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Automatic Bicycle Counting

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Abstract

*This paper summarises research undertaken for Transfund New Zealand (Transfund) by MWH New Zealand Ltd in Christchurch between October 2001 and May 2002 to evaluate automatic bicycle counting technologies. A comprehensive report of the research findings has been published by Transfund as Research Report No. 230 entitled **"Evaluation of Automatic Bicycle Counters in New Zealand"**.*

A literature review and consultation with key staff in road controlling authorities were undertaken to select the types of equipment to test. Rigorous testing was performed on two commercially-available pneumatic rubber tube traffic counting machines. Tests were undertaken both off-street (to simulate conditions in parks and on cycle paths) and on-street in mixed traffic, to simulate typical conditions for cyclists, where cycling data are typically unavailable. Other types of equipment were not tested and may be satisfactory for counting bicycles.

Both counters performed satisfactorily and are recommended for use in New Zealand for counting bicycles, either off-street or on-street, and in both urban and rural situations. They are capable of counting and classifying bicycles and motor vehicles simultaneously. Recommendations are made about correct procedures for using the machines for counting bicycle traffic and for further research into bicycle counting.

The research is important as it demonstrates that automatic bicycle counting is feasible and relatively easy to do as part of routine traffic counting.

1 Introduction

Bicycle counting has usually been a difficult, expensive and labour-intensive task for road controlling authorities. The reliability of many conventional traffic counting machines for counting bicycles has not previously been assessed. In New Zealand, routine manual intersection traffic counts rarely include bicycle traffic, and in cases where these data are captured, the counts may be unreliable because traffic counting staff either don't notice the relatively few bicycles on the road or are fully occupied counting motor vehicles. Consequently, few road controlling authorities in New Zealand (including local authorities and Transit New Zealand) have reliable data on how many bicycles use their roads and streets.

Yet most road controlling authorities undertake routine classified counts of traffic using traffic counting machines, where the composition of traffic is determined from the arrangement of axles of each passing vehicle. The challenge for this research was to see whether the existing technology (or something similar) commonly in use in New Zealand could reliably count and classify bicycle traffic as well.

From a policy perspective, growth in bicycle traffic (rather than motor vehicle traffic) is desirable, as the bicycle is the most efficient vehicle in terms of road space, parking space, fuel consumption and emissions. Increased bicycle use can reduce the need for expensive new road infrastructure. While cycling is supported at a policy level by local, regional and national governments, cost-effective methods of monitoring cycling activity are needed to monitor the effectiveness of existing and future transportation, health, energy and land use policies.

Cost-benefit analyses will be necessary in many cases to justify investment in specific new transport facilities, whether these are to be used exclusively by cyclists or whether cyclists are just one of a variety of road users. Transfund New Zealand (Transfund) allows existing and/or anticipated bicycle traffic volumes to be quantified and given economic value for their health benefits in cost-benefit analyses[1]. Reliable bicycle traffic data will improve the accuracy of these analyses, not only for bicycle facilities, but also for any project where bicycle traffic is a factor.

The main objectives of the research were to:

1. Research the international literature on "state of the art" bicycle counting technologies;

2. Consult with selected practitioners in New Zealand road controlling authorities as to the current needs and existing technologies and methodologies in use locally;

3. Communicate with suppliers (either local or overseas as necessary) for detailed specifications of potentially useful and cost-effective equipment;

[1] Transfund General Circular No. 02/04, March 2002: Implementation of a value for the health benefits of cycling into the PEM (Transfund Project Evaluation Manual).

4. Test one or two of the most promising technologies in a variety of settings, including both off-street bicycle paths and urban and rural on-street locations;

5. Evaluate the effectiveness and ease of use of any associated computer software for each piece of equipment;

6. Make recommendations on the preferred technology or technologies for particular circumstances; and

7. Publish the findings of the research in a user-friendly format and work with Transfund to ensure that the information is easily accessible to end users.

The research was commissioned by Transfund and undertaken by MWH New Zealand Ltd in Christchurch between October 2001 and May 2002. Peer reviewers for the research project were Roger Boulter (Hamilton City Council), Alix Newman (Christchurch City Council) and Tony Spowart (Transit New Zealand, Christchurch). The research is documented in a Transfund Research Report[2].

Field testing of the equipment is illustrated in Figure 1 below.

Figure 1: Marshland Road test site

[2] *Evaluation of Automatic Bicycle Counters in New Zealand:* Macbeth, A. G and Weeds, M. G, Transfund New Zealand Research Report No. 230 July 2002

2 Methodology

An extensive literature review using the Internet was undertaken to help understand the extent of use of automatic counting equipment for counting bicycle traffic. No jurisdictions were identified as current users of such technology. Staff were consulted in Christchurch City Council, Hamilton City Council, Palmerston North City Council and Transit New Zealand, the national "State Highway" road controlling authority. None of these authorities used automatic equipment to count cycles and none was aware of any other jurisdiction in New Zealand which did so.

Inductive loops are a proven vehicle detection technology. However, inductive loops are generally considered to be unable to discriminate between bicycles and motor vehicles. Inductive loops may be suitable for use where long-term counts at a single location (free of motor vehicle traffic) are required, but it was felt that most road controlling authorities are more likely to need a more portable traffic counting technology. Consequently, inductive loops were not tested as part of this research.

A number of manufacturers claimed to have equipment which could count bicycle traffic. Traffic counting equipment suppliers in New Zealand (Harding Traffic) and Australia (MetroCount) provided detailed information about particular traffic counting machines which they claimed could count bicycles. These machines respectively were the Golden River Marksman 410 Bicycle Classifier (GR M410) and the MetroCount Vehicle Classifier 5600 Series (MC 5600).

Both counters are conventional rubber tube pneumatic detector counters common in New Zealand and overseas for counting motor vehicle traffic. The GR M410 is a purpose-designed bicycle counter, whereas the MC 5600 is a routine traffic counter. These counters work by detecting air pulses generated when wheels cross the rubber tubes. By using two parallel tubes separated by a known distance (typically one metre), rubber tube traffic counters can measure the speed (and direction) of vehicles crossing the tubes, as well as the distance between successive wheels or axles. Because bicycles are short vehicles, they could easily be distinguished from other vehicles (including motor cycles) by their wheelbase, assuming the equipment was sufficiently sensitive and accurate to detect bicycle tyres.

After further discussion with the peer reviewers it was concluded that both machines were potentially suitable and extensive testing was begun. Three sites were selected in Christchurch to represent a variety of urban and rural locations typical of New Zealand conditions. Further testing of the equipment was undertaken in an unused section of the consultant's carpark.

Counting involved a minimum sample size of 50 bicycles, most of which were generated by members of the research team riding along the road over the counter and back along the road verge, in a circular motion. In this way, 50 passes of a cycle could be generated reasonably quickly. Variations of the methodology included riding at varying speeds to ascertain the sensitivity of the equipment to this variable. Speeds were measured by a cycle speedometer. Different cycles were used to ensure that both mountain bikes with wide tyres and older 10-speed cycles with narrow tyres were able to be detected, as illustrated in Figure 2 below.

Figure 2: Testing of different bicycle types at Kilmarnock Street

Figure 3: MC 5600 (left) and GR M410 (with case open) counters tested in a carpark, free of other traffic, using four different kinds of pneumatic rubber tubes

In some tests, motor vehicles were present and in others, they were absent, to allow counter reliability to be tested against this variable.

Different types of rubber tube (supplied by the manufacturers) were also tested (see Figure 3, left).

Various lengths of rubber tubes were tested to determine counter sensitivity as a function of tube length.

3 Results

3.1 Golden River Marksman 410

The GR M410 performed well from the outset. It counted all bicycles in the controlled environment of the researcher's carpark. In the on-street, mixed traffic environments of Armagh Street, Kilmarnock Street and Marshland Road, the results of counting are recorded in Table 1 below:

Table 1: Testing of GR M410

Site	Environment	No. of Lanes	Manual Count	Machine Count	Accuracy
Armagh St	Urban	2	122	117	96%
Kilmarnock St	Urban	1	155	142	92%
Marshland Rd	Semi-Rural	1	150	150	100%
Total			**427**	**409**	**96%**

The GR M410 counted bicycles at acceptable levels of accuracy within the scope of the study. Although the recorded average of three tests (as shown above) was 96%, it is possible that the counter was 100% accurate, because the team member counting bicycles was also counting and classifying motor vehicles, and in these circumstances it would be easy to under-count or over-count a few bicycles. In the car park testing, the GR M410 appeared to over-count bicycles by 4% (104 recorded by machine and 100 manually), which was probably a result of manual under-counting. As with much research, the methodology was refined as the research continued. By the time final tests were performed on the MC 5600, two or three staff were counting bicycles to ensure a reliable count, and motor vehicles were merely counted (not classified). The conclusion from the GR M410 tests was that the counter was accurate at counting bicycles.

3.2 MetroCount 5600

After much preliminary (and somewhat unsuccessful) testing of the MC 5600 at all three sites and in the consultant's carpark, a final series of tests was undertaken at the Marshland Road site. Many potential sources of error had been eliminated in the earlier testing, and the remaining variable appeared to be tube length. The results of this testing are shown in Table 2 below:

Table 2: Testing of MC 5600

Test Description	Length of Bicycle Tube (m)	Length of Motor Vehicle Tube (m)	Combined Tube Length (m)	Manual Count *	Machine Count	Accuracy
Bicycles only	5	0	5	50	50	100%
Bicycles and MVs	5	3.5	8.5	47	47	100%
Bicycles only	10	0	10	45	45	100%
Bicycles and MVs	10	3.5	13.5	49	42	86%
* Where fewer than 50 cycles are shown, the difference between the manual count and 50 was the number of cycles travelling slower than 10 km/h.						

The research demonstrated that with tubes not longer than 10 m, the counter performed accurately, but that accuracy declined as the tube length increased. At 13.5 m length (10 m of bicycle tube with an additional 3.5 m of conventional traffic counting tube to span the general traffic lane), the accuracy dropped to 86%. The earlier work had been shown that with 15 m tubes, the accuracy of the machine at counting bicycles was around 42% to 45%, although motor vehicles, which generate a stronger air pulse, were still counted satisfactorily. This suggests that with 10 m tubes, the counter is reliable for counting bicycles, but accuracy declines with tubes longer than that.

Bicycle speeds were tested as part of this phase of the research. When bicycle speeds fell below 10 km/h, the MC 5600 would not detect bicycles. In practice, this would not be an issue on flat ground or a downhill grade, but uphill grades should be avoided as bicycle counting locations where possible. The reliability of the GR M410 was not specifically tested in relation to bicycle speed, but a number of bicycles were recorded travelling between 5 km/h and 10 km/h.

4 Discussion

The published report discusses several aspects of the research, including a number of issues associated with collecting reliable, long-term bicycle traffic data. In the limited space available in this paper, discussion is confined to the shortcomings of existing vehicle classification systems.

There is currently no standard New Zealand or Australian vehicle classification scheme that classifies bicycles separately from other vehicles. Austroads (the Association of Australian and New Zealand Road Transport and Traffic Authorities) in 1994 developed a vehicle classification system with 13 classes, with one class including cars, utility vehicles, four wheel drives, motorcycles and bicycles. Austroads94 is a widely-used standard on both sides of the Tasman.

The Austroads ARX scheme is a later version which separates bicycles and motorcycles from other small vehicles (such as cars), and also accomplishes this within 13 classes by amalgamating double and triple road trains as the largest vehicle class. But bicycles are still not distinguished from motorcycles. The Austroads ARX scheme is generally not used in New Zealand. Transit New Zealand's current 14-class system (TNZ 1999), like Austroads94, groups bicycles, motorcycles and cars in the same class.

Of the vehicle classification systems used in New Zealand, Austroads94 is the only one offered by Golden River. The use of a spreadsheet is necessary to separate bicycles from cars (and motorcycles) on the basis of wheel-base. Golden River is understood to be currently working on adding the TNZ 1999 classification system to its traffic counting machines.

The MC 5600 machine can provide traffic counts based on the Austroads94, Austroads ARX and TNZ 1999 systems. The MetroCount Traffic Executive software is also able to group vehicles into six standard vehicle classifications (car, light commercial vehicle, medium commercial vehicle, two classes of heavy commercial vehicles and buses) to comply with Transfund's Project Evaluation Manual. Bicycles, however, are currently not recognised in Transfund's six-class system. MetroCount's latest software version allows users to define their own vehicle classes but developing a standard New Zealand or Australasian classification system would be preferable.

This research shows that bicycles and motor vehicles can be distinguished using commercially available traffic counting equipment. Furthermore, bicycles can be separated from motorcycles, as bicycles typically have wheel-bases of 120 cm or less (most are around 100 cm to 110 cm), while motorcycles are typically 140 cm or more.

Transfund has recently modified its procedure for economic project evaluation to recognise the health benefits which accrue to society when people cycle[3]. Quantification of the economic benefits of cycling depends on estimates of actual or proposed numbers of cyclists. While both traffic counters tested are capable of distinguishing and recording bicycles, the existence of a standard vehicle classification system would assist practitioners in analysing, storing and reporting traffic counts, including bicycle traffic. Liaising with traffic counter manufacturers would also be prudent, to ensure that any new classification systems can be supported by commercially available hardware and associated software.

Given the increasing importance of cycling from a policy perspective, the time seems right to recognise bicycles as a separate vehicle class in routine traffic counting and the underlying vehicle classification systems.

5 Recommendations and Conclusions

A number of recommendations are contained in the report. These are attached as Appendix A. The key conclusions from the research are:

Both counters performed satisfactorily and are recommended for use in New Zealand for counting bicycles, either off-street or on-street.

Bicycles can be counted accurately in mixed traffic as part of routine automatic traffic counts in both urban and rural environments. Both motor vehicles and bicycles can be counted simultaneously and classified by vehicle type, using commercially available traffic counting machines.

Pneumatic rubber tube traffic counters appear to be the most cost-effective technology currently available for counting bicycle traffic automatically for short-term durations (typically up to one or two weeks).

Vehicle classification systems currently in use in New Zealand need to be updated to recognise bicycles as a class of vehicle distinct from motorcycles, cars, and other motor vehicles.

The research shows that automatic bicycle counting is feasible and relatively easy to do as part of routine traffic counting. It is now up to road controlling authorities to apply the research and count bicycles at key locations.

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3 Transfund General Circular No. 02/04, March 2002: Implementation of a value for the health benefits of cycling into the PEM.

Appendix A: Recommendations

The research report recommends that:

1. When automatic bicycle traffic counts are required, they should be undertaken using special bicycle-sensitive rubber tubes as recommended by traffic counter suppliers or manufacturers.

2. When a road's AADT is less than 7,000 motor vehicles per day, one counter can be used to record both motor vehicles and bicycles.

3. When a road's AADT is greater than 7,000 but less than 14,000 motor vehicles per day, one counter should be used on each side of the road to record motor vehicles and bicycles.

4. When a road's AADT is greater than 14,000 motor vehicles per day, one counter should be used in each motor vehicle and bicycle lane (or typical bicycle trajectory).

5. When using the GR M410 for counting bicycle traffic (with or without motor vehicle traffic), the rubber tubes should not be longer than 15 m.

6. When using the MC 5600 for counting bicycle traffic, the rubber tubes should not be longer than 10 m, and the survey site should not be located on an incline;

7. When using the MC 5600 for counting both bicycle and motor vehicle traffic, composite tubes should be used. These consist of bicycle counting tubes at the edge of the road (to detect bicycles) joined to conventional traffic counting tubes in the centre (to detect motor vehicles).

8. Road controlling authorities should count bicycle traffic as part of routine automatic traffic counts.

9. Transfund should ensure that a national or Australasian standard for automatic traffic counter vehicle classifications is developed and implemented to include bicycles as a separate class of vehicle from other vehicles.

10. Transfund should commission further research to develop robust methods to estimate AADTs for bicycles based on short-term automatic bicycle counts.

11. Transfund should commission further research to establish appropriate AADT limits for simultaneous counting of bicycles and motor vehicles with one traffic counting machine.

12. Transfund should commission further research to establish recommended traffic counting technologies for long-term bicycle counting at control stations.