 1 to 3*
All Respondent Households	All Days	-1.03**	1.85**	0.16	-10.14**	5.51	-6.35*	-9.75**	10.14**	-3.29
		(0.48)	(0.45)	(0.46)	(4.59)	(5.54)	(5.43)	(7.38)	(7.68)	(8.18)
	Weekdays	-1.04**	2.13**	0.37	-8.82**	6.39*	-2.90	-9.19*	11.67**	0.68
		(0.58)	(0.54)	(0.57)	(5.26)	(5.99)	(6.17)	(8.83)	(8.97)	(9.86)
	Weekend Days	-1.01**	1.13**	-0.37	-13.46**	3.30	-14.97**	-11.16	6.32	-13.21
		(0.85)	(0.81)	(0.75)	(9.20)	(12.37)	(11.12)	(13.29)	(14.87)	(14.36)
TS Participant Households	All Days	-1.14**	1.71**	-0.57	-8.13**	1.26	-15.64**	-10.48	3.01	-20.39**
		(0.67)	(0.53)	(0.65)	(6.34)	(6.77)	(7.53)	(10.69)	(9.36)	(11.71)
	Weekdays	-1.07**	1.99**	-0.60	-4.28	0.44	-11.62**	-5.11	0.66	-19.90**
		(0.82)	(0.63)	(0.80)	(7.65)	(7.21)	(8.55)	(13.11)	(10.83)	(14.34)
	Weekend Days	-1.31*	1.01**	-0.51	-17.76**	3.33	-25.68**	-23.91**	8.88	-21.63**
		(1.14)	(0.54)	(0.58)	(6.23)	(8.77)	(8.70)	(9.78)	(10.41)	(10.87)
Non-Participant Households	All Days	-0.93*	2.13**	1.07**	-12.09**	14.52**	5.20*	-9.04**	25.29**	17.98**
		(0.82)	(0.48)	(0.44)	(4.77)	(5.42)	(5.11)	(7.24)	(7.54)	(7.26)
	Weekdays	-1.01*	2.43**	1.58**	-13.21**	19.04**	7.94**	-13.14**	35.05**	26.26**
		(0.99)	(0.57)	(0.54)	(5.32)	(6.07)	(6.24)	(8.66)	(8.85)	(8.72)
	Weekend Days	-0.72	1.40**	-0.20	-9.30	3.24	-1.66	1.18	0.89	-2.73
		(1.44)	(0.85)	(0.68)	(10.09)	(11.51)	(8.91)	(13.19)	(14.43)	(13.07)

* Significant at 95 percent confidence
** Significant at 99 percent confidence

Between waves 1 and 2, the number of daily trips per household fell significantly for both TravelSmart participant households and non-participant households, with the exception of weekend days for non-participants. Between the participants and non-participants, the decreases for the participants were more highly significant and of larger magnitude than for non-participants. In contrast, between waves 2 and 3, trip making increased for all three groups of respondents, and for all days, although the increases in this period were much larger for non-participants than for participants. Comparing wave 1 to wave 3 (which is restricted to those households who responded to both the first and third wave), the participants exhibited a net decrease in trip making, although it was not statistically significant for any of the groups of days, while non-participants showed statistically significant increases for all days and for weekdays. From this, TravelSmart appears to have resulted in no net increase in number of trips over the two-year period, whereas non-participants increased their numbers of trips significantly over the period.

Participant households decreased their total travel distance (person kilometres of travel or PKT) very significantly on weekdays and weekend days, especially between wave 1 and wave 3. In contrast, non-participant households increased their total travel distance significantly on weekdays. The weekday decrease for TravelSmart participant households was 11.6 kms, while non-participant households increased by 7.9 km, suggesting that TravelSmart participant households reduced their travel distances comparatively by an average of almost 20 km per day. Given that the average travel distance per day was around 110 kilometres, this suggests an absolute decrease of about 18 percent, assuming that participants would have behaved like non-participants without the TravelSmart project. Conservatively, based on just the decrease for participant households and ignoring the trend shown by non-participants, the reduction in total household travel distance is about 10 percent. Total travel time shows a similar pattern, with participant households decreasing their total travel time significantly, by an average of around 20 minutes per day, while non-participant households increased their travel time per day significantly by around 18 minutes per day overall, and as much as 26 minutes on weekdays.

Table 4 shows the results for car travel. The number of trips made by car shows only one or two significant changes, such as an increase in trips on weekdays between waves 2 and 3 by participant households, and a decrease on weekends between waves 1 and 3 by this group. Non-participant households significantly increased trips per day between waves 2 and 3 and 1 and 3 for all days, weekdays, and weekend days. Between waves 1 and 2, all groups had significant decreases in travel distance per day. However, non-participants then increased their travel distance per day significantly between waves 2 and 3 and also waves 1 and 3 (except on weekends), while TravelSmart participants reduced travel (but not significantly) between waves 2 and 3, but showed significant decreases in travel distance for all days, weekdays, and weekend days between waves 1 and 3. In terms of travel time, non-participants exhibited a significant increase between waves 2 and 3 and also 1 and 3, while participants decreased travel time significantly between waves 1 and 3 on weekends, and showed decreases that were not statistically significant for waves 2 to 3 and 1 to 3 for all other categories of days.

Table 4 leads to the conclusion that participant households have not increased the number of trips made significantly between waves 1 and 3, while non-participant households did. Also, this table indicates that participants decreased their daily travel by car by about 10 kilometres on weekdays and 36 kilometres on weekend days, while non-participants increased their travel distances by 14 kilometres on weekdays and (not significantly) by 4.5 kilometres on weekend days. It must also be kept in mind that the GPS measurement is unable to distinguish between car drivers and car passengers. Therefore, if shared riding increased for participants, this would lead to an even larger decrease in *vehicle* kilometres of travel than is indicated by the *person* kilometres of travel. If it can be assumed that participants would have behaved like non-participants, without the TravelSmart project, then they have exhibited a decrease of about 24 kilometres per household per day between the first and third waves of the panel on weekdays.

A similar analysis for bus and bicycle revealed a significant decrease in bus trips by all groups for all days between waves 1 and 3. In the period between waves 2 and 3, there was a scattering of significant increases in bus use. In terms of the increases, these are most marked for participant households, which show highly significant increases in numbers of trips on weekdays and all days taken together. Non-participant households show a smaller increase with much less significance for weekdays. In the case of participant households on all days, where there is a significant increase in trips between waves 2 and 3, there are also corresponding significant increases in both travel distance and travel time. Overall, there appears to be some evidence that bus ridership may have increased for both participants and non-participants between waves 2 and 3, although this has not been enough to offset yet the decline in bus use exhibited by both groups between waves 1 and 2. The increase by participants averages 50 percent greater than non-participants on weekdays. Non-participant households showed more significant increases in bicycle trips than participant households, with participants actually significantly decreasing bicycling on weekdays, while non-participants increased bicycling significantly on weekdays. The average travel distance between waves 1 and 3 declined significantly for all groups on all days (except for participants on weekend days, where there was an insignificant change). Similarly, travel time by bicycle decreased in an identical pattern between waves 1 and 3. However, there were very few bicycle trips measured and significance could not be established.

Table 4: Differences Between Waves for Car Travel per Household

Group	Days	Difference (95% Confidence Limit)								
		Number of Trips per Day			*Travel Distance per Day*			*Travel Time per Day*		
		Waves 1 to 2	***Waves 2 to 3***	***Waves 1 to 3***	***Waves 1 to 2***	***Waves 2 to 3***	***Waves 1 to 3***	***Waves 1 to 2***	***Waves 2 to 3***	***Waves 1 to 3***
All Respondent Households	All Days	-0.41*	0.77**	0.10	-12.41**	3.14	-3.31	-1.09	-0.35	6.62
		(0.37)	(0.35)	(0.39)	(5.08)	(6.18)	(6.16)	(7.05)	(7.23)	(8.25)
	Weekdays	-0.26	0.88**	0.30	-9.82**	4.48	0.48	1.19	2.00	10.32*
		(0.45)	(0.42)	(0.48)	(5.68)	(6.41)	(6.72)	(8.33)	(8.06)	(9.66)
	Weekend Days	-0.80*	0.52	-0.39	-20.79**	-1.42	-16.04*	-8.45	-8.38	-5.84
		(0.62)	(0.62)	(0.61)	(11.01)	(15.41)	(14.06)	(12.96)	(15.75)	(15.70)
TS Participant Households	All Days	-0.18	0.69	-0.35	-8.82**	-2.49	-15.86**	2.91	-6.27	-10.01
		(11.01)	(15.41)	(14.06)	(6.96)	(7.59)	(8.50)	(10.50)	(9.07)	(11.92)
	Weekdays	0.09	0.81**	-0.24	-4.05	-2.17	-10.44*	8.23	-5.41	-5.80
		(0.69)	(0.49)	(0.70)	(8.17)	(7.74)	(9.24)	(12.67)	(10.05)	(14.10)
	Weekend Days	-0.86	0.38	-0.62*	-25.59**	-3.62	-35.77**	-15.76**	-9.31	-25.46**
		(0.89)	(0.42)	(0.50)	(7.34)	(11.03)	(11.05)	(9.73)	(11.37)	(12.18)
Non-Participant Households	All Days	-0.64*	0.95**	0.66**	-15.89**	14.93**	11.82**	-4.96	12.05**	26.65**
		(0.61)	(0.37)	(0.37)	(5.27)	(6.00)	(5.76)	(6.68)	(6.70)	(7.26)
	Weekdays	-0.60	1.01**	0.97**	-15.61**	18.73**	14.22**	-5.89**	17.89**	30.60**
		(0.75)	(0.44)	(0.47)	(5.74)	(6.45)	(6.78)	(0.43)	(0.44)	(0.47)
	Weekend Days	-0.75	0.81*	-0.11	-16.70**	2.82	4.52	-2.20	-6.60	14.62*
		(1.02)	(0.63)	(0.57)	(11.97)	(13.99)	(10.84)	(12.38)	(14.29)	(13.19)

* *Significant at 95 percent confidence*
** *Significant at 99 percent confidence*

The overall conclusion is that TravelSmart in this case has decreased overall trip making by participant households, which is in contrast to a number of other TravelSmart results that have been reported. This may be due to the fact that this TravelSmart project was based on solving household travel problems, and not on an overt attempt to persuade household members to change travel mode. It can also be concluded that there has been a highly significant decrease in kilometres of travel by participant households, most of which has occurred for the car. While participant households decreased their travel distances, non-participant households showed significant increases in kilometres travelled, suggesting that TravelSmart not only resulted in a decrease in kilometres travelled, but also reversed a trend of increasing person kilometres of travel.

Table 5 shows a comparison of car ownership for the GPS panel. The car ownership for non-participant households shows an increase as the survey progresses, whereas the ownership level decreases for participant households. However only one of these values is calculated to be statistically significant at the 95 percent level.

Table 5: Comparison of Average Vehicle Ownership per Household for the GPS Panels

	Average Car Ownership per Household			Change in Average Car Ownership per Household		
	Waves 1	Waves 2	Waves 3	Wave 1 to 2	Wave 2 to 3	Wave 1 to 3
All Respondents	1.598	1.680	1.736	0.082	0.055	0.138
TS-Participants	1.797	1.694	1.712	-0.103	0.017	-0.085
Non- Participants	1.497	1.656	1.789	0.159	0.133	0.292*

** Indicates a difference that is statistically significant at 95 percent*

EXPANSION OF FINDINGS

With 22,101 households participating from a total of 64,709 households in the study area, the results from the GPS Panel can be expanded to the full study area. Using the weekday car results, sample participant households reduced their car use by 10.4 kms per day, which translates to a reduction for all participant households of 229,850 kms per day. The sample non-participant households increased their travel by car by 14.2 kms per day, which means that the 42,608 non-participant households in the study area increased VKT by 605,030 kms. If the participant households had increased their travel distance over this period the same as the non-participants, then the increase in travel that would have been expected for the entire region is 918,870 kms. Instead, the actual net increase was 375,180 (605,030 – 229,850). This is based on the wave 1 to wave 3 differences. The savings due to TravelSmart are therefore 229,850 out of 4,756,100, or a reduction over the entire region of 4.8 percent. If one were to take this reduction on the 2005 average figure, then the percentage decrease comes to 6 percent.

DEMOGRAPHIC ANALYSIS

The demographic data collected from the GPS panel are shown in Tables 6 and 7. Table 7 also shows values from the 2001 and 2006 census. For both of these tables, an adult is defined as someone aged 18 or over. As can be seen from both tables, the demographic make-up of the panel is reasonably consistent, with no drastic changes between the waves.

Table 6: Summary Demographics for the Three GPS Waves in South Australia

Demographic (per household)	*Value*	*Recruited households*			*Households Used in Analysis*		
		Wave 1	*Wave 2*	*Wave 3*	*Wave 1*	*Wave 2*	*Wave 3*
Number of Persons	1	20.67%	17.42%	17.54%	20.57%	19.68%	16.35%
	2	35.10%	39.34%	37.28%	34.93%	35.81%	40.38%
	3	16.35%	15.92%	17.11%	16.27%	17.74%	14.90%
	4	21.63%	18.02%	21.49%	21.53%	20.65%	21.63%
	5+	6.25%	3.60%	6.58%	6.70%	6.13%	6.73%
	Missing	0.00%	5.71%	0.00%	0.00%	0.00%	0.00%
Number of Vehicles	0	3.85%	2.70%	3.51%	3.83%	2.90%	2.88%
	1	27.88%	37.24%	33.77%	28.23%	35.16%	34.13%
	2	44.71%	42.04%	42.54%	44.50%	40.65%	40.38%
	3+	14.42%	18.02%	20.18%	14.35%	20.00%	22.12%
	Missing	9.13%	0.00%	0.00%	9.09%	1.29%	0.48%
Number of Bicycles	0				22.49%	26.13%	21.15%
	1				25.36%	20.00%	14.42%
	2				16.27%	16.45%	16.35%
	3+				16.75%	17.42%	16.83%
	Missing				19.14%	20.00%	31.25%
Number of Adults	1				22.97%	23.23%	20.19%
	2				54.07%	54.19%	58.17%
	3				16.75%	14.19%	12.50%
	4+				6.22%	8.39%	9.13%
	Missing				0.00%	0.00%	0.00%
Number of Children	0				70.33%	70.97%	69.71%
	1				11.96%	10.97%	13.94%
	2				14.35%	15.16%	12.02%
	3+				3.35%	2.90%	4.33%
	Missing				0.00%	0.00%	0.00%
Number of Males	0				17.70%	17.10%	13.94%
	1				47.37%	51.29%	57.21%
	2				23.44%	23.23%	20.67%
	3+				9.57%	8.39%	8.17%
	Missing				1.91%	0.00%	0.00%
Number of Females	0				11.00%	8.39%	7.21%
	1				52.63%	59.03%	57.69%
	2				27.27%	24.19%	26.92%
	3+				7.18%	8.39%	8.17%
	Missing				1.91%	0.00%	0.00%
Number of Licensed Drivers	0				15.31%	2.90%	2.88%
	1				23.44%	27.74%	24.52%
	2				39.23%	48.06%	50.96%
	3+				20.57%	20.00%	19.23%
	Missing				1.44%	1.29%	2.40%
Number of Full-Time Workers	0				44.02%	39.35%	42.79%
	1				28.71%	39.68%	36.54%
	2+				26.32%	20.00%	18.27%
	Missing				0.96%	0.97%	2.40%
Number of Retired Persons	0				77.03%	68.71%	64.42%
	1+				22.01%	30.32%	33.17%
	Missing				0.96%	0.97%	2.40%
Number of Full-Time Students	0				68.42%	65.16%	67.31%
	1				12.92%	16.45%	13.46%
	2+				17.70%	17.42%	16.83%
	Missing				0.96%	0.97%	2.40%

The most notable difference is the proportion of one-person households, which drops in wave 3. This coincides with an increase in the number of two-person households, and a slight increase in average household size. The number of workers per household decreases slightly with each wave.

Table 7: Summary of the Demographics for the Three GPS Waves in South Australia with 2001 and 2006 Census Data*

Demographic (per household)	*Value*	*2001 Census - All Households*	*2006 Census - All Households*	*Recruited households*			*Households Used in Analysis*		
				Wave1	Wave2	Wave3	Wave1	Wave2	Wave3
Number of Persons	1	33.7%	32.82%	20.67%	18.47%	17.54%	20.57%	19.68%	16.35%
	2	34.2%	34.45%	35.10%	41.72%	37.28%	34.93%	35.81%	40.38%
	3	14.0%	14.07%	16.35%	16.88%	17.11%	16.27%	17.74%	14.90%
	4	12.1%	12.45%	21.63%	19.11%	21.49%	21.53%	20.65%	21.63%
	5+	6.1%	6.21%	6.25%	3.82%	6.58%	6.70%	6.13%	6.73%
Number of Vehicles	0	15.1%	14.35%	4.24%	2.70%	3.51%	4.21%	2.94%	2.89%
	1	44.1%	42.54%	30.68%	37.24%	33.77%	31.05%	35.62%	34.29%
	2	30.5%	32.05%	49.20%	42.04%	42.54%	48.95%	41.18%	40.57%
	3+	10.2%	11.07%	15.87%	18.02%	20.18%	15.78%	20.26%	22.23%
Average Number of Adults		1.90	1.97				2.08	2.08	2.11
Proportion of Population Adults		80.30%	80.45%				80.26%	80.32%	80.07%
Average Number of Children		0.47	0.48				0.51	0.51	0.52
Proportion of Population Children		19.7%	19.55%				19.74%	19.68%	19.93%
Average Number of Males		1.15 (48.52%)	1.19 (48.77%)				1.27 (48.66%)	1.25 (48.13%)	1.25 (47.53%)
Average Number of Females		1.22 (51.48%)	1.25 (51.23%)				1.34 (51.34%)	1.34 (51.87%)	1.38 (52.47%)
Average Number of Full-Time Workers		0.62	0.66				0.89	0.85	0.79
Average Number of Full-Time Students		0.40	0.45				0.53	0.55	0.50

** The South Australia census statistics are obtained by aggregating Port Adelaide Enfield (LGA45890) with Charles Sturt (LGA41060) and Holdfast Bay (LGA42600) to approximate the evaluation zone.*

Comparing with the 2006 census data, the households in the GPS panel are slightly larger, with an average of 2.08 – 2.11 adults per household (compared to 1.97) and 0.51 – 0.52 children per household (compared to 0.48). This is due to the panel being biased against one-person households and for four-person households. However the proportion of adults in the panel is close to the census data. There are more workers per household than recorded in the census, which may suggest a bias against low-income households. As is typical in almost all transport surveys, non-car-owning households are underrepresented. There is also an underrepresentation of one-vehicle households and an overrepresentation of households with two or more cars. It is interesting to note that the Adelaide Household Travel Survey of 1999 showed more people per household than the census, fewer non-car-owning households, a higher average number of vehicles per household, and more workers per household (Stopher and Pointer, 2004), very much as found in this GPS panel.

CORROBORATORY EVIDENCE

Public transport patronage data indicated an annual increase of over 6 percent in the Charles Sturt and Port Adelaide/Enfield areas since the implementation of TravelSmart, as shown in Table 8. The Holdfast Bay region showed an immediate increase of over 25 percent in 2005, however this coincided with the introduction of three new bus routes to the area. The region showed an increase of over 9 percent between 2006 and 2007. Non-targeted regions showed annual growth rates of less than 2 percent over the same period. The targeted areas also showed annual growth rates of less than 2 percent before the implementation of TravelSmart. All this indicates that TravelSmart had a positive effect on public transport usage in the targeted areas.

Table 8: Changes in Patronage through the Monitoring Period

		Period	*Holdfast Bay*	*Charles Sturt & Port Adelaide*	**Non-targeted areas**
Annual growth rate	Pre-TravelSmart	2003-2004	4.24%	2.18%	1.80%
		2004-2005	1.65%	1.82%	1.69%
	Post-TravelSmart	2005-2006	27.28%*	6.16%	1.43%
		2006-2007	9.64%	7.33%	-1.20%

* *Three bus routes were introduced to the region during this period*

There was no evidence that petrol prices had a significant effect on the travel behaviour changes estimated in this study. A detailed analysis was performed of petrol price changes against measured behaviour changes and no significant effects were established. It was hoped to use SCATS data to analyse traffic volume changes, but the data were not made available for the study and this remains to be done. Although a much larger panel of 1000 households was used for the odometer survey, the results from that survey generally did not provide statistically significant indicators, although the trends were in the same direction for car VKT.

CONCLUSION

This study has attempted to evaluate the success of the TravelSmart project in Western Adelaide in achieving its primary goals by use of a GPS travel survey and by examining corroboratory evidence. This was the largest scale GPS travel survey to take place in the country up to this time. One can also conclude from this study that the 200-household GPS panel has provided very adequate statistics for assessing modifications to behaviour by both participating and non-participating households.

Measurements began before TravelSmart commenced and repeated waves of data collection were carried out until the end of 2007. Panels were drawn solely from the areas targeted by TravelSmart, and consisted of both participants and non-participants. Comparisons between results from the two groups were used to establish behavioural change. A demographic analysis of the panels showed that the GPS panel, which was drawn at random from the region, was representative of the regional population, based on census figures. However, there was a slight bias away from single-person households, as is typical with most surveys. It also showed that the demographic composition of the panel did not change over the three waves of the GPS panel.

The GPS survey results indicated that TravelSmart succeeded in decreasing the person kilometres of travel by participant households over the 2-year survey period by 18 percent, most of which has occurred for the car. Over the same period, the average PKT for non-participant households has risen, especially for car. Comparing households that completed all three waves, participant households decreased their average daily travel distances by 15 km, while non-participant households increased theirs by 5km. This suggests that TravelSmart not only resulted in a decrease in kilometres travelled, but also reversed a trend of increasing person kilometres of travel. The overall decrease in car travel for participant households on weekdays may have been as much as 24 kilometres per day, which represents a decrease of about 22 percent in car kilometres of travel. Assuming that TravelSmart households numbered 22,101 out of a region total of 64,709 households, this interprets to an overall change of about 5 percent decrease in VKT on weekdays as a result of TravelSmart. This reduction in travel has amounted to a significant reduction in car travel, which is by far the most dominant mode of transport in the Adelaide region.

The major weakness of the panel approach was the attrition from one wave to the next, although this was expected based on other panels. It was far outweighed by the advantage of reducing variance in the measures from wave to wave and having information on differences in behaviour of the *same* households. The GPS measurement with 200 households in the panel was far superior to 1,000 households in an odometer panel. The superiority arose partly from the much greater statistical significance of the results (mainly resulting from multiple days of data for the GPS households) and partly from the accuracy of GPS measurement of travel distances and times. In addition, the GPS survey measures all travel, while the odometer survey measures only travel by car. With future improvements in the analysis software to estimate vehicle occupancy, GPS will increase in value as a tool for measuring travel behaviour change.

REFERENCES

Ampt, E. (2001) "The Evaluation of Travel Behaviour Change Methods – A Significant Challenge" Paper presented at the 24th Australasian Research Forum, Hobart, April 2001. Accessed on: 8/07/2004 from: http://www.patrec.org/atrf/index.php

Clifford, E., Zhang, J., and Stopher, P. (2007). Determining Trip Information Using GPS Data, paper presented to the IGNSS 2007 Symposium, Sydney, December.

Government of SA. (2009). TravelSmart Households in the West final report, January 2009. Accessed on: 25/06/2009 from http://www.transport.sa.gov.au/pdfs/environment/travelsmart_sa/Households_in_the_West_Final_Report.pdf

Ker, I. (2002) "Can evaluating be too prescriptive? Appraisal in the age of the Triple Bottom Line" Paper presented at the Australasian Evaluation Society International Conference, October/November 2002, Wollongong, Australia. Accessed on 2/12/2004 from: http://www.aes.asn.au

Huang, H. M. (2006) "Do print and Web surveys provide the same results?" *Computers in Human Behaviour, 22, 3, pp. 334-350*

Makridakis, S., Wheelwright, S. C. and Hyndman, R. J. (1998) *Forecasting: Method and Applications*, 3rd Edition, John Wiley & Sons, NJ.

Red3 (2005), Evaluation of Australian TravelSmart Projects in the ACT, South Australia, Queensland, Victoria and Western Australia: 2001–2005, Report to the Department of Environment and Heritage and State TravelSmart Program Managers. Accessed on 2/11/2006 from: http://www.travelsmart.gov.au/publications/evaluation-2005.html

Stopher, P. and Bullock, P. (2003). *Travel Behaviour Modification: A Critical Appraisal*, Papers of the 26th Australasian Transport Research Forum, Wellington NZ: ATRF

Stopher, P. and Pointer, G. (2004). Monte Carlo Simulation of Household Travel Survey Data with Bayesian Updating, Road and transport research, **13** (4) p. 22-33.

Stopher, P., Greaves, S., Xu, M. and Lauer, N. (2005) *Stages 1.2 &1.3 Development and Scoping of Options for Long-Term Monitoring of the NTBCP,* report prepared by the Institute of Transport and Logistics Studies for the National Travel Behaviour Change Project.

Stopher, P., FitzGerald, C., Bretin, T., and Zhang, J. (2007). Analysis of a 28-Day GPS Panel Survey – Findings on Variability of Travel, Transportation Research Record, Transportation Research Board, Washington, DC.

Stopher, P. and M. A. Montes (2007) *Pilot Testing of a GPS Survey for the Long Range Monitoring Procedure for Voluntary Travel Behaviour Change,* Final Report to the NTBCP partners, Sydney, March.

Stopher, P.R. (2008). Collecting and Processing Data from Mobile Technologies, Invited Resource paper for 8th International Conference on Survey Methods, Annecy, France, May.

Swann, N. (2006) *Evaluation of the Public Acceptance and Perceptions of a GPS Survey for the Long Range Monitoring Procedure for Voluntary Travel Behaviour Change: Final Report*, report prepared by the Institute of Transport and Logistics Studies for the National Travel Behaviour Change Project.

Tideman, J., B. Wotton, and E.S. Ampt (2006) TravelSmart Households in the West: New Ways to Achieve and Sustain Travel Behaviour Change, Papers of the 29th Australasian Transport Research Forum: Surfers Paradise, Queensland.