TRANSPORT RESEARCH LABORATORY

Research on monitoring cycle use

Prepared for Charging and Local Transport, Department of the Environment, Transport and the Regions

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Executive Summary

The Transport Research Laboratory was commissioned by the Charging and Local Transport Division of the Department of the Environment, Transport and the Regions (DETR) to provide guidance to local authorities and others on methods for monitoring cycle use. The guidance is intended to help with obtaining accurate estimates of levels of cycle, survey design, and the statistical interpretation of results. The cycle flow information is needed to assess progress towards the national targets for cycle traffic growth. This report concentrates on the findings of collaborative research, over two years, between TRL, six local authorities and other interested bodies, and which helped frame much of the advice contained in a companion report, which provides guidance on monitoring cycle use (Davies, Emmerson & Pedler, 1999).

The study investigated two areas of monitoring: Quantitative data collection, through automatic and manual cycle counts, on the levels of cycle traffic and data collection, through interviewing and questionnaires, on the characteristics of cyclists and their journeys. Experience of the local authorities and other organisations that attempted regular monitoring of cycle use led to the following conclusions:

Monitoring pedal cycle traffic

- There is considerable demand from local authorities for automatic traffic counting (ATC) equipment that will count pedal cycles. The equipment would fit well with local authority transport policies and monitoring programmes.
- The major problem with the automatic traffic counting (ATC) equipment used in this research was found to be the inability to count cycles accurately in a number of environments. Factors associated with inaccuracies at on-road sites have included interference from motor-vehicles, poor siting and, electrical and radio interferences. The latter two factors have also lead to problems at some off-road sites but more than half of these now appear to be working satisfactorily, at least in one direction.
- Progress has been made by the manufacturer of ATCs during the study, and other manufacturers are now showing interest in producing similar equipment. However, the ultimate aim (that of counting cycle traffic amongst other vehicles) cannot be guaranteed, at present, and this places serious limitations on the type of sites that can be selected for monitoring cycle traffic in general. Monitoring only off-road cycle flows could lead to biased estimates of changes in cycling, especially in the light of the provision of more off-road cycling facilities.
- Developments in the counting technology and software are continuing and better outcomes should be expected from new sites than were obtained from the sites used in this study, provided the published guidance is followed.
- The monitoring of flows over a long period of time has proved possible.
- Local authority resources are limited and problems with the counters have proved time-consuming but the longer battery and memory life of later versions of the equipment has been a boon.
- Local authority staff often have to fit in numerous other duties with monitoring. Activities such as validating cycle counters are not always recognised as a priority.
- Data from national sources have been used to estimate the effects of weather on daily variation in cycle flows and both local and national data have been used to prove estimates of the amount of day to day variation in cycle flows to be expected, once known weekly and month variations have been taken into account. This variation may be used to develop a basis for estimating count periods for monitoring change, either on a scheme basis or over an area, as set out in the guidance report.

Monitoring travel by pedal cycle

- Monitoring programmes should not be over-ambitious. All data collected should have a use and the quantity should be manageable.
- Monitoring methods should not be complex or time consuming as these are likely to be abandoned after one or two repetitions.
- The most cost-effective methods appear to be those where an employer, school, etc. collects the information and passes it straight on to the local authority. However, this requires good co-operation.
- Obtaining permission for a one-off survey is usually not difficult but regular co-operation requires that the employer, school, transport operator, etc. has an interest in the project. This may be best achieved within the context of a Green Commuter Plans initiative or Safer Routes to Schools programme.
- The local authority must help to design and co-ordinate the surveys, ensure that the information is delivered promptly and provide feedback to the partner organisations.
- Counting parked cycles is generally the most practical, reliable and cheapest method of monitoring cycle use at a particular location. These counts work best where there is only a small number of cycle parking locations at a site. Weekly counts, on a certain day and time, are optimal. A few locations, such as Cycle Centres, may be able to provide very detailed information, such as the number of cycles parked per day.
- Where possible at workplaces, counting parked cycles should be combined with counting parked cars, where most employee’s cars are parked on site. This will give a broader picture of the modal split and give the monitoring work a wider relevance.

- Questionnaire surveys of employees, school children, rail passengers, etc. are very valuable and can provide detailed information. However, for a variety of reasons, it will not be practical to undertake them more than once a year - often less frequently - and so they are less useful for monitoring purposes.
- The report concludes that efforts are required to increase the reliability of automatic traffic counters for detecting cycles within traffic flows but there is evidence that improvements are possible. There is a need for clear validation of such equipment under working conditions before large-scale use on trafficked roads can be recommended. A large number of sites now produce continuous cycle count data and many have accompanying weather data. Therefore, more detailed analysis of cycle flow data, taking into account factors such as holidays and weather is possible. With regards to the other monitoring methods suggested, it is vital to seek the co-operation of employers or schools when carrying out surveys at these location types. In addition, it will prove difficult to monitor cycle use at specific destinations regularly without co-operation.

1 Introduction

This report forms the output from a study to provide guidance to local authorities and others on methods for monitoring cycle use. The guidance is intended to help with setting targets, survey design, and the statistical interpretation of results. It is based on a two-year research project in which a number of local authorities and others collaborated with TRL in testing a range of survey techniques. The project was commissioned under contract UG 124 for the Charging and Local Transport Division of the Department of the Environment, Transport and the Regions (DETR).

This report is one of two describing the results of this study. This report concentrates on the findings of the collaborative research between TRL, six local authorities and a number of other interested bodies, and which helped frame much of the advice contained in the companion report (Davies, Emmerson & Pedler, 1999), which is concerned with providing guidance on monitoring cycle use.

1.1 Need for monitoring

Target setting and monitoring is now a prominent feature of transport planning in the UK at the national and local level. This approach is set out in the Government's White Paper 'A New Deal for Transport' and reflects the requirements of the Road Traffic Reduction Act (1997), Air Quality Management Plans and Local transport Plans.

Since the launch of the National Cycling Strategy in 1996, many local authorities have adopted cycle use targets in line with the national target of doubling cycle use by the end of 2002. Many have also adopted other, more detailed local cycling targets. A methodology to monitor cycle use is required to enable local authorities to track progress towards these targets. In addition, Government requirements in monitoring as part of the process to allocate funds for local transport strategies and investments which often include measures to promote cycling. Unfortunately, the methodologies and technology required to undertake adequate monitoring of cycle use are not well established and are inferior to those available for monitoring motor vehicle use. There are also specific problems associated with monitoring cycle traffic which will be detailed in Section 2.2.

1.2 Current traffic monitoring methodology

Current best practice for appraising general traffic measures is contained in the Traffic Appraisal Manual (TAM) now incorporated in the Design Manual for roads and bridges (DMRB) Volume 12 section 1 (DOT, 1996). Detailed information is given in this volume on the sampling rates and methods to estimate changes arising from, say a new road scheme or a new traffic management initiative. Advice is given on the conduct of surveys, counts and the likely errors and uncertainties in the results associated with them. Whilst the advice is primarily related to trunk-road appraisal, increasingly such methodology must be followed where any transport related DETR funding is concerned.

Much of the guidance for traffic appraisal uses information on the variability of motorised traffic and the accuracy of the techniques used to measure such vehicles. The characteristics of cycle traffic are such that some of the underlying assumptions in this guidance may not hold. Cycle flows tend to be considerably lower than cars or goods vehicles and the accurate detection of cycles for automatic counting can involve slightly different procedures. Indeed, automatic cycle counting on roads has not been possible until recently, and is still problematic. In addition, the distribution of cycle flows across the network can be different from that of traffic in general. Some of it will be on dedicated cycleways and the distribution between major roads and minor roads (major and minor in relation to the general traffic) will be less pronounced. Seasonal and weekly fluctuations may well be greater. Figure 1 gives a comparison of monthly and weekly variations in traffic flows for cycles and all traffic, both nationally and at a site in Chingford, London.

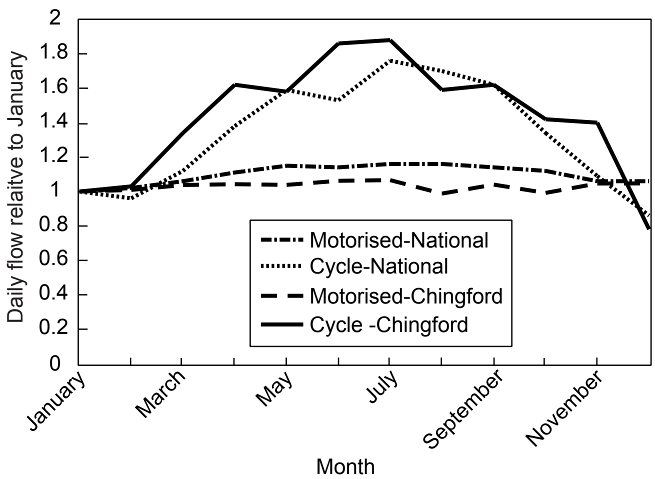

Figure 1 Monthly variation in motorised vehicle and cycle flows. At national and site level (National (1993-95), Chingford (1994-96))

A second major difference between monitoring cycling and monitoring general traffic relates to the size of the schemes usually involved. Department of the Environment, Transport and the Regions (DETR) advice in general was defined in relation to trunk road appraisal, especially those schemes costing over £5 million, and has been extended to smaller local authority schemes where central government moneys are involved. The expenditure of substantial amounts of resources on monitoring such schemes can be justified since monitoring is only a small proportion of the total scheme costs. Cycle schemes in general do not incur such large expenditures and many are marginal cost items on larger traffic management schemes. In such circumstances, the amounts available for monitoring such schemes will be less. In consequence the proposed use of any methodology that is suggested in this report must take into account the likely levels of expenditure that would be spent on cycle specific schemes and the total amount of cycling in the area.

Cycling targets have tended to be either transferred directly from national targets, such as the National Cycling Strategy, or are related to purpose-specific targets such as those relating to journeys to work or increases in safety. Specific targets for individual schemes are rare since the degree of forecasting undertaken is much less than for most trunk road schemes and there are no forecasts available for cycle schemes against which to determine success or failure.

1.3 Outline of study

This study has been concerned with providing advice on how to monitor cycle use so that progress towards meeting cycling targets, be they national or local, can be assessed. In order to do this it was necessary to review what research there was in this area, what targets authorities were setting themselves, and instigate a study into long-term counting of cycle traffic as well as testing out some other possible cycle monitoring techniques. To test out various monitoring techniques, especially the automatic counting of cycle traffic, co-operation with a number of local authorities was sought. Following a general request for authorities to co-operate in the study, six local authorities were chosen from those willing to participate; 2 from the top 25% of authorities, in terms of the percentage of journeys to work by cycle in 1991, 2 from the middle 50% and 2 from the lowest 25%. In addition, the areas chosen provided examples of a wide range of urban areas, from a London Borough to a small free-standing urban area. All the areas chosen were predominantly urban, although the implications for rural areas were discussed through the Advisory panel (see below). The six areas chosen were (with the percentage of residents cycling to work in 1991 in brackets):

1 Taunton - Somerset County Council – 8.3%.
2 Norwich - Norfolk County Council – 9.8%.
3 Hackney - Hackney Borough Council – 4.0%.
4 Guildford - Surrey County Council – 2.9%.
5 Birmingham - Birmingham City Council – 1.3%.
6 Hyndburn (Accrington and surrounding villages) Hyndburn District Council and Lancashire County Council – 1.2%.

After discussion with the local authorities, a list of individual monitoring surveys was agreed with each authority. A list of the individual studies eventually carried out by the Local Authorities is given in Table 1.1. This list differs somewhat from that originally envisaged, as local authorities have changed their priorities and some methods proved impractical.

In addition, an Advisory Panel of interested organisations met regularly during the project to discuss and comment on the progress of the study. These included representatives of the 6 test areas plus:

1 Department of the Environment, Regions and Transport.
2 Scottish Office.
3 Countryside Commission.
4 Sustrans.
5 Greater Manchester Transportation Unit.
6 In addition, valuable contributions were made by the University of Sunderland.

To obtain some idea of the kinds of targets that local authorities have set themselves and the extent of their own cycle monitoring a questionnaire survey was sent to a random sample of authorities in Spring 1997. The results from this survey are discussed in Section 2.

Through discussion with the DETR, it was decided that half the study should be devoted to testing approaches to monitoring cycle traffic through automatic counting. This part of the study would concentrate on producing guidance on the siting, the extent of, and usefulness of, monitoring cycle traffic. As a secondary objective it was hoped to collect nearly a year’s worth of cycle traffic data from the sites in order to supplement DETR data on cycle use in different conditions. The results of this work are detailed in Section 3.

Sections 4 and 5 of this report illustrate some of the approaches to monitoring cycle use at a more disaggregate level, either by stopping cyclists on their journey (Section 4) or by surveys conducted at either ends of cycle journeys (Section 5). Section 6 provides a brief summary of the findings of the study as a whole. Guidance for authorities based on these findings is presented in the companion report rather than here. Section 7 provides a brief look at the implications of the findings for monitoring cycle use. It also presents some recommendations on ways to improve the monitoring of cycle use both for ascertaining long-term trends and for before-and-after monitoring of specific schemes.

2 Local authority surveys

TRL carried out a survey of local authorities at the outset of the project, to ascertain the range and frequency of cycle use targets and monitoring techniques, and therefore which types of cycling statistics are of most interest to local authorities. A questionnaire was sent to a stratified sample of 54 local authorities in England in February 1997. There was a good response to the survey with 30 (56%) local authorities completing the questionnaire. A summary of the responses is shown graphically in Figure 2, and more details are given in Table 2.1.

Cycle use targets had been adopted by 41% of the local authorities that responded, and a further 45% of them stated that they would adopt them in the future. Many of the targets relate to specific areas, such as town centres, or specific journey purposes, such as journeys to work or to school. There is considerable variety in the ambitiousness of the targets. For example, Birmingham is seeking to increase cycle use by 400% over eight years, from 1% of all trips to 5% in 2005 whereas Buckinghamshire is seeking to double cycling over a longer period (twenty years).

All local authorities undertake some counts of pedal cycle use, and many authorities conduct at least one cycle count on a regular basis (63%). The most common form of cycle count is a manual count at specific sites. Only 6 local authorities (20%) use automatic equipment to count pedal cycles. Those authorities that do use automatic count equipment use pressure tubes (3), induction loops (4) and piezo-electric strips (2). (Some use more than one type of count equipment). Where automatic count equipment is

Table 1.1 Summary of surveys carried out in the test areas

Test site methodology	*Birmingham*	*Guildford*	*Hackney*	*Hyndburn*	*Norwich*	*Taunton*
Long term automatic cycle counters.	3 sites 1 main road 1 cycle path 1 canal path.	4 sites 2 main roads 2 cycle path.	3 road sites.	2 sites: 1 on-road 1 on canal route.	6 sites: 5 in Norwich 1 in Kings Lynn.	4 sites: 3 on cycleway 1 on-road (moved to cycleway).
Manual cycle counts.	Screen line counts.	No.	Screen line counts throughout London Boroughs.	Town centre cordon & screen line counts.	IRR cordon (3 sites) Sept 97.	Cordon Sept 97; Compare with 82.
School surveys.	No.	No.	No.	Pupil, form tutor and head teacher questionnaires.	No.	No.
Workplace surveys.	No.	No.	No.	No.	No.	Employer survey as part of Green Travel Plans.
Rail station surveys.	No.	No.	No.	No.	No.	No.
Public parking counts.	No.	Beat survey (Nos only) 2 streets.	No.	Accrington town centre (Nos & turn- over).	No.	October 1998, whole of Taunton.
Road-side interviews.	Origin/ Destination, purpose, age, sex - S. W Birmingham by postal questionnaire.	No.	O/D, purpose, age, sex.	No.	No.	No.
Other.	Household travel diary, attitude survey. Weather data.	No.	No.	No.	No.	Assess feasibility of cycle veh-km in town.
Results of previous surveys made available.					1996 Thetford Schools survey.	1995 school survey. Cycle parking survey.

used, it is mostly used on off-road cycle tracks. Various interview surveys are carried out, the most frequent in descending order being school travel surveys, cyclist attitude surveys, household travel surveys, railway station surveys and cyclist route choice surveys.

A number of local authorities - perhaps the majority - are aware that they need to establish a reasonably accurate base line of cycle use and to develop survey techniques if progress towards targets is to be monitored. However, counts and surveys are mostly undertaken on an irregular or one-off basis. Even when regular counts are undertaken, it appears that most are for one day or less, and therefore subject to unknown levels of background variation.

There is also a tendency to monitor use of cycle routes and dedicated cycle facilities, rather than cycle use in general. This may reflect a need to measure the use of new cycle facilities or to justify cycle route investment. It may also reflect the limitations of current automatic counting equipment and the practical difficulties of doing on-street manual counts.

Five types of cycle use target were identified as important to local highway authorities:

- Cycle flows (general).
- Modal share (general).
- Journey purpose/destination modal share.
- Cycle route use.
- Cycle parking use.

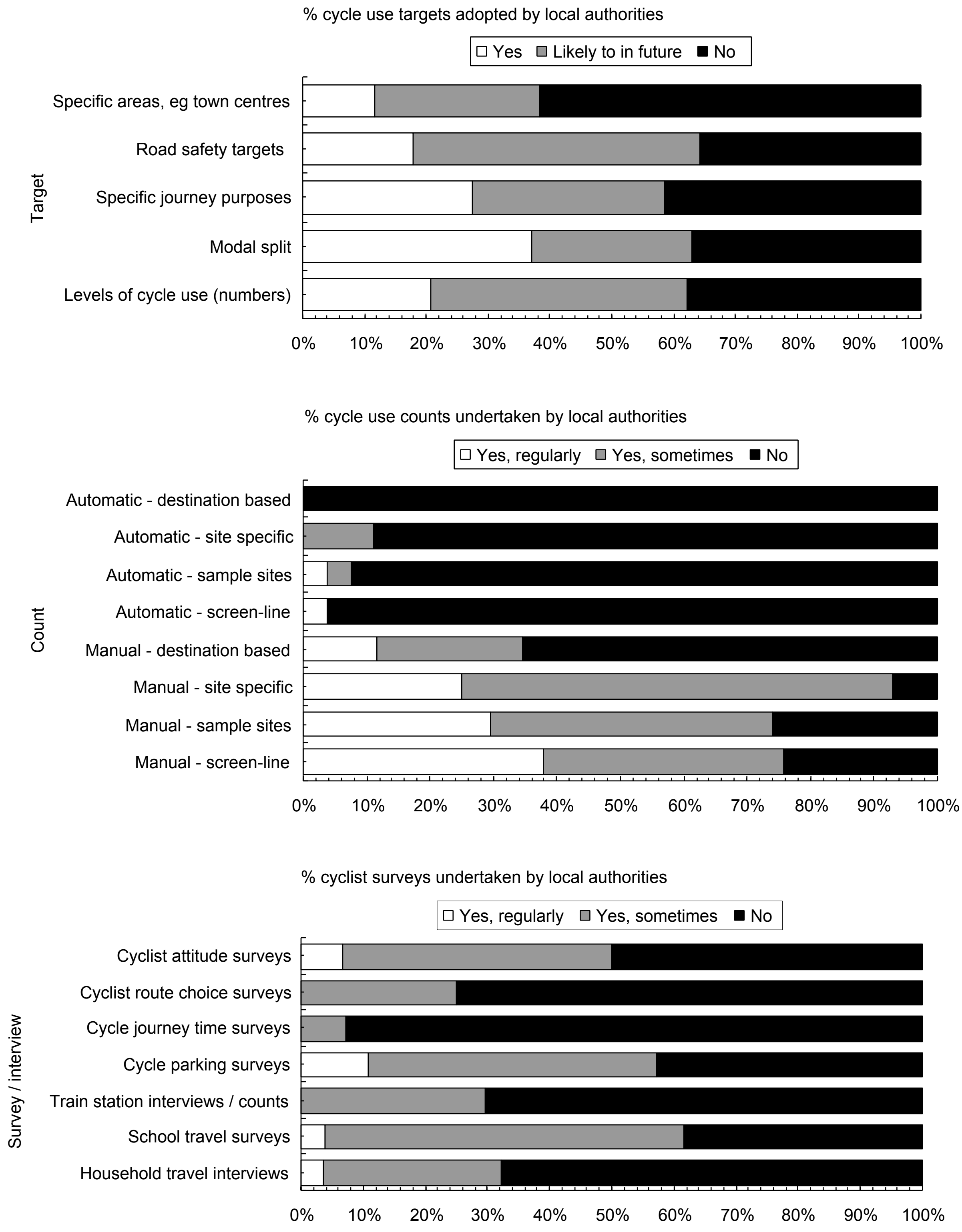

Figure 2 Bar charts to show responses from the local authority questionnaires

Table 2.1 Cycle use targets, monitoring requirements and survey techniques

Target measure	*Monitoring requirements*	*Survey technique*
1 Cycle flows (general).	- Sufficiently accurate to monitor year on year changes. - Area-wide and corridor. - Cyclist characteristics (age, sex, helmet wearing).	Automatic or manual count. ditto. Manual count.
2 Modal share (general).	- Sufficiently accurate to monitor year on year changes. - Area-wide and corridor/route.	Automatic or manual count. ditto.
3 Journey purpose/destination modal share.	- to work. - to school. - to railway station. - all purposes.	Destination (workplace) survey & National Census of Population. Destination (classroom) survey. Destination (rail station) survey. Household survey.
4 Cycle route use.	- cycle flows. - route, origin/destination. - user characteristics. - user views.	Automatic or manual count. Road-side interview. ditto. ditto.
5 Cycle parking use[1].	- use. - user characteristics. - origin/destination. - user views.	Manual count. Destination Interview/questionnaire. ditto. ditto.

[1] *Not strictly a cycle use target, but may be a proxy for use. It appears to be of sufficient interest to local authorities to merit inclusion.*

Four basic monitoring techniques have been identified to assist target monitoring:

- Automatic count.
- Manual count.
- Interview/questionnaire.
- Cycle parking count.

3 Monitoring cycle traffic

3.1 Counting techniques

This section is concerned with research into monitoring cycle flows in terms of the number of cycles per hour, per day or whatever time-period is of interest. As with the monitoring of general traffic, there are two different approaches to measuring the cycle flows: manual counts and automatic counts. Each approach has its advantages and disadvantages.

3.2 Manual counts

Manual counts can be undertaken at little notice and the enumerators can collect other information about the cyclists, for example helmet wearing sex and approximate age, as well as just pure counts. Manual counts can also pick up cyclists that could be avoiding automatic counters, by using the footpath for instance.

The cost of a manual count rises with the length of time and multi-day counting can be expensive. One of the results of this study is that, there will be a need for multi-day counting in most cases if any but the largest changes are to be detected with any degree of certainty. Manual counts can also pick up cyclists that could be avoiding automatic counters, by using the footpath for instance.

Sustrans, in collaboration with local authorities, has used volunteers to undertake counts and interviews on sections of the National Cycle Network. The volunteers generally proved to be reliable. However, it was often not possible to recruit them in sufficient numbers when required, particularly where repeat monitoring was needed. Moreover, the costs involved in recruiting, organising and briefing volunteers often outweighed the savings from using professional survey staff.

3.3 Automatic counts

Where multi-day counting is required automatic counters are much more cost effective than manual counting. However, automatic counters cannot provide the additional information, such as cyclist’s sex or age-group, that can be obtained from manual counts. In the case of counting cycle flows, three types of counter are being used, each with its particular advantages and disadvantages. Whilst such counters are also used for counting motorised traffic, the need to count cycles imposes distinctive conditions on the workings of the counters.

3.4 Tube counters

Tube counters consist of a rubber tube stapled or taped to the road surface and connected to a counter unit. When a vehicle passes over the tube, it depresses it, sending a pneumatic pulse to the counter unit. Some equipment is now able to differentiate between different types of vehicle, by taking account of the differing tyre widths. The tube itself is inexpensive (approximately £50 including installation) and the counter unit may vary from £200 to £2,000 according to its sophistication.

This type of counter has been traditionally used for short-period traffic counts. They are easy to lay, with relatively cheap materials. The disadvantages of these counters are:

- They need frequent checking as they may subject to vandalism and, on heavily trafficked roads, to damage from heavy vehicles.
- Those tubes that are tuned for classifying motor-vehicles may not be sufficiently sensitive to pick up pedal-cycles.
- Coincidence[1] errors lead to undercounting of bicycles in heavy mixed traffic flows.

It is possible, by using two tubes, for the counter software to separate cycles and motor vehicles. Counters can be set to measure cycle flows whilst minimising the greater impact of other vehicles but this, and the impact of coincidence means that there can be an upper limit to the accuracy of the counts in mixed traffic. To count bicycle flows accurately in mixed traffic requires a more sophisticated counter than normally required, which increases the cost the costs somewhat. (An example of the testing of such a counter, by Golden River Ltd in Manchester, is described later in this section.)

3.5 Induction loops

Induction loops work by passing a low-voltage current through a coiled loop of wire, buried just below the surface of the road. When a vehicle passes over the loop, the metal in the vehicle disturbs the electric field and this is detected by the counter unit. The induction loops used in the TRL study were specifically designed for measuring cycles by Counters & Accessories Ltd, and differ somewhat to the standard loops. They cost around £1100 per site, including counter unit, housing pillar and installation (Software for analysis was extra). Examples using external power sources or solar cells may cost slightly more. This type of cycle counter was supplied by Counters & Accessories and used by all the local authorities during the study.

Induction loop technology is the most common method of undertaking long-term monitoring of traffic flows. Simple induction loops, embedded in the pavement surface course, can provide an accurate (at least 95% accuracy) record of motorised traffic and the technology is widely available from a number of suppliers. The main problems are over-counting slow moving traffic and sources of electrical and radio interference. However, with good maintenance, accurate data can be obtained over a long period for total motor vehicle flows, and with somewhat less accuracy for various categories of motor vehicles.

However, it has proved difficult to identify cycles using standard loop technology. One major problem has been the small size of the signal generated by a cycle compared to other vehicles. If the loops are set to a level of sensitivity to pick up cycles, there are problems with the signals from other larger vehicles. This is accentuated by the low metal content of some modern cycles. This problem has been tackled by one manufacturer who has built an induction loop specifically to identify cycles. It does this by generating a more powerful electrical field over a smaller area and using software to discriminate and classify the variety of output signals (in a way analogous to the piezo counter described next). Although the electrical field is stronger, the system can run off battery power (but with limited storage time). The loop is more sensitive to external influences such as bridges with a high metal content, and to electrical and radio interference. During this study, the development of interference suppressers for the counter has reduced this problem.

Plate 1 shows an example of an induction loop specifically designed to count cycles and examples were used by all the authorities in the study. The trapezoid shape of the loop is quite distinct, although the precise shape may vary from site to site. The loop is most sensitive to traffic crossing the sloping side of the loop. At this site, the counter is housed in the small pillar at the side of the cycle track and powered by a battery. The equipment was supplied by Counters and Accessories Ltd.

Courtesy of Norfolk County Council

Plate 1 An induction loop and counter, of the type used in this study, installed on a cycle path

The second problem with induction loops (and tubes) is the phenomenon of two vehicles arriving at the loop simultaneously (coincidence). With standard loops measuring only motorised vehicles this is less of a problem since with each lane having a separate loop the likelihood of two vehicles crossing the same loop at the same time is very low. However with mixed cycle/vehicle or high cycle flows this phenomenon is more likely to happen. In these cases, the counter can miss a cycle as its signal is swamped by the signal of a vehicle crossing the loop in the same direction at the same time. The importance of this increases as vehicle flow increases and can lead to under-counting of cycles by up to 5% of cycle flows at high vehicle flows (1500 vehicles per hour). If the vehicles are travelling slowly as in queues then the effect can be much greater. Much will depend on the ability of the counter software to separate out overlapping signals. Of course, this is less of a problem when changes are being monitored rather than absolute levels, as long as the background motor vehicle flow stays substantially the same. In theory, the worst case scenario would be the traffic calming of a busy main road, where high traffic flows are reduced to much lower levels. In this case, small increases in cycle flows may arise simply due to the reduction in the number of vehicles overtaking cycles at the loops. However, this should be only a small effect, of about 5%, even at this scale provded that moving traffic is involved.

The accuracy of these counters, especially on heavily trafficked roads, proved to be a major problem during this study, although much progress was made. The long-term reliability of this new generation of induction loops is uncertain at the moment, especially when used on heavily trafficked roads, but the reliability and durability should be much better than tubes and not be that different from other types of induction loops.

3.6 Piezoelectric counters.

Piezo technology represents an alternative method of counting traffic including cycles. It utilises the phenomenon of pressure generating an electrical signal. The counter system consists of a linear array of sensors, each about 500mm long. The system senses the presence of a vehicle on a sensor and interrogates the resulting waveform (the signal is proportional to the applied load). The characteristics of the output waveform, which are unique to a particular vehicle type, enable the vehicle type to be classified by the software in the same way that the new generation of induction loop detectors use variations in the electric field caused by different vehicle types.

This type of sensor is used by the STC division of DETR to monitor cycle flows at their continuous monitoring sites and other examples have been used to monitor cycle flows on cycleways. STC require that such counters be accurate to at least 95%. Because each piezo strip is monitored individually, coincidence of crossing between two cycles or between a cycle and a motor vehicle can be detected correctly. Since the strip only extends half-way across the nearside-lane two motor-vehicles cannot cross the strip at one time.

Detailed tests of such a counter at TRL in 1996 suggested that the sensor can detect at least 95% of cycles crossing but it was susceptible to false signals from other vehicles. On a pavement sensor, prams and pedestrians were counted, whilst on the road a variety of vehicles, mainly certain types of goods vehicles, were identified as cycles (this may be due to slight turning movements on vehicles with double wheels). The equipment manufacturer has made advances in software and installation technology since then to reduce such errors.

The major concern is over their long-term reliability because the sensors are subject to wear, being surface mounted rather than embedded like inductive loops. Because the tolerances for the sensors are tight, heavy traffic over the counters tends, over time, to disturb the settings of the sensors, leading to erratic data and possible miscounting. In these cases, the sensor needs to be considered as a consumable. This is unfortunate since the counters are not cheap to install. A fully specified site, with multi-vehicle classification or a high incidence of bunched cycling, and requiring high accuracy could cost up to £5,000 plus an external power source. A less sophisticated installation, used when cycles are segregated and two-abreast cycling is not a problem, would be much cheaper. One manufacturer (Traffic 2000) offers a three-year guarantee on the counter and a one-year guarantee on the detector). Experience with analysing the data from the DETR long-term count sites indicate that some sites had serious reliability problems and usable data varied from 30% to 80% in each year, although some sites were much better than others. No local authority sites with piezos strips were part of this study.

3.7 Initial work

An initial investigation was made of the quality of long-term counts of cycle flows using the DETR’s continuous traffic counter sites and the implications for monitoring long-term changes in cycle flows. Data from the five continuous monitoring sites with the highest cycle flows were examined. All five sites used piezoelectric equipment for measuring cycle flows, along with other traffic on roads. For the five sites (in Hereford, Worcester, Chingford (London), Bidston (Merseyside) and Ormesby (Middlesborough)) three years data, from 1994 to 1996 were obtained, and the data analysed for any factors that might explain the variation in cycle flows. In addition, the amount of residual variation or ambient variability in cycle flows after these factors were accounted for was estimated. These estimates have been used to provide advice on the sampling periods required for monitoring changes of a given size.

A detailed investigation of the data for each site revealed that the quality of the data varied markedly from site to site. That from the Hereford site prove too intermittent to be useful and that site was omitted from further investigation. In the case of the Worcester site the data seemed to be very complete and consistent but showed a distinctive declining trend from 1994 to 1996, at odds with the national trend. Data from the other three sites were intermediate in quality and showed some signs of year to year variability, although not to the same degree as the Worcester data (1995 was omitted from the analysis of the Ormesby data for this reason).

Statistical analysis was performed on the data from the four remaining sites to extract the significant factors explaining the variation in cycle flows. At all four sites ‘Month of the year’ was the major factor, but the importance of ‘year’, school holidays and ‘day of the week’ varied from site to site. Whilst year was a significant factor at three sites, only at the Worcester site was a clear consistent trend apparent. ‘Day of the week’ was important largely to distinguish weekday flows from those on Saturdays and Sundays. Variation between weekdays was much less significant, with slightly lower flows on a Friday being common. Weekday cycle flows during school holidays were generally about 10% lower than those on school-days.

The day to day variation (ambient variability as measured by the ratio of the variance to the mean), after taking into account all significant factors, was estimated to be about 1.5 to 2 times the size of the flows, (a much greater factor than for car traffic). Based on the four sites investigated, this estimate appears to be on the low side, since, for the Worcester and Bidston sites, much of the variation was explained by factors involving ‘year’. If this variation due to the year effect is subsumed into the estimate of ambient variability, the residual variation increases to between 4 and 5 times the cycle flow. At the Chingford site, the ambient variability was much lower even without the year factor.

DETR statisticians suggested that there may also be measurement errors within the data varying in magnitude over time as the piezo strips are disturbed by heavy traffic. This has important implications for the long-term continuous monitoring of cycle flows on heavily traffic roads and may account for the strange results at the Worcester site.

It is known from previous work that weather can have an influence on the amount of cycle traffic. Because of this, it is necessary to estimate the impact of weather factors on cycle flows, both to understand any behavioural implications but also, in the context of this study, to understand any complications in comparing counts from different periods, and estimating the underlying variability in cycle flows.

Using two of the sites discussed above (Bidston and Chingford), it proved possible to match meteorological data and long-term cycle traffic data, to estimate the influence that weather has on daily cycle flows. The sites, one in the north-west and one in the south-east have different weather patterns. The quality of the cycle data at the other high cycle flow sites and the absence of nearby weather stations prevented their use for this part of the analysis. The definition of the weather data, daily data based on a 9am cut-off, was not ideal and the cycle flow data itself was of a variable quality, but meaningful relationships were obtained for both sites. The details of this work have been reported elsewhere (Emmerson, Ryley & Davies, 1998), but a summary is provided below.

Monthly and weekday variations dominated the variation in daily cycle flows and the Chingford site exhibited somewhat different weekly variations to that of Bidston (and other sites investigated). This relates to the relatively higher flows on Sundays and the lack of educational and employment establishments nearby which means weekday flows are relatively low. It is also reflected in the fact that the school holidays have no significant impact on weekday cycle flows.

Surprisingly the data suggest that cycle flows are more influenced by maximum temperatures than by rainfall. A one degree rise in maximum temperature gave an approximately 3 percent increase in daily cycle flows at both sites. In contrast, motor traffic at the Chingford site increased by only 0.2 percent with every one degree rise in maximum temperature.

In general, the incidence of rainfall (after 9am) was also significant, with daily cycle flows reduced by 11 percent and 15 percent at Chingford and Bidston respectively. At the Bidston site the incidence of rainfall in the 24 hour *previous* to 9 am on the day also had a significant additional effect. The impact of the *amount* of rain at that site was much weaker, and non-existent at the Chingford site. Investigations of the interactions between month of the year and the weather variables, whilst significant at both sites, revealed that much of the variation at the Bidston site may be related to the quality of the data and the need for the model to fit to sparse data regions at each end of each year. Fewer problems appeared in the Chingford model and more reliance can be ascribed to its interactions.

Whilst the sites investigated in this study represent high flow sites in relation to the UK's *national* long-term continuous cycle monitoring, sites with much greater cycle flows are known to exist in many towns, and are found amongst our Local Authority sites (see below). At many of these sites and others, weather data has started to be collected for similar purposes but no analysis has been undertaken.

3.8 Local authority counting programme

As explained in the introduction, a major part of this project was to set up a number of long-term automatic traffic counter sites, specifically designed to give estimates of cycle traffic. The local authorities chose these sites, both to reflect their local needs and to reflect the concerns that TRL had for a variety of sites. Table 3.1 gives summary details of each site.

Given the resources available, and the state of the counting technology at the time (especially in relation to estimating cycle flows within general traffic), all the sites used were fitted with a new type of induction loop and counter from one company (Counters & Accessories). More recently, another company (Peek) has tested equipment with one of the authorities and, as will be described later, a third manufacturer's equipment (Golden River) has been tested at a site in Manchester.

3.9 Siting

It was a desire of the study that the sites chosen for long-term counting should cover a wide range of cycling environments; from separate cycle paths, through to cycles travelling amongst motorised traffic. In addition, it was hoped to cover a wide range of cycle flow levels and, where applicable a range of general traffic flows. The nature of the local authorities involved meant that the emphasis in this study has been on urban sites, although some work involving rural sites by the Sustrans charity will be discussed later.

Choosing the sites and their installation started in the summer of 1997 but the time taken to produce reasonable data from the sites varied a lot. At some sites (see later) no reasonable data was produced during the study period, at other sites some data was produced from September 1997 onwards. Data from successful sites, up to September 1998 has been collected and analysed, although no site has produced data continuously for over one year. See Table 3.1 for a summary of each site.

Plate 2 gives some examples of the sites that were monitored. Whilst all were in urban areas, some sites such as French Weir, Taunton and the Rea Valley in Birmingham were away from built-up areas, whilst at the other extreme, Kingsland Road in Hackney and Dereham Road in Norwich represent major urban radial routes.

At the off-roads sites, all the counters counted cyclists in

Table 3.1 The local authority sites

District	*Name*	*Type*	*Counters*	*Power supply*	*Mean weekday cycle flow & S.D*[1]	*History*
Birmingham	Pershore Rd	Road + footpath	8 (6 cycle +2 traffic)	Mains	38 (8)	Full counting of all surfaces at a road narrowing but still interference due to traffic.
	Birmingham & Fazerley Canal	Cyclepath	2 cycle	Battery	47 (10)	On a canal towpath. Initial problems with electrical interference from electrified rail line.
	Rea Valley	Cyclepath	2 cycle	Battery	115 (26)	Mixed cycle pedestrian/cycle path in a linear park, measured at a narrowing.
Hackney	Kingsland Rd	Road	1 cycle + 1 traffic	Battery	484 (56)	Traffic counter does not count all traffic, high traffic flows and parking problems.
	Whitmore Rd	Road	1 cycle + 1 traffic	Battery	235 (33)	'Back street' alternative to Kingsland Rd - on London Cycle Network. -Mean from RSI.
	Lea Valley Rd	Road	1 cycle + 1 traffic	Battery	244 (128)	East-west crossing of River Lea. -Mean from RSI.
Hyndburn	Rishton Rd - A678 Accrington	Road	1 cycle + 1 traffic	Battery	42 (7)	Problems over counting cycles within a traffic flow.
	Leeds Liverpool Canal- Gt Harwood	Cycle path (NCN)	1 cycle + 1 traffic	Battery	137 (60)	Canal towpath, mainly school and recreational traffic. Significant other vehicle use (prams etc). Uncertain results from validation.
Norfolk	Bluebell Rd Norwich	Cyclepath	2 cycle	Battery	561 (122)	Major cycle route to University. Good validation
	Dereham Rd Norwich	Cyclelane	1 cycle + 1 traffic	Battery	331 (30)	On-road cycle lane but some inference with encroaching vehicles. Vehicle count not a complete count. East of DETR site.
	King St Norwich	Road	1 cycle + 1 traffic	Battery	n/a	Very poor siting. Queuing traffic and slow cycle speeds led to unreliable cycle and traffic counts. Data not analysed.
	St Johns Walk Kings Lynn	Cyclepath	2 cycle	Battery	228 (39)	Combined cycle/pedestrian path through park. Siting a problem in that loop only covers cycle part of path but reliable data otherwise.
	Thorpe Rd Norwich	Road	1 cycle + 1 traffic	Battery	96 (29)	Large loop used to collect all traffic on wide road as well as cycles in the westbound direction. Some evidence of interference in cycle counting.
	Marriots Way	Cyclepath (NCN)	2 cycle	Battery	149 (26)	Former rail track, newly tarmaced as a cycle route. No evidence of irregularities. Later installation so data not analysed in this study.

Continued over ......

Table 3.1 The local authority sites — Continued

District	*Name*	*Type*	*Counters*	*Power supply*	*Mean weekday cycle flow & S.D*[1]	*History*
Somerset	French Weir	Cycle path	2 cycle	Battery	326 (37)	Two-way counting on cycle track at a path narrowing. Main problem appears to be undercounting at peak times due to heavy cycle flows.
	Obridge Link	Cycle path	2 cycle	Battery	n/a	This site has proved very difficult to calibrate due to radio interference. Counter now resited at another location.
	Bridge St	Road	1 cycle + 1 traffic	Battery	n/a	In-bound on-road cycle lane. Site has proved impossible to calibrate successfully and the equipment has been resited onto another path.
	Mount Walk	Cycle path	2 cycle	Battery	229 (39)	Similar to the French Weir site with undercounting during peak hours.
Surrey	Quarry St	Road	1 cycle + 1 traffic	Battery	44 (18)	On-road site measuring inbound traffic. Poor validation probably due to traffic interference on a road with very poor cycling conditions.
	Quarry St	Cycle path	2 cycle	Battery	38 (12)	Cycle path in field parallel to the road site. Validation probably spoilt by prams and slow moving cyclists (many cyclist in the process of dismounting to leave path at site point).
	Stoke Rd	Road	2 cycle + 2 traffic	Battery	76 (16)	Poor cycle counts due to slow moving traffic
	Egerton Rd	Path	2 cycle	Battery	58 (11)	Non-segregated path linking superstore to University, used by prams and shopping trolleys as well as cycles.

[1] *SD = Standard deviation of the weekday flows.*

a French Weir, Taunton

b Dereham Road, Norwich

c Egerton Road, Guildford

d Kingsland Road, Hackney

e Thorpe Road, Norwich

f Stoke Road, Guildford

Plate 2 Examples of TRL study sites

both directions separately, using a single loop as at Egerton Rd in Guildford (Plate 2c) or the French Weir site in Taunton (Plate 2a). At some of the sites, both cycles and motor vehicles were counted, in both directions. Where counting was restricted to the road-way separate loops were required in each carriage way as at Stoke Road, Guildford (Plate 2f). In the case of Pershore Road, where cyclists on the footways were also counted, four loops in total were required. At other sites, motor vehicles and cycles were only counted in one direction. Thorpe Road, Norwich (Plate 2e), and Kingsland Rd, Hackney (Plate 2d) are examples of such sites. In the case of the latter site, and the Dereham Rd site, (Plate 2b), the loop was specifically located to maximise the number of cycles counted, but minimise the chances of interference from other traffic. In consequence, the loop did not cover the whole of the lane and consequently, as expected, many motor-vehicles did not pass over the loop. The consequences of this for the validation results are described later.

3.10 Experience

The installation and running of 18 sites, using the same equipment, has meant that some conclusions can be drawn about the conduct of cycle traffic counting with their equipment, over a reasonable timescale.The actual site for any counting must take into consideration factors relating to the flows being measured and the type of counter being used. The following factors should be considered in siting any counter, although circumstances (for example, to complete a cordon) may well mean that sub-optimal sites need to be used.

1 *Choose sites with high cycle flows*. The relative accuracy and relative variability of the resultant data will be better at high flows sites than at sites with low flows. The main exception to this will be sites that have very intensive peak period use, say near schools and factories where cyclists ride two or more abreast at peak times. This was a problem at the French Weir and Mount walk sites in Taunton. At these sites it may be better to choose multiple sites further from the cycle source where flows have split up.

2 *Chose sites where cyclists are as segregated from motorists as possible*. Any counting technology will provide more accurate counts when the physical and electrical interference from motor-vehicles is low. At those sites where cycle flows shared the road with other traffic, there was evidence of other traffic affecting the cycle traffic count (for instance Dereham Rd in Norwich). This occurred because the loop needed to be large enough to catch all cycles travelling on the road but this meant that coincidence was possible and electrical signal from motorised traffic could swamp that of any cycle, even if the motor vehicle did not pass over the loop. (Suppression of such indirect interference has now been incorporated into the latest firmware.) At some sites the interference was such that no reasonable cycle counts could be obtained. The sites in Bridge St. in Taunton and King St. in Norwich (Plate 3), were badly affected and other adverse factors were also present (electrical interference and queuing or slow moving traffic). Plate 3 shows the cycle lane in King Street, Norwich. The site is on an important cycle route, with a dedicated cycle lane (the induction loop can be seen with a cycle symbol in the middle). However, in practice the cycles are travelling too slowly, as they approach the signalised junction (behind the camera), even though the junction approach has an advanced stop-line for cyclists. In addition, there was some interference from motor vehicles that were also travelling slowly or stationary as well as cyclists not using the cycle lane at times of light traffic. In consequence, too many cycles were not being counted and the site had to be abandoned. At other sites, the advances in the technology of the counters have meant that such off-loop effects can be suppressed to a great extent but slow-moving traffic and queues, be they cycles or motor traffic were a major cause of poor validation results.

Plate 3 An example of poor counting conditions – King Street, Norwich, Norfolk

3 *Counters should be positioned so that all cyclists are counted at a site*. For instance, if it is known that cyclists are using a footpath as well as the road or cycle-path at a certain site then it too should be counted. St. Johns Walk in Kings Lynn illustrated this well (See Plate 1). At this cycle-path site, the loop, which counts cyclists in both directions, does not fully cover the pedestrian segment of the dual-use path. Unfortunately, cyclists are in the habit of using the pedestrian side when travelling into the town (towards the camera). Thus weekday inbound ATC flows in June amounted to only 70% of the outbound flows and the validation results were correspondingly poor (see Table 3.2 later). In the case of King Street not all cyclists used the on-road cycle lane provided. At the Pershore Rd site in Birmingham, both the road and the footway were counted, as peak period cycles flows on the footpaths were significant.

4 *Induction loops should not be used at sites, close to potential sources of electrical and radio interference, although current technology can suppress much electrical interference.* During the present project such

sources have included metal bridges, buried cables, rail lines with overhead catenary systems and transmitting stations! Since the project started, the fitting of suppressers has mitigated this problem but such sites should still be avoided, where possible.

5 *Providing that electrical or radio interference is not an issue, automatic counters that will be continuously monitored should be near a power source.* This is important because the battery alternative will require much more frequent visiting and maintenance costs. This was one of the initial conclusions to arise from the study. The original batteries had such a short life that fortnightly or even weekly visits to download data and replace the batteries were necessary. However, as the study progressed, the capacity of the batteries used by the counter has been increased so that at most sites with two channels both the battery and the data memory should last at least a month. Ideally, these should be increased further so that any delays in retrieving data or batteries need not be fatal (the battery life appears to be severely shortened if it is drained too far and its life in winter conditions appears to be less than at warmer times). More recently the equipment manufacturer has produced counters powered by solar cells. The cabinet housing these is somewhat larger than the small one required for a battery operated counter.

6 *The impact of other factors appears to be less but may increase error at low flow sites.* Other factors that can play a part appear to be the direction of counting. The design of the loop (a trapezoid) with one sloping side suggest that, all other things being equal, that flow crossing this face first should be the more accurate. The interference of other metallic vehicles such as prams appears to be random. Certainly, the examination of validation data from the canal towpath at Gt. Harwood (see below) could come to no decision as to whether prams were in general included or excluded.

The Kingsland Road, Hackney site (Plate 2d) illustrates some of the compromises that might need to be taken into account in choosing sites. The road carries quite a high commuter cycle flow and parallels a quieter route to the City, which is part of the London Cycle Network (the Whitmore Road site is located on this route). The road is a major arterial (A10) out of the City of London and a red route, with no parking except in designated spaces. However, along its length, the road carries high traffic flows, is very wide for a single carriageway, and in parts, the road surface is not in a good condition for cyclists. In consequence, a compromise had to be made in order to find a suitable site. The loop has been sited beyond a pedestrian crossing, so the cyclists are not travelling too slowly, and the road surface is reasonable. However, some cyclists miss the loop as they travel further into the centre of the road in order to pass illegally parked vehicles some yards ahead. At this site, most motor vehicles did not pass over the loop but that was not an issue for this site as the local authority did not require counts of motor-vehicles at that point. If motor-vehicle counts were required, then the loop could be increased in size but co-incidence would then become more important.

3.11 Validation

During the course of this project it has been possible to conduct validation exercises at nearly all sites, and at some, especially the Taunton sites, this has been repeated as attempts to improve the accuracy of the counter have been made. At the Hackney sites roadside surveys conducted close to the counter sites provide validation counts for cyclists (see section 4). Table 3.2 summarises the results at those sites at which multi-hour manual count comparisons with the ATC count have been possible.

As the data show, there has been a marked tendency for the ATC data to undercount the total number of cycles. This has been a general, but not a universal, finding. There are a number of obvious reasons for this. In the case of on-road counts, interference from other vehicles is likely to be the main reason, and this is also likely to be an important effect at on-road cycle lane sites. On the off-road sites, the major problem at heavily used sites appear to be the inability to count cyclists travelling abreast especially at peak hours (say above 150 cycles per hour). Sophisticated piezo counters may be the only way to obtain very accurate, long-term counts at such sites. Poor loop siting is known to be the reason behind others such as the King's Lynn site (not in Table 3.2) but at others no obvious factor can explain the large discrepancy.

In contrast, at the Birmingham sites, the ATC totals tend to be higher than the manual count totals with wide variations between the totals for individual hours. No reason was apparent for this although the latest firmware had yet to be installed at these sites. Unfortunately, there were no separate manual classified counts of cyclists on the foot-path and on the road at the Pershore Road site so the relative accuracy of each loop site could not be ascertained.

The validation counts were undertaken by the local authorities and slightly different procedures were used across the sites, such as length of count, employment of outside contractors and classification system. Some of these manual counts may be subject to errors in themselves, and the extent of cycle counting was not clear, for example the counting of all cycles crossing the site (on road and footways) or those just crossing the loops.

At a few sites, as Table 3.2 shows, motor-vehicles are heavily undercounted but these were cases where the loops had not been set to count all vehicles travelling in that direction, so the validation results were expected to be poor (e.g. Dereham Rd, Norwich). At the Hackney sites, only pedal-cycles were counted. Where the loop was expected to count all vehicles in a direction the counter performed well with only one site not managing a count within 5% of the manually classified total.

Generally, the conclusion from the validation work was that the automatic counters were not counting cycles very satisfactory, especially at on-road sites However, three aspects should be borne in mind. In the first case, the results are probably as good as any equipment at the time could produce, with the possible exception of the more expensive, piezo-strip counter. Secondly, the results do not necessarily invalidate any use as a monitoring tool, as long as the errors are consistent over time. Making an allowance for two-abreast cycling in peak hours is an

Table 3.2 Summary of validation counts at TRL study sites

Area	*Site*	*Type*	*Count period (hrs)*	*Counter*	*ATC*	*Manualcount*	*% difference*
Hackney[1]	Kingsland Rd	Road	12	Cycles	375	436	-14
	Whitmore Rd	Road	12	Cycles	321	235	+37
	Lea Bridge Rd	Road	12	Cycles	496	244	+103
Hyndburn	Rishton Rd	Road	12	Cycles(w)	56	21	+167
				Cycles(e)	26	36	-28
				Motor-vehicles (w)	4542	4948	-8
				Motor-vehicles (e)	5209	5341	-2
	Leeds & Liverpool Canal	Cycle path	12	Cycles (w)	65	62	+5
				Cycles (e)	35	54	-35
Norwich	Bluebell Rd	Cycle path	6	Cycles (s)	262	268	-2
				Cycles (n)	77	99	-22
	Dereham Rd	Cycle lane	6	Cycles	153	159	-4
				Motor-Vehicles[2]	2315	3630	-36
	St John's Walk	Cycle path	6	Cycles (e)	117	123	-5
				Cycles (w)	118	173	-32
	Thorpe Rd	Road	12	Cycles	72	90	-20
				Motor vehicles	3935	4049	-3
Guildford	Shalford Rd	Road	12	Cycles	58	114	-49
				Motor vehicles	8093	8155	-1
		Cycle path	12	Cycles (n)	58	62	-7
				Cycles(s)	35	29	+21
	Egerton Rd	Path	12	Cycles (w)	59	67	-12
				Cycles(e)	45	54	-17
	Stoke Rd	Road	12	Cycles (s)	117	90	+30
				Cycles (n)	51	90	-43
Taunton	French Weir	Cycle track	12	Cycles (n)	273	313	-13
				Cycles (s)	277	353	-22
	Mount Walk	Cycle lane	5[3]	Cycles (n)	143	213	-33
				Cycles (s)	173	177	-2
Birmingham	Pershore Rd	Road & footpath	12	Cycles (N)	43	40	+8
				Cycles (S)	54	38	+42
	Birmingham & Fazeley canal	Cycle path	12	Cycles (N)	18	11	+64
				Cycles (S)	12	11	+9
	Rea Valley	Cycle path	12	Cycles (N)	45	57	-21
				Cycles (S)	57	47	+21

1 and 2. ATC's did not cover all carriageway so vehicle validation not applicable 3. Consists of 2 hours in AM peak and 3 hours in the afternoon

example of a factor that may need to be made if peak-hour changes in cycle flows are expected. Thirdly, since the validation exercises were undertaken, Counters & Accessories claim that the equipment and the software have improved markedly. Appendix A gives an example of the improvement that new firmware can make to the validation results. Unfortunately, it was not possible to install the new firmware in any of the other study sites during the study period in order to check this.

3.12 Results

Table 3.1 as well giving details of the sites, gives a summary of the experience with the monitoring of cycles at each site. A number of sites have been abandoned during the study as not capable of counting accurately enough, due to miscounting or interference (Bridge St and Obridge St, Taunton, and King Street, Norwich). Two of these sites are on-road where cycles are mixing with motor vehicles. Siting is of vital importance, and as noted above, potential sites with known electrical interference, poor lane discipline and queuing or slow moving traffic (motor vehicles or cycles) should be avoided. At the other on-road sites that are still being monitored, improvements to the counters (suppressing electrical interference and the effect of vehicles passing close-by), have improved the *reliability* but there is still room for improvement in the *accuracy* of the count values, with under counting a general problem.

On-road cycle lanes are rare in this data-set (Dereham Rd, Norwich) but their reliability and accuracy could be expected to be higher than true on-road sites. However, there may be problems in ensuring that all cyclists cross the loop, and do not use the footpath or the road itself. In one case (King St, Norwich) the site had to be abandoned because cyclists were travelling too slowly to be counted accurately and some did not use the cycle lane.

One of the objectives of this study was to provide estimates of the underlying variability of cycle flows. The initial work using DETR sites produced estimates based on a small number of sites as well as estimates of the impact of weather at two of them. As part of this study, a preliminary investigation of the underlying variability of the TRL sites has been made. The estimates do not include the impacts of holidays, or that of weather, although data on rainfall, and other weather variables have been collected from various sources for Taunton, Norwich and Birmingham. These data-sets could be used to look at the impact of such weather, within an urban area.

In all, the cycle data from 21 separate sites (18 if all the Pershore Rd, Birmingham counters are combined together), have been analysed. For some sites, almost a whole year's data has been available but for the Hyndburn and Hackney sites only 3 months data were available and data from the newly sited loop on Marriot's Way in Norwich have been omitted.

The data have been analysed in a similar way to that used in earlier work on the impact of weather; that is the cycle flows have been assumed to be Poisson-like distributed, and a log-linear relationship assumed between cycle flows, and day of the week and month of the year[2]. With this model form, variations between days and between months take the form of proportionate differences rather than absolute differences. In the following figures, the emphasis is on the variation in flows rather than their absolute levels so the data is given relative to some base (either Monday flows or January flows).

The variation over a week is depicted graphically in Figure 3 and the variation over the year is shown in Figure 4. In the case of weekly variation, there is little variation between Monday to Friday for most sites. At five sites there was no significant difference between the weekdays (Bluebell Rd, Norwich, one of the Pershore Rd counters, Kingsland and Whitmore Roads in Hackney, and Stoke Rd in Guildford). The behaviour of the sites during the weekend however does vary widely. At most sites, Saturday flows are lower than the weekday flows (the exception being Dereham Rd, Norwich) but the Sunday flows can be higher (The Birmingham Canal site for example), or lower (Bluebell Rd, Norwich (near the University) and Mount Walk in Taunton, near several school sites).

The estimating of monthly variation is much more problematic since there are fewer observations than for each day and such impacts as weather could be expected to have a greater impact. There may also be biases in the results, especially in the early months of each site as the counter is fine-tuned. This would be expected to affect the early months of each site - usually data from October to December 1997. It is worth noting that, for the seven sites with relevant data, levels of cycling in December are within a few percent of the January levels.

The pattern of variation by month, shown in Figure 4, is dominated by the behaviour of three, largely recreational, routes, the two Birmingham cycle paths (Rea Valley and the Birmingham Canal routes) and the River Wey Route, where the Spring/Summer flows are over twice the January level. For the other sites, a general pattern is not discernible but flow levels in December and January are low at almost all sites. The variation between sites is about 50% with some sites showing higher flows during the July/August (King's Lynn and Pershore sites) and at some sites a lower flow level than earlier months (Bluebell Rd, Norwich, and Mount Walk, Taunton). Those sites for which no January data were available (the Hyndburn and Hackney sites) have been excluded from the figure. These variations by month again show the quite distinctive characteristics of cycle flows dominated by cyclists from educational establishments, as well as the more leisure orientated cycle sites, such as the Birmingham cycle path sites.

At only one site was there a significant interaction between month of the year and day of the week (Rishton Rd site in Accrington), where Sunday traffic in August was higher than in previous months. This was a little surprising given that the effect of holidays had not been allowed for.

When considering monthly variations, the DETR data, covering at least three years data, may be more reliable as a general indicator than the TRL study sites. Without longer data periods from the TRL study sites, the long-term variation by month shown so far must be treated with some degree of caution. Even together, the sites cannot be said to be nationally representative of all cycling conditions. The full national road-traffic survey data (both continuous site data and manual count site data), and the National Travel Survey are better estimators of the mean monthly effects, but the sites analysed in this study do show the amount of variation of the monthly effects that can be expected *between* sites, even in urban areas.

3.13 Estimation of cycle flow variability

One of the by-products of this analysis was to produce estimates of the underlying day-to-day variability of cycle flows. By underlying variability one means the variation in daily cycle flows due to random effects such as would occur if the counts were restricted to certain types of day, say Wednesdays, during school-term. Some of this variation is know to be associated with day to day changes in weather as described earlier but most is not. Estimation of this variation enables estimates of the number of days of counting required to estimate changes in cycle flows over a period of time to a particular degree of accuracy. It can also be used to estimate the degree of confidence that an observed change in cycle flows was different from no change.

After allowing for the impact of day of the week and month of the year, the residual variation was compared with the mean weekday cycle flows. The residual variation is expressed as the standard deviation of the data divided by the mean cycle flow and so is more precisely the relative variation. Bearing in mind the somewhat uncertain nature of some of the early count periods and the uncertain impact of holiday periods (not allowed for in the analysis of the local authority data), these values may be conservative. Figure 5 shows how the relative variation in day to day cycle flows varied with the mean weekday flow

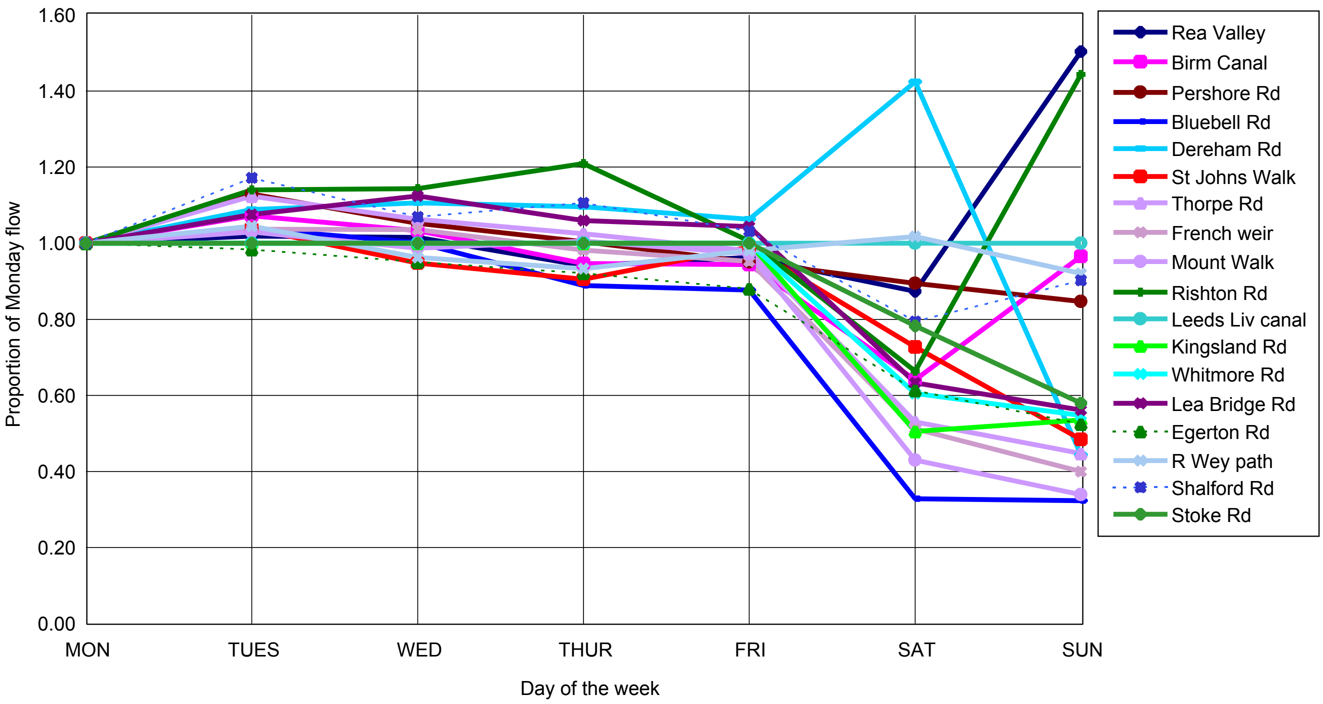

Figure 3 Cycle flows by day of the week

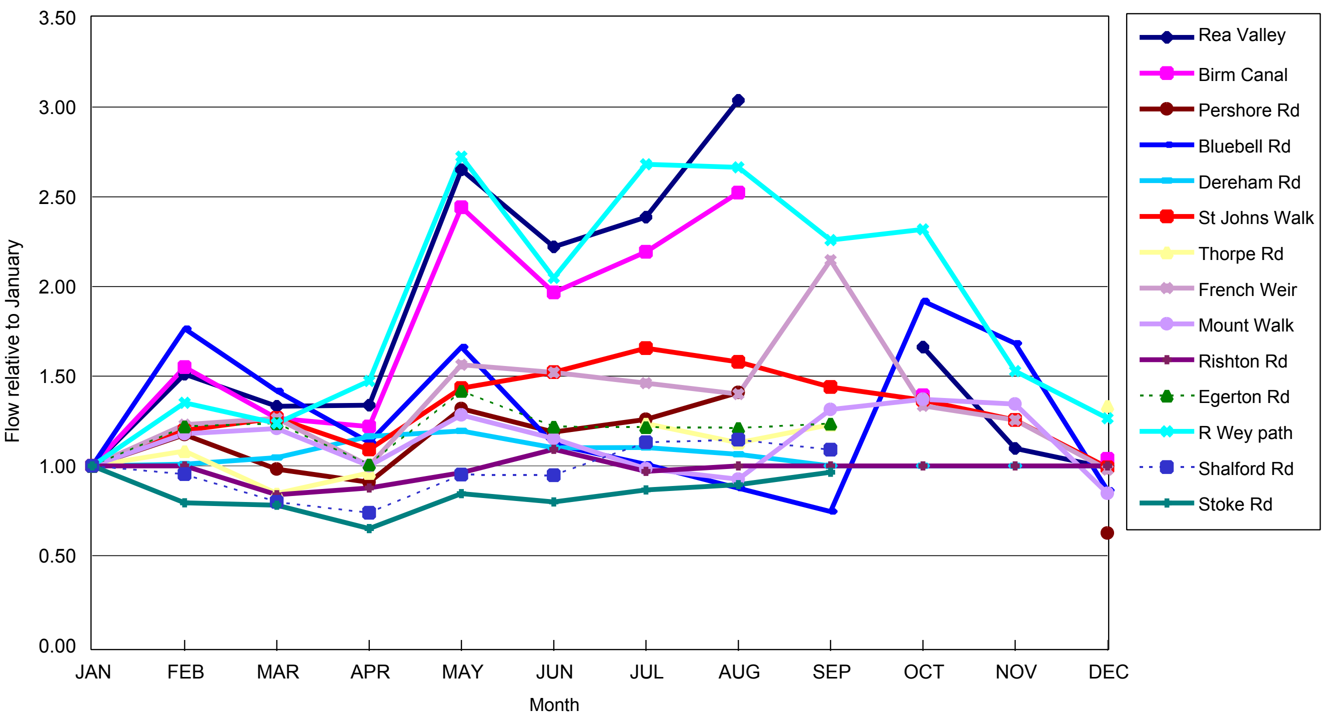

Figure 4 Variation in cycle flows by month

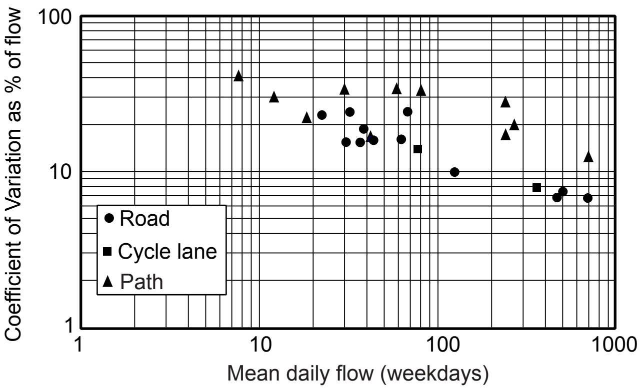

Figure 5 Variation in cycle flows with mean flow

for some 25 sites (from both Counters & Accessories loop sites and 5 DETR piezo-strip sites). The relationship between this residual variation and the mean flows was estimated to be:

Coefficient of variation (CV) = 0.5677 * weekday flow $^{-0.2676}$ for flows in the range (10 – 1000 cycles per day).

However only about half the variation in the data was explained by the relationship and there was a wide degree of scatter around the regression line. In these circumstances, it was felt better to group cycle sites by daily flow bands and be conservative in the predicted variability of the data. The day to day variations in Table 3.3 could be expected.

Table 3.3 Day to day variation in cycle flows after allowing for weekly and monthly effects

Cycle flow levels	*Coefficient of variation (CV)*
<10	0.5
10-100	0.3
100-250	0.2
250+	0.15

where CV = standard deviation of the flow/mean flow

These figures are used in the guidance report (Davies, Emmerson & Pedler, 1999) to estimate count periods for monitoring purposes in the absence of local data. When further data becomes available, from a wider variety of sites and types of counter, a finer degree of segregation may be valid. However a very close relationship is not to be expected and none have been found for motor-traffic.

The figures in Table 3.3 above are based on the analysis of *daily* flows. No analysis has been undertaken to see if flows of the same magnitude during part of the day have the same day to day variability; for example peak-hour flows on a busy cycle route but it would seem a reasonable first approximation to assume so.

3.14 Other work: Sunderland

At the same time as TRL was carrying out its study of approaches to monitoring cycle use, the University of Sunderland was conducting research into the same subject on behalf of the five local authorities of the metropolitan area of Tyne and Wear, through the Tyne & Wear Joint Transport Working Group, the Government Office (North-east), Sustrans, the former Tyne and Wear Development Commission and Nexus. The aim of the work carried out by Cope & Dowson (1998) was a monitoring exercise to ascertain both qualitative and quantitative data on cycle use within Tyne & Wear. Three different approaches were used.

The automatic cycle traffic monitoring programme used the same equipment as the TRL study and monitored 12 sites over the period August 1997 to June 1998; initially with only 5 counters, rotating in six-weekly periods around 10 of the sites, but later continuously at all sites. Like the TRL study, a variety of sites were covered from a semi-rural cyclepath on the National Cycle Network (Derwent Walk, Gateshead) to a number of heavily trafficked roads, with both on-road cycle lanes and no segregation such as the Tyne Bridge (Gateshead) and the Wearmouth Bridge (Sunderland). There were counter failures at some sites over some periods but generally, continuous data has been available over a longer period than at the TRL study sites. This data has been used to estimate firstly the monthly and daily variations in cycle use at 11 of the sites, using interpolated data to filling in periods when counter data were not available at a given site. In Sunderland and Newcastle, seasonal peaks were not marked, probably as a result of a high proportion of utility trips. However, in the other three boroughs, Gateshead, North Tyneside and South Tyneside August was the peak month, with recreational cycling predominating.

Unfortunately, no validation data is available for any of the sites. Because of siting considerations, some counters may underestimate the total flow of cycle traffic, for instance because the loop only covers a cycle-lane in one direction omitting both cyclists on the road and on the cycle lane in the other direction (Wearmouth Bridge). Nevertheless, with some adjustments the traffic data has provide a base data-set that can be used to factor other cordon counts

In addition to monitoring cycle traffic, the study was also concerned with estimating the level of cycle use, actual and potential, through a series of surveys. Surveys were conducted with participants in the National Bike Week, with users of selected Metro lines, and with parents or guardians of school children in the county. These questionnaires, whilst important in gaining insights into the behaviour of cyclists and potential cyclists have less important implications for the monitoring of cycle use.

3.15 Other work: Manchester

Greater Manchester Transportation Unit (GMTU) have investigated two techniques for automatically monitoring bicycles in mixed traffic (Jackson, 1998). In early 1997 GMTU installed a temporary, surface mounted loop at an already established permanent automatic traffic counting site (ATC) on the A6010 in East Manchester. The road at this site is a four-lane dual carriageway with on-road cycle lanes on both sides. The road itself is a very busy one with around 25,000 vehicles per day of which 13% are goods vehicles.

For the purposes of the first trial, a loop in the shape of a parallelogram with sides measuring about 1m was made. The loop was positioned within the cycle lane at a position where there was good lane discipline by both vehicles and cycles. A standard counter (Golden River) in a temporary housing was connected to the cycle loop and calibrated using the counter's loop sensitivity parameters. It was found that in order to only count cycles the loop's sensitivity had to be reduced. The result of this however was that the counter counted each wheel as it passed over the loop. Once this was taken into account a very accurate count of pedal cycles was achieved.

Data were collected throughout November 1997. The cycle data reflected the daily variation of the motor traffic but with a greater daily variability. (The coefficient of variation of weekday pedal cycle flows was 0.11 (on a flow of about 75 cycles per day), whereas for all motor vehicles, over the same period, it was only 0.03 (on a flow of 13,000 vehicles per day)).

The temporary loop showed signs of wear after a year and it has now been replaced by a permanent loop. Problems with the precise siting of the new loop showed again that a great deal of care has to be taken to ensure that such loops are positioned where both streams of traffic (cycles and motor vehicles) have good lane discipline. Whilst the loop and counter were by a different manufacturer than the TRL equipment, there were similar problems of short battery life and the need for frequent visits (at least every 2 weeks).

In addition, GMTU have been testing new pneumatic tube detection equipment, by the same manufacturer, which measures tyre contact width. To date the equipment has had mixed success. The counter can detect traffic in both directions and detect cycles separately. The counter classifies accurately in one direction, but cars are often mis-classified as pedal cycles when travelling on the carriageway nearest the counter. The manufacturer is working to lessen this phenomenon.

3.16 Estimating total cycle traffic in an area

One of the major problems with monitoring changes in cycling in an area is that the current level of cycling is generally unknown. In order to look at general changes either some estimate of the total veh-kms of cycling in the area must be calculated or representative base sample constructed. Somerset County Council, as part of the TRL study did consider the first approach but concluded that the resources needed to form a reasonable estimate of total cycle veh-kms were too high.

The University of Sunderland, as part of their Tyne & Wear study, used ATC and cordon count data to estimate a base level of cycle traffic in order to measure future changes. In addition to the automatic counts, cordon counts were undertaken in June and October in each of the five boroughs, with a mixture of on-road and off road sites. These have been used to estimate the base level of cycle traffic in the various boroughs in Tyne & Wear and can be used in conjunction with the limited existing count data, and the new cycle ATC data to provide estimates of total annual cycle traffic at a counter, by cordon, and by district, which can be updated by both the automatic counters data and the biennial cordon counts.

3.17 Estimating the change in cycle traffic in an area

One of the issues that many of the local authorities raised during the project was the possibility of monitoring changes in cycling levels by using a large number of one-day counts as opposed to a small number of multi-day counts. These could take the form of one-day screenline counts or a sample of sites throughout the area.

In the case of flows aggregated across a screenline, estimates of proportionate change may be more accurate than at individual sites since the *relative* variability of the sum of a set of counts is usually less than for individual sites. Provided that the level of cycling is high, the relative variability may be similar to a single site with that level of flow. In this case, either a smaller number of days need to be counted to be as certain of a given change, or any observed change will have a much greater degree of certainty attached to it than that for any individual site on the screenline or cordon. At present, information on the variability of aggregate cycle flows across a screenline is not available. As with general motor traffic, one can visualise circumstances in which the variability may be less than at a single site with the same average flow, (day to day site variability caused by route-switching), or more (where highs and lows occur on the same day at all sites on a screenline, say due to weather conditions or a local event).

The case for a sample of sites across the area is even more uncertain and no definitive guidance could be given from the evidence examined. Two useful data-sets were found which compared one-day counts separated over a number of years and which could be useful for future work. The first data-set was for some 17 sites in Taunton which had been counted for one-day in 1982 and the same sites revisited in 1995, 1996 or 1997. Whilst the overall change in cycle flows (assuming no difference between the counts in the 1990's) was a 2.3% decline in 12 hour flows and a 4% decline in am peak flows, individual sites showed a wide range of values for the changes over the period. Using only sub-samples of such a data-set could give very different answers. The second data-set consisted of 80 sites used to monitor the wearing of cycle helmets in 1994 and 1996 (Bryan-Brown and Taylor, 1997). These sites were spread out over England and Wales and were surveyed on equivalent days in each year but could not be deemed to be spatially random since they were biased towards urban sites. In this data-set, the net change was an increase in 12 hour cycle flows of 2.0%. However, this increase was dominated by 2 sites where a dramatic increase in cycling occurred (one incidentally on Bluebell Rd in Norwich, very near this study's monitoring site!). If these two are excluded, the increase dropped to 1.0%. However, the variation in percentage changes between sites were still quite large and choosing a sub-set of sites on which to based a change could give very different estimates of the mean values.

For both data-sets, a quick examination suggested that variations in the growth-rates between sites could not be explained by day to day variation in cycle flows as estimated in this study. Such data-sets, plus those from the ATC sites within this study, could provide some evidence on the usefulness of single-day multi-site counts as opposed to a multi-day counting strategy at a limited number of sites.

3.18 Costs of traffic monitoring

Perhaps one of the most important aspects of monitoring cycle traffic is the costs involved. Whilst the initial costs of the equipment were reasonable compared to say counting motor traffic, the on-going monitoring costs were much higher than expected. Initially this was caused by the need to collect data on a fortnightly basis due to the poor battery life. Whilst this problem has been largely overcome there were also problems with ensuring that the cycle traffic was being counted accurately which often necessitated numerous site visits. The ongoing costs of even the small number of sites in this project have persuaded at least one authority to abandon the monitoring exercise at the end of the study.

What did become obvious during the study is that the identifiable costs of any monitoring exercise (in this case cycling but probably any mode) varied markedly between local authorities, depending on their charging practices and the degree of integration of the cycle monitoring exercise with other traffic monitoring work. Because of this, it has not been possible to produce definitive costs per site.

However, the experiences of the monitoring costs incurred during this study may not reflect those faced by a local setting up a series of count sites now. The choosing of a site and guidance on installation, summarised in this report, and given in the guidance report (Davies, Emmerson & Pedler, 1999), as well as improvements by the equipment manufacturers, means that the installation of good counters should be much easier and cheaper in the long-term. Improvements in storage capacity and batteries means that cycle monitoring should be easier to integrate into any general traffic monitoring scheme. Whatever the problems over the accuracy of the counters, or battery life found during the study, they have proved reliable and only two have had to be replaced due to a malfunction. One was hit by a vehicle and one by a lawn-mower!

4 Monitoring cycle traffic — Roadside interviews of cyclists

4.1 Introduction

In order to obtain data on cycling by journey purpose and/ or route, and origin/ destination, it is necessary to interview cyclists. (Unlike cars, cyclists have no number-plate or other standardised, uniquely identifying feature that can be easily-recorded. Non-interventionist methods to obtain such information, such as number-plate surveys, are therefore not possible.) Interviews to obtain cyclist data can be carried out at the roadside (on-cycle surveys), or at specific destinations (trip end surveys). The cost of conducting interview surveys is much greater than that for counts, and there are additional complexities, but it is the only way to collect the information required.

4.2 On-cycle surveys (e.g. Cordon surveys)

Procedures for roadside interviews with drivers are well established. There is also a reasonable amount of experience of roadside interviews with cyclists. For example, in the 1980s the Greater London Council undertook a number of cyclist origin/destination surveys using roadside interviews and other local authorities have done similar surveys. TRL has also carried out many cyclist roadside interview surveys, some taking ten minutes or more per cyclist, in which route and origin / destination information was collected. However, the aim should be to minimise the survey time, subject to getting the necessary information efficiently and safely.

The type of data collected by a relatively short questionnaire could include the following:

- journey origin;
- journey destination;
- journey purpose;
- cyclist’s age (in wide bands);
- cyclist’s sex (observed).

Additional questions may be included in the surveys but, for surveys intended for monitoring only, the aim should be to keep the focus on monitoring of cycle use and cyclist characteristics. Conversely, it may be possible to piggy-back questions onto other interviews of cyclists (such as surveys of attitudes or use of cycle facilities) provided that the sample size is large enough and not biased (as a result of response or sampling bias).

During the course of this study, Birmingham City Council, Hackney and Tower Hamlets Councils, Sustrans and GMTU undertook ‘roadside’ interviews of cyclists in a variety of locations, including public roads, canal towpaths and cycle paths on disused railways. In Birmingham, cyclists were stopped and given a postal questionnaire to complete. At most locations, nearly all cyclists were willing to stop and be interviewed except at very busy times, although as will be detailed later problems were experienced at some of the London survey sites. Only GMTU had a police presence at their sites. All surveys included questions on origin/destination, journey purpose and age. The sex of the cyclist was also recorded. Some surveys included other questions such as user satisfaction with the route, etc. Excluding attitude questions, the basic interview took only 2-3 minutes per person.

4.3 Birmingham

A total of 810 questionnaires were handed out to cyclists on a screenline in south-west Birmingham (near the University) during the survey period between 23 February 1998 and 15 March 1998. The type of sites varied and included roads, on-road cycle paths, off-road cycle tracks and a canal towpath. The screenline locations were adopted to provide a count of cyclists travelling between two areas of Birmingham and the questionnaire provided the opportunity to identify the attitudes and behaviour of the cyclists. A total of 508 questionnaires were completed giving a 63% response rate. The following results are of interest:

- 82.5% of cycle trips were for commuter purposes
- More off-road cycle routes and less traffic on the roads were the two most important factors that would encourage people to commute by bicycle.
- 95% of cyclists who returned the questionnaire cycle at least 2-3 times per week. This could indicate that when people decide to cycle they cycle regularly.

4.4 Hackney Borough Council

Vincent Knight Sanchez Consultancy (VKS) was commissioned by the London Boroughs of Hackney and Tower Hamlets to carry out a screenline survey of cyclists in their boroughs. The screenline chosen followed the line of the Regents Canal and the Lea Navigation to the north and east of Central London, so intercepting cyclists commuting to Central London from a north-east segment of the outer areas. Some 65 sites were surveyed on Tuesdays, Wednesdays or Thursdays from 0700 to 1900, over a four week period from Wednesday 17 June to Thursday 9 July. Temporary signs were erected at each site to alert cyclists that interviewing was in progress. On busier roads, such as the Mile End Road (A12) (Plate 4), a lower percentage of cyclists were willing to stop and be interviewed than at the quieter sites. However in this survey, the numbers who refused to stop were not noted. Noting refusals is important to assess any bias in the sample interviewed. Wet weather also reduced the willingness of cyclists to stop and very few cycle couriers were ever willing to stop for interview. Interviews were checked on site by the supervisor. Whilst all sites were checked for safety, the desire to locate the screenline sites as close to the screenline as possible seemed to leave interviewers in a vulnerable position with respect to motor vehicles at some sites. Plate 4 shows an instance of the interviewing of a cyclist using the foot-way and at busy sites this can be an important factor.

The results of the survey, in terms of the analysis of the road-side interviews, were not available at the time of this report.

Plate 4 Roadside interviewing site in an urban area. Mile End Road, Tower Hamlets, London

4.5 Sustrans

In early 1998, fifteen sites on the National Cycle Network were chosen as survey sites. The majority of the sites have automatic cycle counters installed to give usage for 1998. The sites cover a variety of locations (e.g. urban and rural) and included two sites covered by TRL ATC counters (Marriot's Way in Norwich (Plate 5), and the Leeds Liverpool canal at Gt. Harwood).

Plate 5 Interviewing cyclists and pedestrians at an off-road site. Marriots Way, Norwich, Norfolk

Between June and September 1998, four twelve hour surveys were carried out at each site to supplement the automatic data by undertaking manual counts determining user and trip characteristics of both pedestrians and cyclists. 4,000 interviews were completed. The four days covered a weekday and a weekend day in term time and school holidays.

It was observed that cyclists were not able to provide accurate trip length information for very long or very short trips, when compared to routes measured off a map.

Most of the monitoring work was been undertaken in partnership with local authorities, who organised and supervised the surveys, with Sustrans contributing to the costs and analysing the data. Some of the sites were surveyed using Sustrans volunteers. However, as result of the experience it is not thought cost-effective to rely on this type of interviewer for future monitoring work. Maximising collaboration and co-operation has enabled sound data on the use of the National Cycle Network to be obtained and will assist local authorities in their own monitoring work.

In the future, it is proposed to survey on-road sites and encourage employers within a kilometre of the National Cycle Network to develop cycle links.

4.6 GMTU

GMTU have carried out roadside interviews of cyclists with police assistance. They were very successful with no refusals. In the case of roadside interviewing of drivers there is a need to have a police presence in order to stop vehicles and control traffic. With cyclist-only surveys this is usually not necessary provided that the interview location allows cyclists to stop safely and to be interviewed without causing danger or obstruction. There may be situations where a police presence is needed, for instance if there are heavy vehicle flows on unsegregated roads. This is an important aspect of survey design as hiring a police officer adds greatly to the cost of interviews, the police will need advance notice and they may not be available when required.

5 Monitoring cycling — Trip ends

The local authority surveys showed that a number of authorities need to monitor cycle use at specific sites as well as or in addition to general changes in cycle use in the district/ borough/county. These forms of survey need not stop moving cyclists and hold out the promise of easy and cheap counting. Various types of such surveys can be distinguished.

5.1 Town-centre surveys

Examples of passive cycling surveys in town centre are parking surveys. Active surveys may involve attaching questionnaire to cycles at stations or in town centres, or interviews in a cordon drawn around the town-centre of a parking sites. Each of these methods has been used and has particular advantages and disadvantages.

5.1.1 Surrey County Council

Surrey County Council undertook a series of surveys of cycles parked on streets in the centre of Guildford. An enumerator walked a beat, once only, on a weekday morning and a Saturday morning, every three months, recording the number and location of parked cycles. The survey was easy to organise, inexpensive and gave useful information about the level of demand for cycle parking. However, the number of cycles recorded was affected by the weather and other factors, which makes the one-off survey less useful for accurate monitoring. Also the information was probably not sufficiently focused to justify repeating the survey regularly. A more focused example would concentrate on an isolated site such as the railway-station and conduct the surveys at more frequent intervals.

5.1.2 Somerset County Council

As part of the assessment of how much cycling is used to gain access to the centre of Taunton a cycle parking survey was carried out in October 1998, after the new cycle parking facilities had been installed. The survey involved systematically reviewing each property where cycles could be parked and noting the number of cycles. The survey staff made inquiries about possible parking sites wherever possible however, there will always be some cycles parked inside buildings and therefore the assessment is only a guide. The survey was intended to provide a base line figure of cycles parked within the central zone to assess changes in cycle use as traffic restraint measures are applied. The number of parked cycles counted in Taunton in October 1998 was 453. Over £400,000 will be spent on cycle facilities in Taunton in the next few years. Once a cycle spine route is completed it is hoped a significant increase in cycling will be seen, and one of the monitoring items would be a count of the number of parked cycles.

GMTU have monitored cycle parking at 100 locations (private correspondence).

5.2 School surveys

Common examples of site specific surveys are those connected with school travel. Three different techniques can be adopted all of which have been used by different authorities. They are, in increasing sophistication and cost:

- To count the number of cycles in cycle sheds: This is very quick, easily repeated at intervals, and can be done without disrupting the school activities. The data is fairly basic but can be supplemented by information on school attendance on the day.
- To ask pupils what travel mode they used to get to school. Perhaps this is most easily done at assembly by the teacher. Very cheap, and a relatively quick method of estimating the mode-choice on a particular day. It does however require active co-operation from teachers and more processing time as well being open to some respondent ‘inaccuracies’.
- To hand-out questionnaires to pupils. This is the most sophisticated method and a large amount of information can be obtained. However, the school usually has to be sampled and there may be biases in the response rates, without active teacher co-operation. It was this method which the University of Sunderland used to elicit the cycling behaviour of pupils’ guardians (see Section 3 above). However, the variable response rate between schools, is a warning against using such an approach by itself to monitor area-wide cycle behaviour.

What is of interest is the relative accuracy of the common items of information obtained, i.e. total cycle flows, and the marginal cost of the additional information. The first and third approaches could be adopted for place of work studies, although the level of co-operation and response rates may be lower.

5.2.1Hyndburn Borough Council

In conjunction with this study, Hyndburn Borough Council carried out school surveys by interviewing children (9-15 years), form tutors and head teachers. The children were asked questions about their age, where they live, their journeys to school, and what would encourage them to cycle. Form tutors were asked about the age of their pupils, the numbers of children travelling to and from school by mode and the likelihood of changing children’s mode of travel to school. The head teacher’s questionnaire consisted of questions about school policy towards cycling. The journey type/destination modal share information will be used to establish the current base level, and surveys in future years will be used to gauge changes in cycling habits and the demands of the current nine year olds as they progress through school. Thus, the survey will provide both a description of the current day situation and a basis on which to provide a monitoring programme in futures years, as well as information to help with policy formulation.

32 schools out of an initial list of 40 agreed to take part in the survey and 3-4,000 questionnaire have been received from 23 schools. The results of the surveys were not available at the time of publication.

5.2.2 Transport Research Laboratory

Gray, Gardner and Pedler (1998), surveyed cycling at two schools. 600 questionnaires were distributed at McEntee School, Waltham Forest. Two research representatives were present if any problems arose. A total of 240 questionnaires were returned for analysis. However, although completed under limited supervision there was evidence of some misunderstanding and inconsistencies. However, some trends were clear and useful information was obtained, particularly from the responses to open-ended questions. At Myton School, Warwick, a smaller sample size was chosen, allowing close supervision by two research workers. Subsequently, the questionnaires were completed to a much higher standard. A total of 101 questionnaires were available from Myton School for analysis.

Both schools were given the same questionnaire but the most useful data was from the school which had closer supervision. The open-ended questions were found to be the most informative. TRL experience has shown that within schools, a member of staff committed to cycle monitoring and acting as a co-ordinator and organiser is vital for the success of the research.

5.3 Employment surveys

Employer surveys are especially useful when establishing a Green Commuter Plan. Collecting information on the mode of transport employees use to travel to work enables a transport strategy to be developed, which can assist in encouraging more sustainable modes of transport to be used for commuting.

5.3.1 Surrey County Council

Surrey County Council investigated the feasibility of manually counting cyclists entering a sample of workplaces in the Guildford area. Employers were generally co-operative. However, for small companies (the majority) with less than 20 employees, this would have been a relatively expensive method; and large companies tended to have more than one entrance and sometimes with flexible working hours, so that several survey staff would have been required. The local authority therefore decided, not to pursue this survey method.

5.3.2 Somerset County Council

Surrey County Council have recently been carrying out employer surveys in Taunton as part of their Green Commuter Plan initiative.

5.3.3 Cambridgeshire County Council

Cambridgeshire County Council have set up a system of monitoring travel to work by employees of those companies supporting TravelWise in Cambridgeshire. Employers send in standard information every three-months and the County Council collate and disseminate it. The local authority also hopes to use the Origin and destination information to update its traffic model for Cambridge.

5.3.4 Nottinghamshire County Council

Nottinghamshire County Council’s Employee Transport Co-ordinator monitors the number of cycles parked in the County Council’s Cycle Centre. The Buildings Superintendent uses security CCTV to scan the cycles and phones the information through once each week.

5.4 Railway station surveys

Integrated transport strategies have placed new importance on cycle parking at railway stations. Train operating companies (TOCs), Railtrack, local Passenger Transport Authorities and other bodies with public transport interests undertake passenger surveys. Wherever possible, these should ask about mode of travel to the station. It should also be possible to organise station staff to undertake a regular (weekly) count of cycle parking at the station, say at 10.00 each Wednesday morning (if early closing days are avoided). Crucial factors will be the co-operation of the station authorities and staff, and ensuring that the data are collated promptly and results published.

5.4.1 Transport Research Laboratory

As part of an earlier study for DETR, TRL carried out questionnaire surveys at railway stations and at Park and Ride Sites (Taylor, 1996). Questions were developed which aimed to discover the value of the sites to people who were already cycling and the potential for encouraging those who did not cycle to use the sites. The questionnaires were brief so as not to disrupt the respondent’s journeys. Face to face interviews were undertaken lasting about 3-4 minutes. Questions asked included, journey purpose, modal choice and origin/destination.

In a more recent study of the market for transporting cycles on trains in East Anglia, postal questionnaires were attached to bikes at railway stations and received a response rate of a third to a half (Guthrie and Gardner, 1998). However whilst two days of survey were done at the larger stations, no measure of the bias in response was available and the purpose of the survey was to elicit attitudes of representative types of cyclists, rather than estimating the true make-up of the cyclists parking at the stations.

5.5 Household surveys

Some local authorities undertake household interview surveys for a variety of purposes. They may be exclusively about transport or may include transport within a more general household survey. All such surveys are relatively complex, requiring detailed planning, well trained staff, and lengthy analysis. Some of these are large surveys at regular intervals such as the GLTS and LATS travel surveys in London, others are continuous surveys of smaller samples of households such as undertaken by Birmingham. Such travel surveys usually include travel diaries to record all travel by most persons in the household and so collect a good deal of information on the cycle habits of those people which could not be easily collected in any other way (such as full origin and destination movements, alternative modes etc.).

Large one-off travel surveys are excellent vehicles for collecting extensive travel information, especially when most of the costs are borne by those interested in the majority modes. However their occurrence, because of costs, will rarely be often enough to provide regular monitoring and the analysis of the data takes so long that the results are often dated by the time they become available. Given that only around 14 % of the population cycle on a reasonably regular basis, it is not cost effective to undertake a household survey primarily to assess cycling.

Smaller scale household travel surveys are becoming more common. These usually take the form of sampling a small sample of wards each year, in a rolling survey in much the same way as the National Travel Survey which now has a continuous survey with a smaller sample per year rather than a large one every three years or so. Birmingham's travel survey is an example of this. However their low sampling rates means that they cannot be used to monitor changes at anything below a very aggregate level since the sampling errors, particularly on minority modes such as cycling, are so large that year on year changes have very wide confidence limits. In general, data for three years or so needs to be aggregated together to provide meaningful results. However, in large cities, where cycling is known to vary markedly from area to area, even three years data may give a biased estimate of the cycling population. In such circumstances household surveys are more useful for understanding the socio-economic characteristics of the cycling population (and so help provide the basis for more attitudinal based surveys) than providing a basis for monitoring changes per se.

One other possible use of household surveys is in relation to single site or single areas of concern, for example surveys of households connected to schools (children, teacher etc.). This kind of survey could monitor the linkages involved in mode choice, between members of the household (for example to understand school escort trips), or a single housing estate where cycle provision is intended. However, unless the area is tightly focused or the sample is easily contactable, survey costs can be quite high and the sample may need to be quite large to monitor any changes with any degree of confidence.

National Travel Surveys regularly monitor household bicycle ownership and cycle use, and this can be related to other transport and socio-economic factors. Given the above costs, complexities and limitations of undertaking local household surveys, it is recommended that local authorities rely primarily on the NTS for general cycling information, supplemented by more local data where possible, but should try to piggy-back questions on travel by cycle onto other more general household surveys.

5.6 Conclusions on interviewing and parking surveys

The experience of those local authorities and other organisations that have attempted regular monitoring of cycle use at specific locations suggests the following guidelines:

- Monitoring programmes should not be over-ambitious. All data collected should have a use and the quantity should be manageable.
- Monitoring methods should not be complex or time consuming as these are likely to be abandoned after one or two repetitions.
- The most cost-effective methods appear to be those where the employer, school, etc. collects the information and passes it straight on to the local authority. However, this requires good co-operation.
- Obtaining permission for a one-off survey is usually not difficult but regular co-operation requires that the employer, school, transport operator, etc. has an interest in the project. This may be best achieved within the context of a Green Commuter Plans initiative or Safer Routes to Schools programme.
- The local authority must help to design and co-ordinate the surveys, ensure that the information is delivered promptly and provide feedback to the supplying organisations.
- Counting parked cycles is generally the most practical, reliable and cheapest method of monitoring cycle use at a particular location. These counts work best where there is only a small number of cycle parking locations at a site. Weekly counts, on a certain day and time, are optimal although monthly counts will still be useful. It is impractical to expect organisations to undertake daily counts and a single count once a year will be subject to considerable sampling error.
- A few locations, such as Cycle Centres, may be able to provide very detailed information, such as the number of cycles parked per day.
- Where possible at workplaces, counting parked cycles should be combined with counting parked cars, provided that most employee's cars are parked on site. This will give a broader picture of the modal split and give the monitoring work a wider relevance.
- Questionnaire surveys of employees, school children, rail passengers, etc. are very valuable and can provide more detailed information. However, for a variety of reasons, it is probably not practical to undertake them more than once a year - often less frequently - and so they are less useful for monitoring trends in cycle use.

6 Summary

This study was designed to provide outputs that would aid local authorities in devising approaches to monitor the progress towards increasing cycling as required by the National Cycling Strategy. The study was designed as a collaborative project with a selection of local authorities and covering a cross-section of cycling environments, although with a mainly urban emphasis.

The resources of the study were split almost equally between an investigation of the feasibility of mounting a cycle traffic monitoring scheme and investigating other methods of monitoring cycling.

At the time of the start of the study, and after a review of existing cycle counting technologies, all the local authorities in the project chose the same counting equipment. This loop based equipment was fairly cheap, yet of sufficiently sophisticated design to attempt to distinguish between cycles and other vehicles passing over the same loop in a variety of on and off-road environments. These factors inevitably lead to compromises in the design of the equipment, most notably in the short life of the battery and hence of memory.

Apart from the battery, the major problem with the equipment has been the inability to count accurately in a number of environments. Most attempts to measure cycle flows within a general traffic environment have been unsuccessful, partly due to the interference of motor-vehicles affecting the counting of cycles but also through poor siting and other interference. These two factors have also lead to problems at some off-road sites but more than half of these now appear to be working satisfactorily, at least in one direction.

There is no doubt that progress has been made by the main ATC equipment manufacturer (Counters and Accessories) during the study, and other manufacturers are now showing interest in producing similar equipment. However, at present, the ultimate aim - that of counting cycle traffic amongst other vehicles - cannot be guaranteed at a every site and, at present, the sites chosen need to be selected very carefully. This can have serious implications for monitoring cycle traffic in general since there must be concerns over monitoring only off-road cycle flows which could lead to biased estimates of changes in cycling, especially in the light of the provision of more off-road cycling facilities.

Nevertheless the monitoring of flows over a long period of time has proved possible both in this study and in the similar University of Sunderland study. Most of the TRL study and University of Sunderland sites have cycle flows well above any in the DETR Core Census programme and so they can provide evidence of the variability of high cycle flows, unavailable from the Core Census sites, and their usefulness will increase as the length of counting increases.

One aspect of the study that was not appreciated fully in setting out the programme of ATC counts, was the effect on the resources of the local authority. This has had a number of repercussions on the progress of the ATC count programme.

1 Firstly counter maintenance that does not fit in with the general traffic counting programme was found to be very time-consuming and inconvenient and the longer battery and memory life of later versions of the equipment has been a boon.

2 The actual setting up of a counter site can require a great deal of preparation and consultation between the authority and the equipment manufacturer and there may be a long delay between the initial choice of site and finally receiving reasonable data from that site.

3 The outputs from sites need regular checking supplemented with site visits to repeat the counter validation, especially for on-road sites.

Local authority staff have numerous other duties and monitoring cycling has to be fitted in around them. Consequently, one-off actions such as validating counters are vulnerable to being repeatedly postponed.

With regards to the other approaches to monitoring cycling, most authorities chose surveys that they felt could act as both a monitoring survey and provide them with information they required for other purposes. Thus many of the local authorities opted for cycle parking surveys but did acknowledge that one-off or periodic parking surveys are not ideal monitoring approaches but do provide much needed information on cycling behaviour and thus had a dual purpose.

Because of other commitments many of the authorities were unable to carry out proposed surveys within the time-period of this study and a some surveys were abandoned as impractical after initial ground work.

7 Way forward

Based on the experience of the participants in this study a number of proposals can be made to improve the monitoring of cycling in an area.

- Automatic traffic counting - Efforts are required to increase the reliability of automatic traffic counters for measuring cycles within traffic flows and to reduce the impact of outside electrical interference. At least three major manufacturers are involved in producing such equipment. Even with improved ATC equipment there will still be a need for clear validation of such equipment under working conditions before large-scale use on trafficked roads can be unhesitatingly recommended.
- ATC data - There is now a considerable quantity of continuous data arising from both the TRL study sites, the Sustrans sites, and the Tyne & Wear sites, many with accompanying weather data. There is scope to undertake more detailed analysis of cycle flow data, taking into account factors such as holidays and weather. This data set does have the advantage over the DETR traffic census data in covering a wider range of sites with higher cycle flows but the DETR sites still have the advantage of multi-year data and short-term accuracy.

With regards to the other monitoring methods suggested there are a number of variations that have not been tried out that may be worth testing. A comparison at a small number of schools of attendance surveys and cycle parking surveys, as well as daily parking surveys could be carried out at a reasonable cost, with the schools' co-operation.

The need for multi-day parking surveys for monitoring purposes in for instance workplaces or town-centres has not been fully covered in this study and this again should be tested further in a sample area.

The conducting of interviews, be they at school or at workplaces, is difficult to justify on the basis of monitoring alone but regular travel surveys for schemes such as TravelWise or Green Commuter Plans can provide cycle information and reveal indicative trends.

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2 Somerset County Council with W S Atkins
3 Norfolk County Council
4 Hackney Borough Council
5 Surrey County Council
6 Birmingham City Council with JDT (Mott MacDonald)
7 Hyndburn District Council and Lancashire County Council

The additional members of the Advisory Panel:

1 Department of the Environment, Regions and Transport
2 Scottish Office
3 Countryside Commission
4 Sustrans
5 Greater Manchester Transportation Unit
6 London Cycle Network
7 School of the Environment, University of Sunderland

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Appendix A: Siting issues in choosing ATC sites to count cycles – an example

Shalford Road sites - Guildford

A good deal of experience has been gained about the siting and the monitoring of cycle traffic during this study. It is instructive to consider these sites in Guildford as examples of some of the issues that have arisen during the study and which must be borne in mind when siting these counters. They also illustrate advances in the ATC technology during the study period.

These particular sites were designed to measure cycle traffic entering Guildford from the south on the east-side of the River Wey. The road site measures northbound cycle and motor vehicle traffic on the A281 just as it enters Guildford. The other site counts cycle traffic in both directions using the River Wey cycle path just before it reaches the A281 and is located only some 10 metres from the road site (See Plate A1).

The validation counts were undertaken in May 1998 at both sites. The results, shown in Table A1 (reproduced from Table 3.2 in the main text) were not promising, although motor-vehicles were counted very accurately.

Table A1 Validation at the Quarry Street sites

Type	*Counter*	*ATC*	*MCC*	*% difference*
Road	Cycles	58	114	-49.1
(north bound)	Vehicles	8093	8155	-0.8
Cycle path	Cycles (n)	58	62	-6.5
	Cycles (s)	35	29	20.7

Arising from these poor cycle traffic validation results, Counter and Accessories and Surrey County Council investigated both sites. At the road site, it became evident that the major problem concerned cycles missing the loops. At this point on the road, cyclists were being forced into the kerbside by cars passing on the narrow single-carriageway and were therefore often not passing over the trapezium part of the loop which, started about 0.3 metre from the kerbside. In addition, there was some doubt over the position of the Manual Classified Count against which the ATC count was being compared.

In the case of the cycle-path, the reasons for the poor validation results were more complex. The site is less than 10 metres from a turnstile (where the cycle-path joins the road) and numbers of cyclists were either passing slowly

a Off-road site at the end of the River Wey cycle route. The induction loop, the counter pillar and the gradient at the site are all clearly visible

b The on-road site was on the side nearest the counter pillar. The start of a cycle lane is just visible and the off road site is on the opposite side of the hedge

Plate A1 Off- and on-road cycle monitoring sites – Shalford Road, Guildford, Surrey

over the loop or were mounting and dismounting on the loop. Counters and Accessories investigated this site, as part of a scheme to upgrade their firmware by taking into account a greater range of electrical profiles of cycle passing over loops at different speeds and trajectories. The company reported that the improved firmware was verified at this site on 7 September 1998 using an independent company who videoed throughout the day and compared the results with the recorder data from the loop counter. The loop counter had been set to one-minute data so that any errors could be attributed to specific events. The morning data, using the older version of the firmware, yielded an accuracy of 89%, largely arising from the cycle behaviour described above. In the afternoon, the improved firmware was fitted and yielded an accuracy of 98%.

By the end of the study the ATC counter on the cycle-path did appear to be working well but the ATC results *may* still not reflect the true number of cycles, for instance if cyclists are not passing over the loop, for one reason or another. This does lead to a consideration of what the true validation should represent; the counting of all cycles on the site or just those passing over the loops. In practice, both should be measured if there is any doubts the latter figure validates the working of the counter and the former a validation of the site.

It should also be appreciated that most of the validation counts, for the study as a whole, were undertaken at sites without the benefit of the new firmware, which was not available at the study sites by the end of the survey period (generally October 1998). Where the study sites are still operational, repeating the validations now with the new firmware should improve the validation results.

Notes

[1] Coincidence in this instance refers to a cycle and another vehicle crossing the pneumatic tube at the same time. This problem also affects other automatic counters such as induction loops and is returned to under that heading. However, as a tube is much narrower than a loop, each vehicle will pass over it much more quickly and therefore the risk of coincidence will be considerably less.

[2] An inspection of the residuals from the analyses showed that the assumptions about a Poisson distribution were valid for flows of less than 250 cycles per day, but flows above that tended to be Normally distributed.

Abstract

The Transport Research Laboratory was commissioned by the Charging and Local Transport Division of the Department of the Environment, Transport and the Regions (DETR) to provide guidance to local authorities and others on methods for monitoring cycle use. This report concentrates on the findings of collaborative research between TRL, six local authorities and a number of other interested bodies on a range of cycle monitoring techniques. This part of the study assisted in framing much of the advice contained in a companion report, which is concerned solely with providing guidance. The guidance is intended to help with setting targets, survey design, and the statistical interpretation of the results (Davies, Emmerson & Pedler, 1999).

Related publications

TRL395 *Guidance on monitoring local cycle use* by D G Davies, P Emmerson and A Pedler. 1999 (price £25 code E)

TRL371 *Alternative routes for cyclists around pedestrian areas* by D G Davies, T J Ryley and M E Halliday. 1999 (price £25 code E)

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