

AUTOMATIC CYCLE COUNTING PROGRAMME DEVELOPMENT IN HAMILTON

Authors:

John Lieswyn

BsC

Transport Planner, ViaStrada Ltd

john@viastrada.co.nz

Axel Wilke

BE (Hons), ME (Civil), GIPENZ

Director, Senior Traffic Engineer and Transport Planner Traffic Engineer, ViaStrada Ltd

axel@viastrada.co.nz

Steve Taylor

NZCE (Civil), AIPENZ

Transport Engineer, Hamilton City Council

steve.taylor@hcc.govt.nz



IPENZ Transportation Group Conference Auckland March, 2011

ABSTRACT

Prioritisation of land transport funding and justification of investment by mode has long favoured easily measured motorised journeys. The collection of data on active transport trips has traditionally been limited to manual counts.

Following on from the 2008 NZTA funded investigation by ViaStrada into methods of continuous cycle counting, this conference paper summarises the literature on the latest methods, count durations, how many sites are needed, and where they should be placed to gain a representative sample of the cycling levels throughout a given network.

This knowledge has been applied in the development of automatic cycle counting programmes for three New Zealand cities of a range of sizes: Christchurch, New Plymouth, and Hamilton. This paper presents the development process, planning, and implementation to date of the programme for Hamilton City.

The topics will be of interest to decision-makers and transportation planners working to quantify the effectiveness of investment in active transport networks.

INTRODUCTION

Prioritisation of land transport funding and justification of investment by mode has long favoured easily measured motorised journeys. The collection of data on active transport trips has traditionally been limited to manual counts.

As noted by Jones et al (2010), “While funding for pedestrian and bicycle facilities is typically limited to ‘transportation’ functions only, funding for roadways, transit, and other systems make no such distinction. The result is a potential funding bias against non-motorized facilities, as well as a potential resistance to accommodate non-motorized modes in new projects...” To redress this and ensure the most effective allocation of resources, it is crucial that cycle traffic volumes, trends and distributions are understood. A monitoring programme is required to provide an accurate indication of cycling activity levels throughout the city and to monitor trends over time.

This paper begins with a summary of the literature on cycle counting technologies and implementation methods. The subsequent sections describe how this research was applied in the development of an automatic counting programme for Hamilton City. The paper concludes with a commentary on applications for other cities.

CYCLE COUNTING METHODS – BEST PRACTICE

Research objective

Cycle counting technologies have been rapidly advancing and research has yielded a wealth of information regarding the relative limitations, applications and operation of each (Jones et al., 2010, Cope et al., 2009, ViaStrada, 2009, Alta, 2009, Schneider et al., 2005).

However, less is known about the specification of a cycle counting programme, including how many counters are needed, how long to count for, and where to locate them on a network.

State of knowledge

Site selection to monitor a transport network, even for motor vehicles, is not a well documented topic perhaps due to the complexity of the task. Most guidance simply suggests something along the lines of “a sufficient number of representative sites should be chosen”.

For example, a report on the regional bicycle count for Tucson, Arizona, USA (PAG, 2008) states that “locations were chosen based on estimated levels of cycling activity and achieving a reasonable regional / geographic distribution.” Similarly, an investigation into cycle monitoring in Hertfordshire, UK (Strong, 2004) states “there is at present little or no guidance on the number of counters required in any given geographic area in order to provide robust data.”

When questioned about the methodology employed by the UK’s Sustrans in monitoring its national cycle network, Andy Cope, Sustrans’ research and monitoring director, said: “In short, I don’t think a formula exists to determine how many and where to situate counters. I think it needs to be a pragmatic judgement based on existing networks and proposed interventions”. (Cope, 2009 *pers comm.*) This is similar to the approach taken by VicRoads (Victoria, Australia) in determining numbers and locations for their off-road cycle path counters. VicRoads does not conduct any on-road automatic (i.e. machine) counts. The Auckland Regional Transport Authority (now superseded by Auckland Transport) Regional Cycle Monitoring Plan Provisional Guidelines (2006) emphasises the importance of having consistency in terms of count programmes throughout the various local authorities in the Auckland region but does not suggest how the number, locations and durations of counts should be determined.

Monitoring cycling activity levels

The three broad types of (potentially complementary) data sources are surveys, crash data analysis, and cycle traffic counts (Davies et al., 1999, Cope et al., 2009).

Survey methods include:

- national survey data such as the New Zealand Household Travel Survey and the Census;
- local interview or destination surveys can provide additional levels of detail such as trip length and purpose, however these surveys are generally prohibitively expensive to undertake regularly enough to develop time-series data;
- parked bicycle counts are straightforward to undertake but limited where bicycle parking is diffuse or concealed (i.e. indoors); and
- school “hand-up” counts are again straightforward but may be influenced by external factors such as peer pressure or recent media coverage.

Crash data analysis can reveal important clues about where cyclists are travelling, however under-reporting rates are at least 54% (NZTA, 2010, Turner et al., 2009), crash causation reporting is often biased (Wood, 2008) and crash numbers may not reflect the reality that a given network element may be so dangerous that cycle trip making demand is suppressed.

Cycle traffic counts are the focus of this paper, and are used in three general ways:

- cordon counts give useful information but only represents a limited proportion of cycling activity occurring city-wide. For example, Hamilton currently undertakes a central city cordon count for cyclists;
- screen line counts commonly follow natural or artificial barriers and if all potential crossing points are counted, they can be useful to check home interview or other transport survey data. For example, Hamilton’s Waikato River and railway main trunk line are natural screen lines; and
- a sample of network locations selected to be generally representative of the range of trip purposes and geographic areas.

Cycle traffic counts have historically been undertaken by means of manual (i.e. a human surveyor) counts. Sample sizes are necessarily limited by resource availability. For example, Hamilton has been undertaking small sample (one day per year) manual counts of cyclists since at least 1980.

Automatic Cycle Counters

Automatic cycle counters are the primary method of cycle monitoring recommended by most reviewed sources as they can generate larger sample sizes. A network of automatic count sites is required to build an understanding of cycle volumes and trends throughout a city.

The design of an automatic cycle counting programme is dependent upon the technology chosen, as counter performance varies depending on the facility type (e.g. on-road cycle lanes versus off-carriageway paths).

Jones et al (2010) describe a range of automatic traffic counters which are available worldwide, although they do not seem to be aware of the potential for automatic pedestrian / cyclist differentiation as will be presented in this paper. The principal types of counters are:

- infrared (passive thermal contrast or active beam interruption);
- ultrasonic;
- radar;
- video imaging (computer analysis of pixel changes);

- piezometric pressure sensitive (above ground pneumatic tubes or in ground cables); and
- inductive magnetic field loops (in-pavement).

A web-based search and personal observations on study tours indicates that piezometric and inductive technologies are commonly used in western Europe. In North America, infrared counters have been used primarily off-road but there has been little development of on-road counting technologies (Schneider et al., 2005, Alta, 2009). San Francisco has successfully trialled inductive loops and planned on implementing them at 33 sites city-wide throughout 2010 (SFMTA, 2010).

In New Zealand, piezometric pneumatic tubes are commonly used for temporary count sites. Based on previous automatic counter research (ViaStrada, 2009) in-ground inductive loops are now being installed at 22 sites in Christchurch. Piezometric in-ground loops have now become available but were not reviewed for this research. A prospective counter technology user is advised to consider new technological developments before selecting a product.

Number and Location of Counting Sites

In terms of number of counting sites, Davies et al (1999) recommended that:

- At least one, and preferably several, control sites should be established, equipped with permanent or long-term automatic (i.e. mechanical) traffic counters to provide counts of background levels of cycle traffic.
- Manual counts are not suitable as the main method of cycle monitoring but should be used in conjunction with other counting methods to provide supplementary information and to calibrate automatic counters.

In terms of location of counting sites, the same report recommended that:

- Permanent counters should be located at sites with major cycle flows (preferably over 250 cycles per day) where no major cycle infrastructure changes are anticipated in the near future.
- If more than one permanent counter is installed they should be spread between different route types.

The best guidance the report gives in terms of site selection is that sites should be selected based on strategic and local criteria. Strategic (i.e. a given road or path) site selection is the primary criterion and dictates that all sites in a monitoring programme should contribute towards its requirements. Local (i.e. specific location along a road or path) site section criteria such as road and traffic characteristics must be suitable for the counter.

Other important guidance from the UK comes from Cycling England's "Cycling Demonstration Towns Monitoring Report 2006 to 2009" (Cope et al., 2009). Monitoring is considered key to determine the effectiveness of investment in measures to stimulate increased levels of cycling in six "demonstration towns". Automatic counters were the main method used. In terms of number and placement of automatic counters, the report states:

"the distribution of the automatic counters is planned on a pragmatic basis, using existing networks of counters... fundamentally aiming to capture the majority of the cycling flow to key destinations. There is no sensible formula to determine an appropriate density of counters in a given area, rather the number of counters was based in each case on a geographical analysis of the town to create appropriate cordons and screen lines and weighing up the data requirements against costs."

This research, perhaps one of the most intensive cycle monitoring schemes undertaken recently, confirms that there is no standard method of determining the required number and placement of cycle counters for a cycle counting programme.

However, an empirically based model has been developed by Strong (2006) which suggests a range of counters dependent on urban population. Additional factors such as the minimum number of sites to represent the range of facility types, geographic and socio-demographic features should also be considered.

Once the approximate number of counters and the strategic site selection criteria are determined, the coverage area of potential sites is considered. A GIS (geographic information system) analysis could help determine the coverage area of a cycle site, but the benefits of this may not be justified given the additional expense.

The coverage area is influenced by the location along a ride and the direction of travel. Each automatic count site will count cyclists travelling in one direction or both directions on off-road path. Generally a single site will only provide a reliable estimate of cycle volumes for the midblock section of road on which it is taken. The various route options introduced at intersections make it difficult to understand where cyclists will travel, unless specific intersection surveys are made.

Count Durations

Counts do not need to be permanent to give an indication of yearly volumes. New Zealand's Cycle Network and Route Planning Guide (CNRPG) (LTSA, 2004, Gravitas, 2009) provides a method for estimating cycle AADT (average annual daily traffic) from counts done for part of a day. This method allows short-term counts to be factored according to daily, weekly and seasonal changes to estimate yearly volumes at a specific site. It is important, however, to understand what durations these "short-term" counts should have to provide statistically meaningful information.

One could simply adopt the two week duration typically used for motor traffic monitoring. For cars, this duration is generally sufficient to reliably compare year on year flows ("time series analysis") and detect relatively small trends because there are thousands of vehicles counted and there is a small variation from the mean traffic volumes.

Counting bicycles is another matter, as the relatively few bicycles counted at a given site requires a long duration (sample size) to enable statistically reliable comparisons. Davies et al (1999) suggest a count duration of seven days per year to achieve a 90% confidence of detecting a 20% change in volumes¹, assuming a coefficient of variation (CV²) of 0.15 for sites with 250 or more cyclists per day.

In the absence of significant interventions (such as the UK's Demonstration Towns or the NZTA's Model Communities), a 20% increase per year in cycle volumes may be overly optimistic for most New Zealand urban areas and thus a longer count duration will be required. On the other hand, higher cycle traffic sites in New Zealand will have volumes in the 301 to 450 range, thus a lower CV can be used.

To compare with the typical two week motor vehicle count, to achieve 90% confidence of detecting a 10% change in volumes, a CV of 0.10 is required. A recent analysis of permanent count sites in Christchurch gives a CV of around 0.35 (Hughes, 2010), but shows strong correlation between two of the three permanent count sites. This suggests that given sufficient permanent count sites which exhibit good correlation and careful matching of site characteristics, a shorter duration for temporary sites may still be possible.

Further research on New Zealand specific CVs will be required to determine appropriate temporary count durations. In the meantime, two week durations for temporary sites should be the absolute minimum and longer durations are preferable.

¹ Refer to pages 13-15, in particular Table 3.1 and Figure 3 of Davies et al (1999) for a more in-depth description.

² Coefficient of Variation – a measure of the relative variation of data, taken as the standard deviation of the cycle volume divided by the mean cycle volume. CV is normally lower for sites with higher volumes, i.e. there is less variation when volumes are higher.

HAMILTON CITY CYCLE COUNTING PROGRAMME

Background and Methodology

The current Hamilton City Council (HCC) annual manual count programme includes 20 intersections around the central city (undertaken annually since 1980), with three pathway sites and six suburban intersections added to the programme in 1996. HCC required an automatic counting programme to augment or replace the manual counts.

Counting programme development may be divided into three broad phases. Phase one would include determination of the number of counters, strategic site locations, counter types, time frames and indicative costs. Phase two would be to specify exact site locations and installation details required for contractors. Phase three would be the collection and analysis of data. HCC commissioned ViaStrada to undertake phase one, while equipment suppliers Integrated Traffic Solutions (ITS) are completing phase two.

In developing the programme, factors must be considered somewhat simultaneously and iteratively as they involve many interdependent relationships. These factors, which are also the heading titles of the next sections of this paper, are:

- Number of sites required
- Strategic site criteria
- Counting equipment types
- Counting durations
- Counting methods
- Site locations
- Programme costs
- Implementation options

Number of Sites Required

The work of Strong (2006) suggests a city of Hamilton's population (approximately 140,000) should have around 6-9 counting sites. In addition to this population based method there should be enough counter sites to represent a mix of geographic areas and facility/user types (Davies et al., 1999). Considering these factors in an iterative process, a minimum of 9 count sites were recommended for Hamilton.

As an automatic count programme recently developed for Christchurch used a similar analysis to recommend 22 sites, it is useful to compare the two cities (Table 1).

Table 1: City size comparison

Criteria	Hamilton	Christchurch
City population (2009)	141,504	386,100
City area (km ²)	98	240
Cycleways on and off street (km)	101	154

In a mix of geographic and population terms, the city of Hamilton is a little less than half the size of the city of Christchurch. This comparison indicates a consistency between recommendations for the minimum number of sites.

The project identified more sites than the minimum to enable flexibility based on the outcomes of phase two. A further increase in the number of sites may be justified as budgets permit, new facilities are developed, or to satisfy other monitoring objectives.

Strategic Site Criteria

Based on the literature review and previous experience, inputs to the Hamilton strategic site selection process included the cycle network map, cycle and general traffic count data, the road hierarchy map, and major trip generators (e.g. schools, tertiary institutions, hospitals, and the central city). These inputs were considered along with strategic criteria including:

- network coverage criteria including the selection of locations with high cycle volumes to maximise the data accuracy and principal origins / destinations, and screen lines;
- a mix of on-road and off-road facilities, especially considering potential impacts from the proposed completion of contiguous off-road routes;
- a mix of tidal directions based on peak period considerations; and
- site specific factors including pavement surface, the effect of curves, parking and lane lines upon the typical line taken by riders, and intersections.

Counter types, durations and methods

A total programme cost analysis showed that using in ground inductive loops at all sites was not significantly more expensive than a mixed system employing above ground piezometric tubes at short term sites. Further reasons to employ a full inductive loop system were the Boundary Bridge active warning sign (where an inductive loop is employed to activate the sign) and the ability to integrate with pedestrian counters on shared path installations.

The programme development included a review of existing manual programme peak periods. Automatic counting durations were divided into permanent (full-time) and short term (two-week) counting sites. Permanent sites are especially important for establishment of locally appropriate factors to be used in scaling as per the CNRPG method mentioned previously.

As a result of the iterative development process, it was determined that the short term sites could actually be counted for longer periods (up to 10 weeks each) due to the number of counters required. This would improve the sample sizes and data reliability.

The existing manual intersection cycle count programme gathers behaviour, gender, age, and turning movements. Manual counts are also required for calibration of the automatic counters. The addition of an automatic count programme provides an improved estimate of cycle traffic throughout the city's network and should make it possible to reduce the existing manual counting programme. Subsequent steps identified opportunities for this.

Table 2: Counter types, durations and methods

Method	Counter	Duration
Permanent	Automatic counter (in ground)	Year-long
Short-term	Automatic counter (in or above ground)	2 weeks minimum
Manual	Manual counter	Peak periods

Strategic Site Locations

One on-road and one off-road permanent count site plus ten short term count sites were identified. Each site was tabulated against the aforementioned criteria, possible equipment type, and relationship to existing manual count sites. All sites were rank ordered, with sites 13 to 20 retained as "alternatives" for future consideration.

Site locations were initially mapped in a web-based programme which could be edited by HCC staff to obtain feedback. Subsequently, a more detailed "fixed" map with colour coding corresponding to direction, facility type, and implementation programme was produced. An example of the latter map is shown in Figure 1.

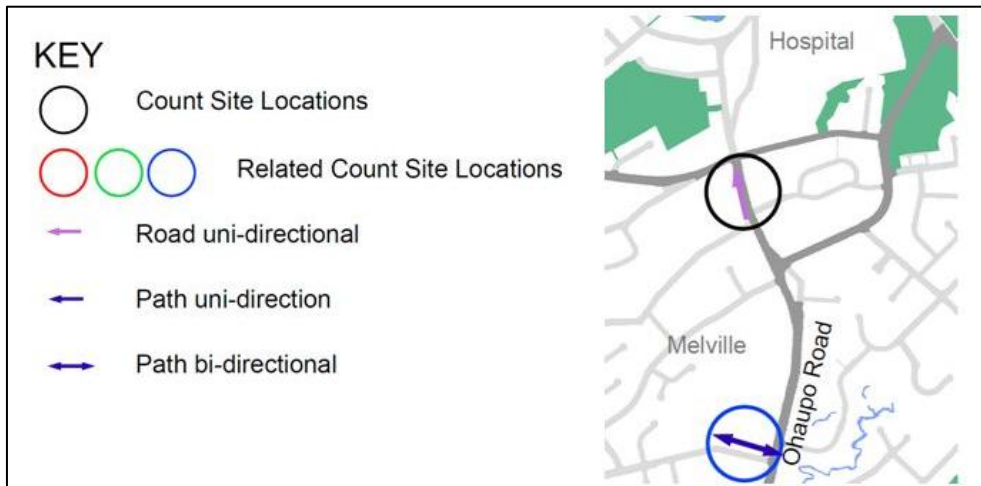


Figure 1: Excerpt of Hamilton count site map

Programme Costs

Capital and operational cost estimates for various count types were collated. To reflect uncertainty in cost estimates, upper and lower bound estimates were used. For two permanent sites serviced by two counters and ten short term sites serviced by two counters on rotation, the start up capital cost was estimated as \$43,800. The annual operational cost including data collection was estimated to be \$4,200. To inform HCC budget allocations, the upper bound capital and operational costs were projected over a 20 year programme duration including an assumed replacement of all loops at year ten (Figure 2).

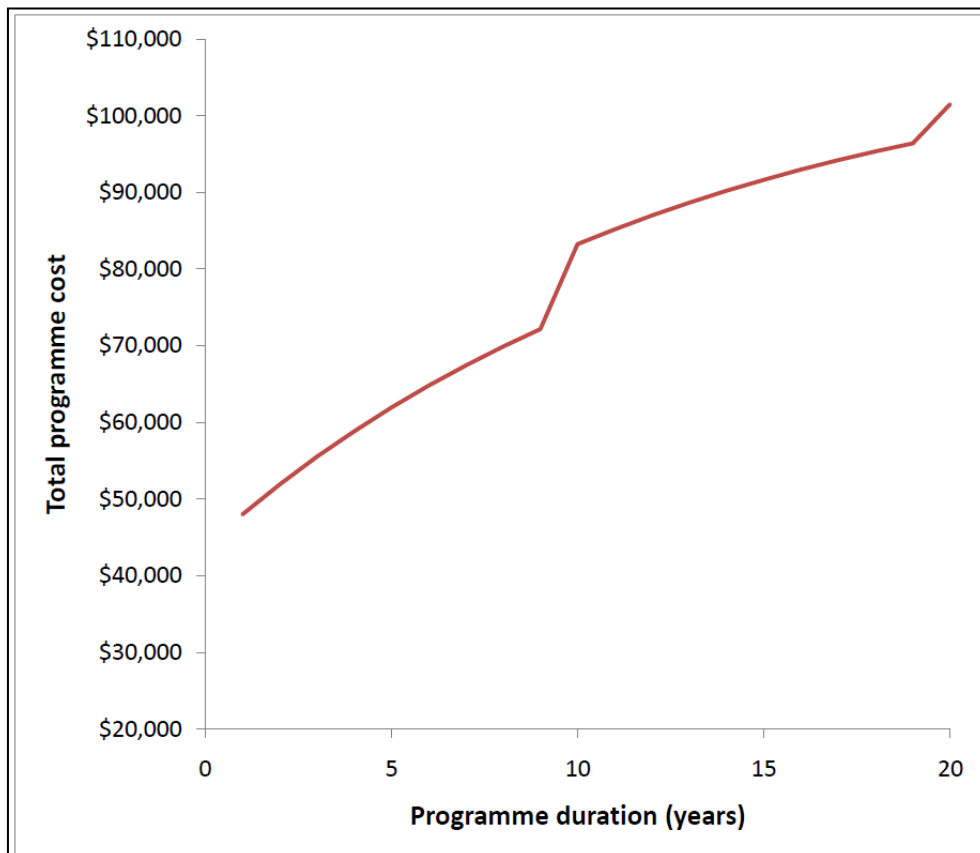


Figure 2: Programme cost estimate over various durations

Based on an analysis of the existing and recommended count locations, eight of the 29 manual count sites were recommended to be eliminated, saving about \$4,800 per year.

Implementation Options

Full (all 12 sites) or partial (six sites) programme sizes and immediate (all sites installed in first year) or staggered (two permanent sites in first year, remaining sites installed in two batches over subsequent years) implementation timeframes were compared. Costs per site year (i.e. cost per survey) analysis showed that the full programme, immediate implementation option (option 1) was the most cost effective over the long term and obviously generated the most data (Figure 3). The programme cost range represents the upper and lower bound estimates as previously mentioned.

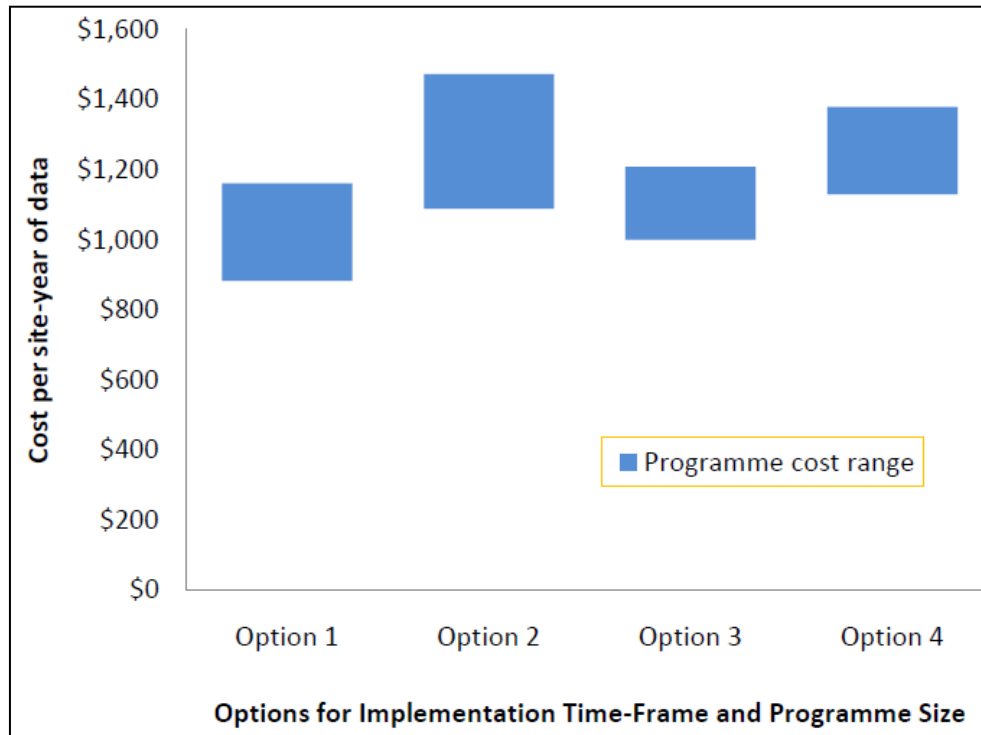


Figure 3: Cost per site-year for various implementation options

Phase 2: Local detailed site investigations

Following the initial strategic report, Hamilton City Council and equipment suppliers ITS visited the recommended sites to undertake detailed investigations focusing on the technical aspects of counter installation. This is a critical step as the path of a cyclist is dependent on many factors such as surface conditions and path or road user interactions. These site specific factors were considered at every location to establish sensor placement and data logger configuration. Installation of permanent and temporary count sites is ongoing with the aim of all sites being operational in 2011.

Since the original programme development, a new data logger has become available with telemetry allowing data to be remotely uploaded to the internet. This has increased upfront costs but may be more economical over longer analysis periods due to reduced data collection costs.

CONCLUSIONS AND OTHER NEW ZEALAND APPLICATIONS

Good bicycle traffic volume data can aid strategic planning, transport system modelling, and network management. Larger sample sizes offered by automatic counting technologies enable robust time series data analysis.

The literature includes limited explicit guidance on cycle counting programme development. For Hamilton, a minimum of 6-9 automatic counters was estimated based on the work of Strong (2006) and comparison with the recently developed Christchurch City Council cycle

counting programme. After consideration of a range of strategic criteria, 12 sites were recommended with at least two of these to be permanent count stations. Capital and operational costs of an automatic count programme for Hamilton were estimated to be \$43,800 and \$4,200 respectively. Comparison of the existing and proposed sites showed that a reduction of eight (out of 29) manual count sites would yield savings of about \$4,800 per year.

The project demonstrated that an iterative, step by step approach is a useful method to develop a cycle counting programme. Careful strategic site selection is required to ensure that a range of facility types, geographic features, and key cycle trip generators are included. The development of implementation options will also be specific to each city.

The re-evaluation of equipment choice may be warranted by new advances in technology. With automatic counting programmes now being launched in cities including Hamilton, Christchurch, Auckland and New Plymouth, results should soon become available to help establish minimum temporary count durations and refine locally appropriate scaling factors.

REFERENCES

- ALTA 2009. Automatic Count Technologies. *National Bicycle and Pedestrian Documentation Project*.
- ARTA 2006. Regional Cycle Monitoring Plan Provisional Guidelines 2006-2008. Auckland: Auckland Regional Transport Authority.
- COPE, A., MULLER, L. & KENNEDY, A. 2009. Cycling Demonstration Towns Monitoring project report 2006 to 2009.
- DAVIES, D. G., EMMERSON, P. & PEDLER, A. 1999. Guidance on Monitoring Local Cycle Use. TRL Report 395. Berkshire, UK.
- GRAVITAS 2009. Manual Cycle Monitoring in the Auckland Region. Auckland.
- HUGHES, T. 7 October 2010. *RE: Permanent cycle count coefficient of variation in Christchurch*. Type to WILKE, A.
- JONES, M. G., RYAN, S., DONLON, J., LEDBETTER, L., RAGLAND, D. R. & ARNOLD, L. 2010. Measuring Bicycle and Pedestrian Activity in San Diego County and its Relationship to Land Use, Transportation, Safety, and Facility Type. Berkeley: Institute of Transportation Studies - UC Berkeley Traffic Safety Center.
- LTSA 2004. Cycle Network and Route Planning Guide. Wellington: Land Transport Safety Authority.
- NZTA 2010. Economic Evaluation Manual. New Zealand Transport Agency.
- PAG 2008. 2008 Tucson Metropolitan Region Bicycle Count. Pima Association of Governments (PAG).
- SCHNEIDER, R., PATTON, R., TOOLE, J. & RABORN, C. 2005. Pedestrian and Bicycle Data Collection in United States Communities. Pedestrian and Bicycle Information Center.
- SFMTA 2010. City of San Francisco 2009 Bicycle Count Report. San Francisco, USA.
- STRONG, M. 2004. Monitoring of Cycling in Hertfordshire: Report on the Current Situation and Proposals for Improvement. Brighton, UK: Transport Initiatives.
- STRONG, M. 2006. Practical Monitoring of Cycling. *Transport Practitioners' Meeting*. Transport Initiatives, LLP.
- TURNER, S., ROOZENBURG, A. & BINDER, S. 2009. Cycle safety: reducing the crash risk. Wellington: NZ Transport Agency.
- VIASTRADA 2009. Continuous Cycle Counting Trial. Wellington.
- WOOD, K. 2008. *Bicycle Crashes in New Zealand: Revised Web Version*. Masters, Lincoln University.

ACKNOWLEDGEMENTS

The initial literature review and count programme development methodology was developed by Megan Fowler (formerly of ViaStrada) and Jeanette Ward of ViaStrada in 2008. Research on developments since 2008 and application of the methodology to Hamilton was primarily undertaken by the first author of this paper.