23rd Australasian Transport Research Forum
Perth, Western Australia. 29 September – 1 October 1999

A Survey Method for Cycle Networks – A Swiss Example

Anthony Richardson
University of Sydney, New South Wales

Abstract

The development of on-road and off-road cycle networks within Australian cities has seen cycling become more of a mainstream mode of transport for a variety of trip purposes. To support this new position, surveys of cycle travel patterns need to be conducted using state-of-the-art professional survey techniques. This paper will describe one such survey conducted on the Swiss Veloland Cycle Network, which used an intercept survey of cyclists at various sites on the network. Three survey techniques were employed; a full count of cyclists at each site, a short trackside interview with a random sample of passing cyclists at each site, and a more comprehensive self-completion questionnaire which sampled cyclists were given to complete and return by post after their trip had finished.

The paper will outline the basic methodological requirements of all intercept surveys. It will then describe the techniques used in the conduct of the Veloland survey, in the development of weighting techniques, including non-response weights, in the simplified GIS representation of the survey results, and in the estimation of system-wide usage of the network from the data obtained at the survey sites.

While the Veloland survey was for a national network of cycling routes, it will be proposed that the same survey techniques can be applied to metropolitan cycle networks in Australian cities.

Contact Author

Anthony Richardson
Institute of Transport Studies
University of Sydney
Sydney NSW 2006

Phone: +61 2 9351 0076
Fax: +61 2 9351 0088
e-mail: ajr_tuti@hotmail.com

Introduction

The development of on-road and off-road cycle networks within Australian cities has seen cycling become more of a mainstream mode of transport for a variety of trip purposes. To support this new position, surveys of cycle travel patterns need to be conducted using state-of-the-art professional survey techniques. This paper will describe one such survey conducted on the Swiss Veloland Cycle Network, which used an intercept survey of cyclists at various sites on the network. Three survey techniques were employed; a full count of cyclists at each site, a short trackside interview with a random sample of passing cyclists at each site, and a more comprehensive self-completion questionnaire which sampled cyclists were given to complete and return by post after their trip had finished.

This paper outlines the basic methodological requirements of all intercept surveys. It then describes the techniques used in the conduct of the Veloland survey, in the development of weighting techniques, including non-response weights, in the simplified GIS representation of the survey results, and in the estimation of system-wide usage of the network from the data obtained at the survey sites.

Methodological Requirements of Intercept Surveys

Intercept surveys are often considered for adoption when attempting to conduct surveys of "rare" populations, such as users of specific roads, public transport users or cyclists. By taking the survey to the designated population, the inefficient process of finding these people among the general population is eliminated. However, intercept surveys have a number of distinctive features which must be accounted for if reliable estimates of population behaviour are to be obtained. These features include the following:

- The survey should be conducted at representative points of the network (preferably randomly selected) and across all times of the day, week and year (to pick up diurnal and seasonal variations in travel);
- A full count of the population from which the sample is drawn must be obtained in order to enable statistical expansion of the sample to represent the population;
- The sample must be drawn randomly from the population. This random selection is usually done by pre-specifying a sampling rate and a sampling rule to be applied by the field surveyors to the population. For example, every nth traveller arriving at the survey point could be selected for the sample. The value of "n" is chosen to obtain the required sample size without overloading the survey team at that location. No substitution sampling should be allowed in the selection process.
- Where respondents are being asked about a trip in progress, they must not be allowed to complete the survey at the survey site. Otherwise, they will be guessing at what they might do on the remainder of their trip. This could be particularly important in surveys of cyclists, where the return leg of their journey may be very different from the outbound leg, but not known in advance. This implies that respondents should take a questionnaire with them to be completed at the end of their journey.

- Since not all respondents will return the questionnaires, the survey process must be designed to account for the measurement and investigation of the non–response effects in the survey. There must be confidence that the respondents are representative of those who were actually selected in the sample or, if this is shown not to be the case, then information must be obtained to allow for the correction of the effects of this non-response on the final results. A technique which permits this is to collect basic information about all people who are selected in the sample, and to compare their characteristics with the characteristics of those returning the completed questionnaire. Non-response weights can then be calculated to be used in the expansion process
- To facilitate comparison of respondents and non-respondents, identification numbers should be printed on all questionnaires and these identification numbers should be recorded when the questionnaire is distributed.
- Those travellers who make more use of the network have a higher probability of being included in the sample. For example, in a survey of public transport users, where the sample is chosen from boarding passengers, those who make more trips in a day have a higher chance of selection, and hence must be down-weighted in the analysis process to account for this increased probability of selection. Such a procedure has been described for a survey of public transport users in Melbourne (Richardson, Harbutt and Lester, 1998). In a cycle survey with (randomly placed) fixed survey sites across the network, those cyclists who ride longer distances are more likely to pass one of the survey sites. Allowance must be made for this bias by means of special weights in the expansion of the sample data in order to obtain an unbiased analysis of the characteristics of cyclists using the network.

The Veloland Schweiz Survey

The Veloland Schweiz National Cycling Route system was introduced in May 1998 to encourage and promote cycling in Switzerland. The system consists of nine routes covering all the major cycling areas, as shown in Figure 1.

Following the introduction of these routes, Veloland Schweiz (an organisation within the Swiss Tourism Federation) wanted to undertake user surveys to ascertain the level of usage of these routes by various types of cyclists. They also wanted to get demographic and geographic descriptions of the users and an indication of the amount of money spent on bicycle-related activities while using these routes.

Based on the above-mentioned features of intercept surveys, and on the general principle of minimising the response burden for respondents, the 1998 survey was designed to yield an intercept survey technique which would give reliable and politically credible results. A more complete description of the survey and the results is contained in a report to Veloland Schweiz (Richardson, 1999)

The survey process consisted of four basic steps for the interviewers:

- Counting cycle riders and pedestrians
- Sampling cycle riders
- Conducting a track-side interview

- Handing out the questionnaire

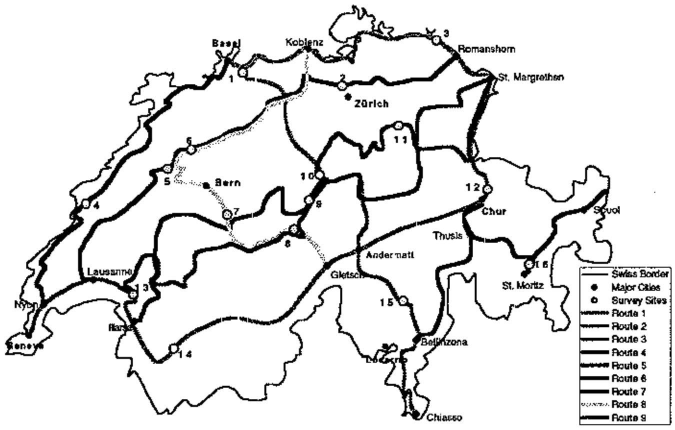

Figure 1 The Veloland Schweiz National Cycling Network

The Interviewer Control Sheet

All the information about the survey was recorded on the Interviewer Control Sheet by the surveyors. In particular, the Interviewer Control Sheet recorded all the counts and the results of the Track-side Interview (see below). At seven of the sixteen survey sites, two surveyors (one doing each direction) were used, while at the other nine lower flow sites only one surveyor was used, doing both directions.

Counting Riders and Pedestrians

At the two-surveyor sites, each surveyor was responsible for one direction of travel on the route, but could assist the other surveyor if the workload was unbalanced between directions at any time. Each surveyor was to count ALL riders travelling in their assigned direction and record this count on the Interviewer Control Sheet using a tally-count procedure. At the one-surveyor sites, the surveyor had to record cyclist flow in both directions, and record them in the appropriate column. Surveyors were also instructed to count all pedestrians walking along the route in their assigned direction and record this on the Interviewer Control Sheet in the pedestrian count column.

Sampling Riders

It was important that riders were selected randomly for the survey. To ensure this, surveyors were instructed that they MUST select every n^{th} rider passing in their direction (where n was specified for each site in the interviewer instructions). This rider may have been by themselves, at the head of a group, in the middle of a group or at the rear of a group. When the n^{th} rider arrived and the surveyor had recorded this in the cyclist count column, they were then to record the time at which they arrived (to the nearest minute) on the Interviewer Control Sheet, together with their estimate of the cyclist's age, their sex and the size of the group in which they were riding. The surveyor then requested this rider to stop to receive a survey. If the selected rider refused to stop, this was to be recorded on the Interviewer Control Sheet by ticking the NO box in the Survey Accepted column

If the selected rider was in a group, the surveyor was instructed to keep counting those following in the group on the next line of the Interviewer Control Sheet It was stressed that it was important that the surveyor maintain a count of ALL riders passing the survey site If a group contained more than n riders, then more than one rider may have been selected for interview. The cyclists were selected according to the order in which they reached the survey location. The surveyor was instructed to continue to count passing cyclists while conducting the interview with their selected rider (see below). It was stressed that this count information was extremely important for later analysis of the results.

When the track-side interview was finished, the surveyor was instructed to continue counting until the n^{th} rider after the previously selected rider arrived. If more than n riders passed while an interview was being conducted, the next multiple of n should be used to select the next rider for interview (for example, if six riders passed while an interview was being conducted at a survey site where n=4, then the surveyor kept counting up to eight before selecting the next rider)

If a child was the selected rider, then the interview was conducted with that child (even though an adult in the group may have assisted if required). Surveyors were instructed to stress that it was the child who was to fill out the questionnaire about their journey (with adult assistance, if necessary).

The Track-side Interview

In addition to the information about the selected rider that surveyors had already recorded on the Interviewer Control Sheet, an initial Track-side Interview was conducted with every n^{th} rider to record the following information on the Interviewer Control Sheet:

1. "Where do you currently live?"
   (Town and Postcode, or Country for non-Swiss-residents)
2. "Do you know which National Route you are now travelling on?"
   (if the rider said YES, then they were asked the number of the Route)
3. "Has this bicycle journey included an overnight stay?"

The information from the Track-side Interview was used to provide an overall picture of cyclists' characteristics which were later used to investigate whether those who returned the questionnaire were similar to all riders who were selected in the sample

The Questionnaire

Once the Track-side Interview was completed, the selected rider was given a questionnaire asking more detailed questions about their current trip (copies of the questionnaire were printed in German and French, depending on the preferred language of the selected rider) Questionnaires were to be taken away and returned by post after the end of the bicycle journey. This ensured that respondents were not guessing about the remainder of their journey. If a selected rider refused to accept a questionnaire, this was to be recorded on the Interviewer Control Sheet by ticking the NO box in the Survey Accepted column.

Conduct of the Survey

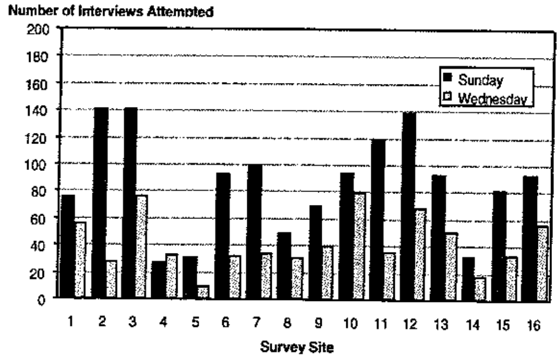

Figure 2 Number of Surveys Attempted by Site and Day

The surveys were conducted at the 16 sites between 1000 and 1700 hours on Sunday 20th September and Wednesday 23rd September, 1998. A total of 2,076 interviews were attempted on the two days of the survey. The distribution of these attempted interviews across the sites and survey days is shown in Figure 2. It ranged from a total of 10 attempted interviews at Site 5 on Wednesday up to 141 attempted interviews at Sites 2 and 3 on Sunday.

Methodological Results from the Survey

The survey process as described above had four stages by which cyclists could be included in the final database of returned questionnaires. Firstly, they had to be selected from all the passing cyclists; secondly, they had to stop for an interview; thirdly, they had to accept a questionnaire; and fourthly, they had to return a completed questionnaire.

Selection Rates

The selection of cyclists was based on a pre-specified sampling interval for each of the sites. On Sunday, about 1 in 4 cyclists were actually selected, whereas on Wednesday about 1 in 3 cyclists were selected.

Acceptance Rates

Once the cyclist had been selected, they were then expected to stop to be interviewed and then accept a questionnaire. Not all cyclists stopped when requested, not all cyclists who stopped then answered the interview questions, and not all cyclists who answered the interview questions then accepted a questionnaire (although it seems that it was an exception for someone who stopped not to then accept a questionnaire). Since it was often not clear from the Control Sheet information at what stage a refusal precisely occurred, these three behaviours have been grouped into one measurement. The Acceptance Rate is defined as the proportion of cyclists selected who eventually accepted a questionnaire.

Figure 3 shows the acceptance rates at each of the survey sites on each of the survey days. It can be seen to vary substantially from over 90% on both days at sites 8 and 11, down to about 40% on both days at site 13. Overall, acceptance rates were higher on Sunday (72%) than on Wednesday (66%)

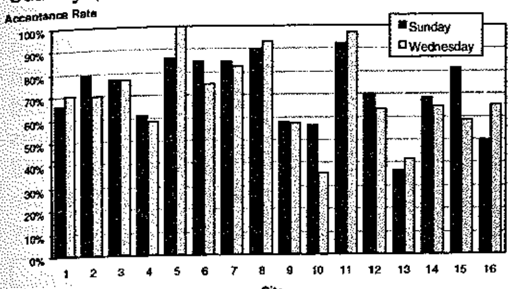

Figure 3 Acceptance Rates by Site and Day

When the cyclist was selected at the survey site, three variables were recorded; age, gender, and size of the group in which the cyclist was riding. It is therefore possible to check for any differences in acceptance rate within each of these variables. Table 1 shows the acceptance rates for difference size groups on each of the survey days. It can be seen that the acceptance rate for cyclists who were riding by themselves was much lower (about 60% acceptance rate) than for cyclists riding in groups (about 80% acceptance rate). It appears that the peer pressure of being in a group had the effect of encouraging the cyclist to stop and accept the questionnaire, while lone riders were more likely to just continue riding without stopping

Table 1 Acceptance Rates by Group Size

	Acceptance Rate		
Group Size	Sunday	Wednesday	Both Days
1	62%	60%	61%
2	84%	78%	83%
3	77%	82%	79%
4	86%	79%	85%
5->10	81%	63%	77%
>10	98%	31%	80%
TOTAL	76%	67%	73%

	Acceptance Rate		
Group Size	Sunday	Wednesday	Both Days
Lone Rider	62%	60%	61%
Group	84%	75%	82%

The acceptance rates for cyclists of different age and sex are shown in Figure 4. It can be seen that while the acceptance rates show little variation by age, the acceptance rates for females (an average of 78% acceptance) are consistently higher than for males (an average of 68%)

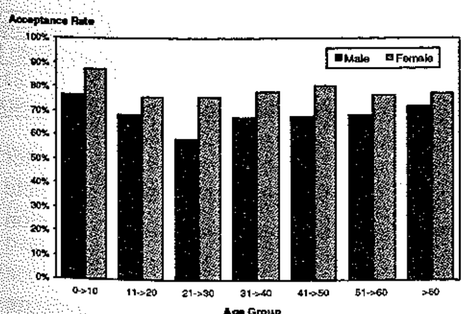

Figure 4 Acceptance Rates by Age and Gender

When cyclists stopped for an interview at the survey site, they were asked whether the trip they were making included an overnight stop. The acceptance rates for those on overnight trips and those on day trips are shown in Figure 5. For those cyclists who did not stop at all, their type of trip was unknown (a total of 420 cyclists) while a few cyclists who accepted the questionnaire (13 in total) did not answer (or were not asked) the question about the type of trip. It can be seen that cyclists on overnight trips are more likely (96%) to accept the questionnaire (once they have stopped) than cyclists on day trips (87%).

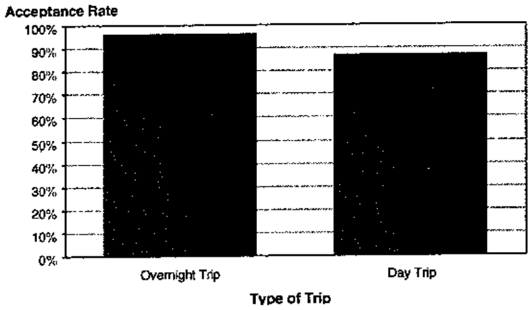

Figure 5 Acceptance Rates by Type of Trip

Response Rates

Not all cyclists who accepted a questionnaire actually completed and returned it to the Veloland office. The proportions of cyclists who accepted a questionnaire and who did return it (the "response rate") are shown by site and survey day in Figure 6.

Overall, the response rate on Sunday was 45% while on Wednesday it was 42%. However, there was substantial variation in response rates between the sites, ranging from 11% at site 10 on Wednesday up to 75% at site 15 on Wednesday.

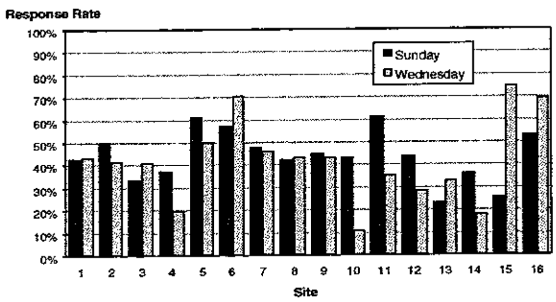

Figure 6 Response Rates by Site and Day

It was shown in Table 1 that the acceptance rate for lone riders was less than the acceptance rates for cyclists in groups. A similar phenomenon occurred for response rates, as shown in Table 2. While 49% of cyclists in groups returned their questionnaire, only 35% of lone riders returned them. This difference exists for both the Sunday and Wednesday surveys

Table 2 Response Rates by Group Size

	Response Rate of those Accepting		
Group Size	Sunday	Wednesday	Both Days
1	37%	32%	35%
2	51%	52%	51%
3	45%	51%	47%
4	47%	55%	48%
5->10	30%	20%	28%
>10	43%	60%	45%
TOTAL	45%	41%	44%

	Response Rate of those Accepting		
Group Size	Sunday	Wednesday	Both Days
Lone Rider	37%	32%	35%
Group	48%	51%	49%

	Response Rate of those Selected		
Group Size	Sunday	Wednesday	Both Days
Lone Rider	23%	19%	21%
Group	40%	38%	40%

Once again, it appears that the peer pressure of being in a group, or perhaps the greater support for cycling by group riders, has the effect of encouraging the cyclist to complete and return the questionnaire, while lone riders are more likely to ignore the completion of the questionnaire, even after they have bothered to stop and accept one at the site.

Combining the effects of the acceptance rate and the response rate, the differences are even more pronounced, as shown in the last part of Table 2. It can be seen that while

40% of cyclists in groups who were selected actually accepted and returned a questionnaire, only 21% of lone riders selected actually accepted and returned a questionnaire.

Of those accepting a questionnaire, it can be seen in Table 3 that females are slightly more likely to return it (46%) compared to males (44%). The only difference by age is that teenagers (i.e. those between 11 and 20 years of age) are much less likely to return the questionnaire than any other age.

Table 3 Response Rates by Age and Gender

	Response Rate of those Accepting	
Age Group	Male	Female
0->10	50%	43%
11->20	26%	26%
21->30	45%	53%
31->40	42%	49%
41->50	46%	49%
51->60	47%	50%
>60	49%	41%
TOTAL	44%	46%

	Response Rate of those Selected	
Age Group	Male	Female
0->10	38%	38%
11->20	18%	20%
21->30	26%	40%
31->40	28%	38%
41->50	31%	39%
51->60	32%	38%
>60	36%	32%
TOTAL	30%	36%

Combining the acceptance and response rates by age and gender, it can be seen that the major effect is the higher proportion of females selected who return the questionnaire, particularly in the age range of 21 through 60 where most of the observed cyclists were observed to exist.

Of those accepting a questionnaire, it can be seen in Figure 7 that cyclists on overnight trips are more likely to return it (60%) compared to those on day trips (43%).

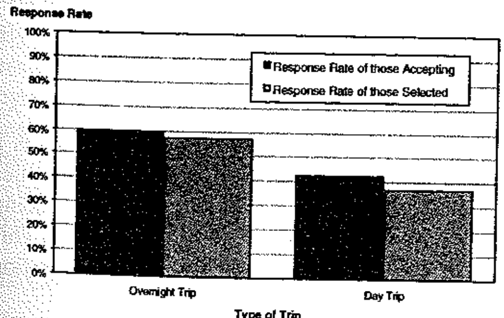

Figure 7 Response Rates by Type of Trip

Combining the acceptance and response rates by type of trip, it can be seen that the difference between the two groups is reinforced, with 57% of cyclists on overnight trips who were selected actually returning the questionnaire, compared to only 37% of cyclists on day trips.

The intercept surveys conducted at the 16 sites collected information about the population of cyclists passing each site. As noted in the previous section, however, biases exist as to which cyclists accepted and returned the self-completion questionnaire. Therefore, if the data from the returned questionnaires are to be used to represent the population of cyclists passing each site, adjustments need to be made to the sampled questionnaire data to account for the differential acceptance and return rates of the questionnaires by different groups of cyclists.

This weighting of the data is performed by comparing the user composition of the returned questionnaires (in terms of sex, group size and type of trip by survey site and day of survey) with the user composition observed by the surveyors in the field. Weights are then applied to the questionnaire data to bring it into line with the proportions of each group in the field survey data. At the same time, the sample questionnaire data is expanded to estimate the population totals of usage by comparing the number of returned questionnaires with the number of observed cyclists at each site on each survey day.

Estimation of System-Wide Network Usage

While the analysis has taken account of differential acceptance and response rates, it has not, so far, taken due account of the differing degrees of exposure of different cyclist groups to being included in the initial survey. Firstly, since the survey sites were spread geographically around the network, cyclists who made longer trips were more likely to have passed one of the survey sites and hence have a chance of being in the survey population. Therefore, the results observed at the 16 sites have to be inversely weighted by the length of the trips observed, with longer trips having a lower weighting factor. Secondly, the results obtained will depend on the specific location of the survey sites. A survey site which is located closer to a major urban area will generally have a higher proportion of day trips than a survey site in a rural area, where the proportion of overnight trips will be higher. To the extent that the 16 survey sites are not necessarily representative of the entire network, the results obtained from the selected survey sites need to be re-weighted to account for their specific locations.

These two weighting processes are related, because they are both a function of the length of cycling trips made on the network. They will therefore be handled in the one process by a technique which estimates the total annual usage of the entire network. This is done by first developing a model of usage at any point on the network, and then applying this model to the entire network.

Developing the Model of Network Usage

The basic idea underlying the model is that usage at any point of the network is a function of the distance of that point from centres of population. Points close to cities will have larger flows of cyclists than points further away from those cities, while being close to a large city will generate more cyclists than being close to a small city. This concept is that of the familiar Gravity Model, as used in many models of transportation and locational studies.

For each survey site, the distribution of distances from that site to the residential location of the cyclist making each trip was calculated and grouped into distance intervals of 4km. The data used were from the track-side survey of selected cyclists, since this survey contains information on the residential location. The x–y coordinates of the residential location were obtained from a table of x-y coordinates and populations of all Swiss communities provided by GEOSTAT (a Swiss mapping Authority), while the x-y coordinates of the survey sites were obtained by mapping the survey sites onto an underlying map of the Swiss communities. The residential access distance distributions for all sites, and the entire population, were calculated for day-trips and overnight trips. The cumulative distributions of residential access distances for day trips and overnight trips are shown in Figure 8.

It can be seen that the day trips, as expected, come from residential locations much closer to the survey sites than the overnight trips. 80% of day trip residences are within about 10km of the survey site, and 100% within about 100km. On the other hand, 80% of overnight trip residences are within about 100km of the survey site, and 100% within about 200km.

Using the GEOSTAT database of the population and x-y coordinates of all Swiss communities, the total number of residents living at various distances (in 4km intervals) from each survey site was also calculated. The cumulative distribution of residential access distances for the Swiss population to all the survey sites is shown in Figure 9.

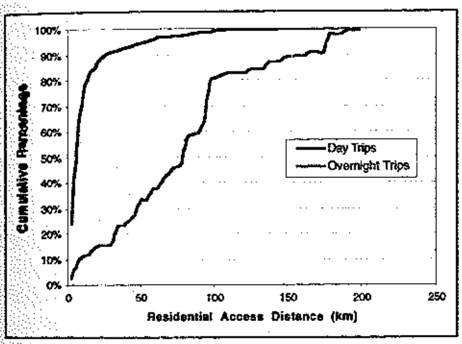

Figure 8 Residential Access Distances for Day and Overnight Trips

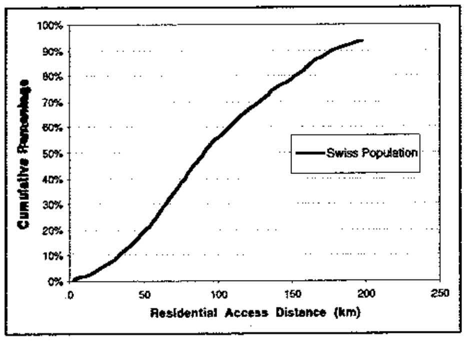

Figure 9 Residential Access Distances for the Swiss Population

By dividing the number of cyclists observed at a survey site by the total number of residents (for each 4km interval), it is possible to calculate the number of observed cyclists per 1000 resident population (the "trip rate") for each residential access distance interval. Plotting the trip rate (number of cyclists per 1000 resident population) against the average distance within each distance interval (for all sites combined, given the relatively small sample size at some sites) gives the results shown in Figure 10 for day trips and Figure 11 for overnight trips.

To these plots, a model of the following form was fitted:

$$\frac{T}{P} = c + Ae^{-nd}$$

where T = number of observed trips from distance interval
P = residential population of distance interval
c = a constant reflecting the balance between town size and access distance
A = a constant reflecting the overall attractiveness of that site for cycling trips
e = the base of logarithms

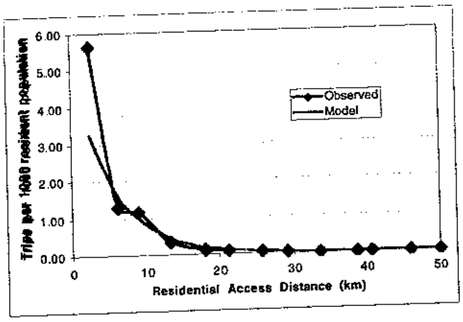

Figure 10 Day Trip Rate (per 1000 residents) by Residential Access Distance

are shown in Table 4.

n = a constant reflecting the impedance effect of distance to the survey site

d = the straight-line distance from the residential location to the survey site

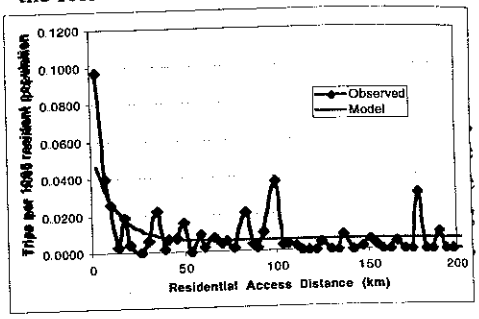

Figure 11 Overnight Trip Rate (per 1000 residents) by Residential Access Distance

Table 4 Parameters for the Day and Overnight Trip Models

	Parameter		
Trip Type	C	A	N
Day Trip	0.0040	5.0	0.18
Overnight Trip	0.0057	0.5	0.08

Applying the Model of Network Usage

The models developed in the previous section allow the prediction of trip numbers at any point on the route based on the proximity of that point to areas of population. The model is applied by calculating such usage at many points along the route to obtain an overall profile of usage on the route, rather than just at the selected survey site, using the following process.

Calculate the Distances from Route Points to all Swiss Communities: Each route was digitised by locating the x-y coordinates of towns or other sites through which the route passes, including the survey sites which lie on each route. The distance from each of these points to all the Swiss communities in the GEOSTAT coordinates/population database was then calculated.

Apply the Trip Rate Models: Using the models developed above, the expected number of cyclists (on day trips and overnight trips) from each community at each point along the route was then calculated, based on the distance of that point from each Swiss community and the population of that community. The estimated number of cyclists from each Swiss community was then summed to obtain the total number of cyclists expected at each point along the route. The results of these calculations for day and overnight trips on Route 1 (see Figure 1) are shown in Table 5.

Several features are apparent in the results in Table 5. Firstly, the number of day trips is generally much higher than the number of overnight trips. Secondly, this is not always the case, however, as can be seen at the remote town of Gletsch in the Swiss Alps where there are more overnight than day trips. Thirdly, the number of day trips varies much more along the route than the number of overnight trips. Being much longer, the overnight trips tend to be observed at many places along the route (thus evening out the flows). On the other hand, the day trips are much more sensitive to the nearness of large towns, as shown by the high flows at Lausanne and Geneva

Table 5 Predicted Cyclists Flows on Route 1

	Day Trips	Overnight Trips
Andermatt	43	42
Gletsch	32	42
Brig	129	43
Leuk	105	43
Sion	211	45
Site 14	138	44
Martigny	142	44
Port-Valais	178	47
Villeneuve (VD)	205	47
Site 13	160	46
Montreux	246	47
Lausanne	698	53
Nyon	245	48
Geneva	1004	56

Compare Predictions and Observations at the Survey Sites: This process was repeated for all routes, to obtain initial estimates of the route profiles. Within these route profiles, the 16 survey sites were found among the digitised points, and a table of estimated flows at these points compared to the flows observed in the surveys was constructed. In most cases, the differences between the modelled and the observed flows may be explained by specific features of the site (or route) in question. These differences may be incorporated in the model by the use of route-specific weighting of the predicted flows. For each route (or route segment) the ratio of the sum of the observed flows at survey sites along that route to the sum of the estimated flows at survey sites along that route was calculated. This ratio was then used to multiply the attractiveness constant A, to reflect the differential attractiveness of each route (or route segment). The "scaled" number of trips estimated at each point along each route was then recalculated and used as the final estimate of flow at any point on the route.

Construct Route Profiles: The location of each point along the route was then calculated, using the x-y coordinates of each point to calculate the distance between adjacent points and then summing cumulatively to obtain the chainage of each point from one end of the route. The estimated length of each route was then compared with the official Veloland length (as given in the Route Guides). The estimated length is always shorter because it is based on straight-line distances between points on the route. The ratio of the lengths was then calculated and used to adjust the estimated chainages such that the estimated total length is the same as the actual total length.

The total number of cyclists expected at each point along the route was then plotted as a function of the chainage of that point to obtain a flow profile for each route. The results for Route 1 are shown in Figure 12 for day trips. As noted in Table 5, the route profile for Route 1 shows peaks as the route passes Lausanne (chainage = 250km) and enters Geneva (320km).

Calculate the "Locus" of each Point on Route: Each digitised point on the route in Figure 12 in fact represents a section of the route from halfway between neighbouring points on each side. It is assumed that cyclists observed at each point will in fact traverse the whole of that section of the route. For example, if 200 cyclists are observed at a point, and it is 10km in one direction to the next point and 8km in the other direction to the next point, then that point represents 9km of route and the 200 cyclists are assumed to travel a total distance of 1800kms. For each digitised point on each route, the "locus" of each point is calculated as described.

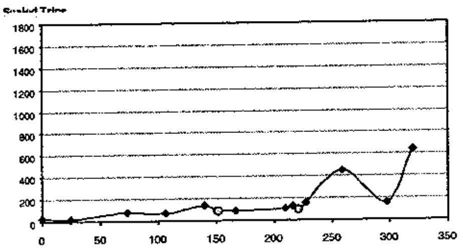

Figure 12 Flow Profile for Route 1 (Andermatt to Geneva)

Calculate Trip Kilometres for each Point and for Whole Routes: This locus is then used to estimate the trip kilometres for each point. On sections of the network which are shared between routes (e.g. routes 8 and 9 co-exist between Meiringan and Spiez), the estimated flows in the route profiles are split between the sharing routes (to avoid double-counting of flows at these points) before calculating the trip kilometres on each route. The trip kilometres for each point are then summed across each route to obtain the total trip kilometres which would have been observed on each route during the survey period (between 10am and 5pm on the surveyed Sunday and Wednesday).

Calculate Trips on each Route: The estimated numbers of trips on each route (between 10am and 5pm on the surveyed Sunday and Wednesday) are obtained by dividing the total trip kilometres on each route by the average length of each trip (in kilometres). The average trip lengths for day trips and overnight trips are obtained from the survey results as 40 km and 195 km respectively.

Expand Results to a Full Day: The survey was conducted only between the hours of 10am and 5pm on the survey days. Therefore the survey data does not represent a full day's data, i.e. it does not cover trips passing the sites before 10am and after 5pm. By plotting the observed trip numbers as a function of time of day and making reasonable assumptions about the likely numbers outside the surveyed period, an estimate of the full day's trips can be made. On both days, a full day is about 18% more than the surveyed day, in terms of number of trips observed.

Expand Results to a Full Week: The survey was only conducted on Sunday and Wednesday of the survey week. If it is assumed that a Saturday is like a Sunday and each weekday is the same as a Wednesday, then it can be shown that a week would have about 2.75 times as many day trips as observed on the survey days and, because of different proportions of overnight trips on Sundays and Wednesdays, about 3.14 times as many overnight trips as observed on the survey days.

Expand Results to Month of September: The estimated weekly flow can be converted to a monthly flow (for September) by multiplying by a ratio of 4.28 (=30/7).

Expand Results to Annual Totals: Figures supplied by Veloland show that September contains about 9% of the annual cycle trips. Assuming that this figure applies to both day trips and overnight trips, an annual estimate can be obtained by multiplying the September total by a factor of 11.

Application of all these temporal expansion factors gives an estimate of the total number of trips per annum on each of the cycle routes. Multiplying by the average length of day trips and overnight trips gives an estimate of the annual trip kilometres on each route.

Annual Estimates of Network Usage and Expenditures

The estimated annual results are summarised in Table 6. Several features of these results are important. Firstly, in terms of trips, day trips vastly outnumber overnight trips, with overnight trips comprising only 4% of all trips. However, because of their much longer average length, overnight trips make up 15% of the trip-kilometres on the network. The survey method is better at estimating trip kilometres than trips, because when standing by the side of the track counting cyclists, as was done in the Veloland surveys, it is really short sections of trips, measured in trip-kilometres, which are being observed, rather than trips themselves. For this reason, the results reported from simple analysis of the survey data match more closely with the trip-kilometre figures than they do with the trip results. The second major feature is the order of magnitude of the results. There are over 3 million day trips made on the network annually, and about 120,000 overnight trips (from a total Swiss population of about 7 million). These trips generate a total of about 150 million kilometres of travel per year.

Table 6 Estimated Annual Trips and Trip-Kilometres on National Routes

Route	Day Trips	Overnight trips	% Overnight Trips	Day Trip-kms	Overnight Trip-kms	% Overnight Trip-kms
1	192,127	5,702	3%	7,685,075	1,111,813	13%
2	743,702	32,960	4%	29,748,073	6,427,113	18%
3	301,487	4,419	1%	12,059,472	861,706	7%
4	413,666	14,328	3%	16,546,659	2,793,986	14%
5	317,680	17,148	5%	12,707,200	3,343,896	21%
6	121,192	11,352	9%	4,847,671	2,213,718	31%
7	257,971	2,065	1%	10,318,853	402,722	4%
8	402,085	17,462	4%	16,083,413	3,405,142	17%
9	457,528	15,232	3%	18,301,131	2,970,310	14%
TOTAL	3,207,439	120,669	4%	128,297,546	23,530,406	15%

The annual expenditure by cyclists on these trips can be estimated by applying the average expenditure per trip by day-trippers and overnight tripmakers, as calculated from the Veloland questionnaire survey, to the annual number of trips. The average expenditures per trip are shown in Table 7, while the total annual expenditures are shown in Table 8.

Table 7 Average Expenditures per Trip

	Day Trips	Overnight trips
Eat & Drink	SFr. 12.69	SFr. 178.35
Transport	SFr. 4.01	SFr. 31.92
Accommodation	SFr. 0.00	SFr. 183.92
Other	SFr. 2.42	SFr. 35.09

Table 8 Total Annual Expenditures

	Day Trips	Overnight trips	TOTAL
Eat & Drink	SFr. 40,692,381	SFr. 21,521,394	SFr. 62,213,775
Transport	SFr. 12,876,058	SFr. 3,851,583	SFr. 16,727,641
Accommodation	SFr. 0	SFr. 22,193,945	SFr. 22,193,945
Other	SFr. 7,764,281	SFr. 4,234,834	SFr. 11,999,114
TOTAL	SFr. 61,332,720	SFr. 51,801,756	SFr. 113,134,476

It can be seen that the total annual expenditure of cyclists using the Veloland network on trip-related items is approximately 110 Million Swiss Francs (about 120 Million Australian dollars at time of writing). This amount is split about evenly between day trips and overnight trips. Although overnight trips have far higher expenditures per trip, the sheer number of day trips means that the total expenditure on day trips is, if anything, slightly higher than on overnight trips. A useful index can be obtained by dividing the total expenditures by the total trip-kilometres for each type of trip. This shows that day trips have an expenditure rate of about SFr. 0.50 per kilometre, while overnight trips have an expenditure rate of about SFr. 2.00 per kilometre.

Application to Australian Cities

The survey methodology described in this paper has been developed for a national network of cycle routes which serve four different types of cyclists; those on long tours containing more than two overnight stays, those on tours with one or two overnight stays, day-trippers riding for recreational reasons, and other cyclists making utilitarian trips for work, shopping and other purposes. While the nature of trips on Australian urban cycle networks is very different, being composed almost entirely of day-trips and utilitarian trips, the scale and network complexity of urban Australian cycle networks is not all that dissimilar to the Swiss national network (after all, Switzerland is not very big, while Australian cities are very big). The survey technique and analysis methods described above should therefore apply equally well in Australian cities. In particular, the three-component survey method (consisting of full counts, trackside interviews and mailback questionnaire surveys) should be used for any intercept survey of cyclists. The analysis of acceptance rates and response rates should also be conducted in order to determine the need for, and magnitude of, weighting factors to ensure the calculation of representative population estimates.

To compensate for the non-random placement of survey sites, and to allow for the over-representation of longer cycling trips, a model of network usage should be developed based on a Gravity Model formulation as described in this paper, or using other model formulations. The development of this model should be easier for Australian cities, given the higher relative accessibility of GIS network descriptions and the availability of spatial descriptions of the population from the Australian Bureau of Statistics. The modelling should also give better overall results, given that the Swiss model of day trips was much better than the model of overnight trips.

As with the Veloland Schweiz surveys, which are now being used on a regular basis as a means of monitoring trends in usage of the cycle network, such surveys in Australian cities could also be used on a monitoring basis to determine the effect of various policies to encourage cycling.

Conclusions

This paper has described the methodological requirements for intercept surveys, and has shown how such a method has been applied to a survey of cyclists on a national network of cycle routes in Switzerland. Three aspects of the survey were of particular importance. Firstly, the survey used three different, but coordinated, methods to obtain information. A full count of all passing cyclists established the overall size and characteristics of the population. A trackside interview established the characteristics of the selected sample. A mailback questionnaire obtained more detailed information about the cyclist and the trip being made. Secondly, a detailed analysis was conducted of acceptance rates and response rates to determine the need for, and magnitude of, weighting factors to correct for biases in acceptance and response patterns. Thirdly, a model of total network usage was constructed and applied to obtain estimates of network usage which were not biased by the specific placement of the survey sites and the over-representation of longer cycle trips in the observations at the survey sites

It is considered that such a thorough survey design is appropriate and necessary for cycle networks in Australian cities, as cycling becomes more of a mainstream mode of transport which must be monitored and assessed on the same professional basis as other modes of urban transport.

References

Richardson, A.J. (1999). The 1998 Survey of the Veloland Schweiz National Cycling Routes. Report to Veloland Schweiz, Bern, Switzerland.

Richardson, A.J., Harbutt, P.L. and Lester, C. (1998). " Public Transport Ticket Usage Surveys – a Methodological Design ". Forum Papers, 22nd Australasian Transport Research Forum, Sydney, pp. 697-712.