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MEASURING IMPACTS OF NEW HIGHWAY CAPACITY - A DISCUSSION OF POTENTIAL SURVEY METHODS

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ABSTRACT

The paper reviews survey methods that might be used to detect the various impacts of new highway capacity (changes in flow and network travel times; behavioural responses such as rerouting, change in departure times, change of mode, redistribution and change in trip frequency; and changes in land use). The review was conducted in the context of a study for TRRL which sought to establish the feasibility of measuring responses to new highway capacity.

The paper considers, in turn, surveys of traffic flow, public transport usage and network travel times, methods of estimating origin-destination matrices and a variety of questionnaire and interview techniques which might be used to collect individual travel data (roadside interviews; stopline surveys; household interviews; trip-end interviews; self completion questionnaires; retrospective, prospective and stated preference questions; panel surveys and indepth interviews). There is also a brief discussion of methods to determine freight movements and land use effects.

The paper should not be regarded as a source of detailed information about the various types of survey but rather as a review of their comparative strengths and weaknesses in the given context.

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The views expressed in these reports do not necessarily reflect those of TRRL or the Department of Transport.

Reports in the series are:

The Feasibility of Measuring Responses to New Highway Capacity (by Bonsall PW). TRRL Contractors Report No CR200, due early 1990.

Travellers Response to Road Improvements: Implications for User Benefits (by Mackie PJ and Bonsall PW). Traffic Engineering and Control 30 (9), 1989. Note that this paper was prepared in advance of the TRRL contract.

User Response to New Road Capacity: A Review of Published Evidence (by Pells SR). ITS Working Paper 283, 1989.

Sample Size Determination to Evaluate the Impact of Highway Improvements (by Fowkes AS and Watson SM). ITS Working Paper 282, 1989.

Measuring Impacts of New Highway Capacity: A Discussion of Potential Survey Methods (by Bonsall PW). ITS Working Paper 289, 1989.

Evidence on Ambient Variability and Rates of Change (by Watson SM). ITS Technical Note 257, 1989.

Application of Stated Preference Methods to User Response to New Road Schemes (by Bates J and Wardman MR). ITS Technical Note 258, 1989.

Some Observations on Appropriate Time Scales, Siting and Location of Surveys and on the Use of Panels to Measure Responses to Highway Improvements (by Goodwin PB and Jones PM of TSU, Oxford). ITS Technical Note 259, 1989.

User Response to New Road Capacity: What The Experts Said (by Bonsall PW, Mackie PJ and Pells SR). ITS Technical Note 260, 1989.

Calculation of Costs of Surveys to Measure User Response to New Road Capacity - Worked Examples for Typical Schemes under Alternative Survey Strategies (by Bonsall PW). ITS Technical Note 261, 1989.

CONTENTS

1 INTRODUCTION

1.1 In this paper, we will review the various survey methods that might be used to study response to new highway capacity, highlighting their strengths and weaknesses and other practical issues. The review was conducted as part of a project which sought to establish the feasibility of measuring the impacts of new road schemes on travel behaviour, land use and network performance.

1.2 This report does not set out to provide full details of the various methods - further details of the best known techniques can be found in chapter six of TAM (DTp, 1981) and in IHT/DTP (1987).

1.3 We will deal first with relatively simple traffic flow studies, moving to progressively more complex surveys.

2 ESTIMATION OF LINK FLOWS

2.1 Link flows can be determined by human observers ("Manual Classified Counts") or by automatic methods. The choice between them will depend on the duration of the survey, the required disaggregation and site specific factors. The observations can be taken mid link or at a junction - in which case the data can be disaggregated by movements through the junction.

2.2 Manual Classified Counts involve enumerators recording the flow of vehicles onto forms or directly into data loggers. The flow is normally classified by direction and up to 11 vehicle types. The survey is relatively simple to organise, is not disruptive of the traffic and is the most economic means of measuring flow for periods of up to about two or three days. For surveys of longer duration, one of the automatic methods (see below) might be more economic but might not provide the necessary classification.

2.3 Problems can be experienced when attempting to classify traffic after dark and, therefore, if classified night-time flows are required, it may be necessary to use one of the more sophisticated automatic methods.

2.4 Accuracy will depend on the quality of staff, site conditions and the workload given to each enumerator but it should be possible to achieve accuracies of $\pm$ 10% (at 95% confidence) at an average site in average conditions using good quality staff with a realistic workload and shift length. Accuracies achieved for individual components of the total flow will, of course, be somewhat lower (see for example Phillips, 1979a). Survey points will ideally have good visibility from a location where a car could be parked but it will often be better to have the enumerator standing at the roadside, (particularly when separate turning movements are to be identified). It is very difficult to conduct manual counts at very large junctions.

2.5 At sites where it is impractical for enumerators to record the data on site - e.g. at very high flow sites >20,000 vpd or at complex junctions, it may be economic to take a video film of the location and play it back in the laboratory where enumerators can type the relevant data directly into a computer. This method is generally more expensive than on site observation but can produce higher accuracies - particularly in poor lighting conditions where use can be made of infra red or image intensifying lenses.

2.6 Automatic processing of video images now enables one to dispense with the human enumerator. The accuracies achievable by this method are somewhat less

than those achievable with enumerators and the equipment costs are not insignificant. It is however expected that this technology will soon provide very strong competition to the more traditional means and developments should obviously be kept under review.

2.7 The methods of automatically counting traffic as it passes along a link that are the most widely used in the UK are the pneumatic tube (which strictly counts axles, rather than vehicles) and the induction loop (which can classify as well as count). Other methods include electromagnetic and piezo-electric cables, photoelectric cells and microwave detectors. The field is under constant development and, again, it would be wise to keep economic and technical developments under review.

2.8 The techniques widely used in the UK fall into two categories - those that are installed on the surface of the highway and those that must be buried within it. The significance of this distinction is that the surface-mounted devices can be installed at much lower costs and with much less disruption to traffic than the 'buried' devices. In practice the buried induction loop is not economic for surveys of less than three months or so.

2.9 Correctly installed, a pneumatic tube can produce accuracies of up to $\pm$ 5% (at 95% confidence interval) after allowing for error in the conversion from axles to vehicles (a conversion that must be based on a sample MCC survey), (see Phillips, 1979b). It is well-known, however, that unless monitored on a regular basis, it is quite common for the tube to deteriorate resulting in missing or, much worse, erroneous data. Also, reliability is reduced in urban areas or at junctions where there may be slow-moving or standing vehicles.

2.10 Correctly installed, an induction loop can count vehicles to accuracies of up to $\pm$ 5% (at 95% confidence) although classification (by length, speed and lane usage) into sub-groups obviously results in slightly lower accuracies on the sub-group totals. Reductions in accuracy over time are much less likely than with pneumatic tubes but are not unknown.

2.11 Pneumatic tubes and, to a lesser extent, buried induction loops, have to be carefully sited. The road surface should be smooth, the trajectory of vehicles predictable and areas of significant acceleration or deceleration avoided.

3 SURVEYS TO ESTIMATE PUBLIC TRANSPORT PATRONAGE ON SPECIFIED ROUTES

3.1 There are essentially three methods of collecting this data: on-vehicle counts, off-vehicle counts and analysis of ticket receipts.

3.2 On-vehicle counts involve the enumerator travelling with the vehicle and counting either the number boarding and alighting at each stop (suitable for buses), or the number on board between stops (generally more suitable for trains).

3.3 Off-vehicle counts involve either estimating the number of passengers on board when the vehicle passes a certain point (clearly not suitable for trains, but can be done to within $\pm$20% with buses), or having enumerators at each stop to count boarding and alighting passengers. The choice between these various methods will depend on network and service patterns. The off-vehicle methods are generally less accurate but do not require the operator's co-operation.

3.4 Depending on the ticketing system in use, it is sometimes possible to estimate loadings directly from analysis of receipts, perhaps by means of the 'average fare' method. Some ticketing systems can theoretically provide O-D information, as well as estimated loadings. In practice, however, this information is rarely straightforwardly available and, as with all ticket receipt data, is likely to be regarded as commercially confidential by the operator. The attitude of the operator to one's request for data or co-operation is clearly crucial in determining how public transport patronage on specified routes might be estimated.

4 SURVEYS TO ESTIMATE LINK TRAVEL TIMES

4.1 Link travel times can be estimated by a variety of methods. The most popular in the UK being registration plate matching and moving observer methods. Other methods include vantage point surveys, input-output surveys and series of spot speed estimates.

4.2 In the registration plate matching method, survey sites are established at either end of the link of interest and the registrations of individual vehicles (together with the time at which they were seen) are recorded at each site. The records are then matched and the time taken to travel between the two sites thus determined. The records can be made on paper, spoken to audio tape or typed directly into a data logger (the best choice of recording medium will depend on flow levels see Bonsall et al, 1988).

4.3 Even after allowing for errors in synchronisation of time records and biases in matching it is thought that registration plate matching can produce estimates of journey time to within ± 5 seconds, given favourable site conditions (good visibility, low flows and 'bunching' of traffic) and skilled enumerators.

4.4 Use of video cameras to record registration plates is the subject of much current research and experimentation. It seems to be quite successful on high flow roads with good vantage points (e.g. motorways - with the camera attached to a bridge). If the video record is then analysed by human enumerators the overall costs are very high but the development of automatic means of 'reading' the video image has now reached the stage where accuracies of up to $\pm$ 2 seconds are achievable for flows of up to 3,600 vehicles per hour. The hardware costs are still very high but, yet again, it would be wise to monitor developments quite closely.

4.5 The moving observer methods involve driving in stream of traffic and recording the time taken to pass along the link(s) of interest. The driver can be instructed to 'float' in the traffic (overtaking as many vehicles as overtake him) or, more realistically, corrections can be made for having driven slower or faster than the average by recording details of the traffic flow and the numbers of vehicles overtaken/overtaking.

4.6 If reliable estimates of average journey times are required it is necessary to make several runs along the route during the period of interest (e.g. a single peak hour or all the peak hours during a week). The more runs that are made per unit time the more accurate will be the estimate (provided that the survey vehicles do not become so significant an element in total flow that they are themselves affecting the mean journey time). It is thought that, if nine runs per hour are achieved then it is possible to obtain accuracies slightly above $\pm 6\%$ at 95% confidence.

4.7 In practice the moving observer method is well suited to the estimation of average journey times over a period of several days while the registration plate matching method is preferred for the estimation of journey times for very short

periods within a single day (travel times vary considerably at different times of day and from one day to another and a survey over several days is necessary to produce an estimate of 'average' conditions). The registration plate method would be very costly if continued for several days whereas the moving observer method is well suited to such a time scale.

4.8 The vantage point method involves observing and timing the passage of individual vehicles from a position from which the entire route is visible. Such positions might include tethered balloons, high buildings and distant hillsides. In practice, the combination of weather conditions and topography means that such conditions are rarely available. Furthermore, unless the route is very short, it will take a considerable time to track each vehicle and this will make it very expensive to collect sizeable data sets.

4.9 Input-output methods involve recording the mean time at which a cohort of vehicles enters a link and the mean time that it exits and then taking one from the other to produce a mean journey time. The method is a very attractive technique if the cohort can be readily identified but falls down completely if it cannot. It is an ideal method for estimating travel times through a tunnel or on a motorway where overtaking is impossible, but is not reliable in urban areas where there are significant opportunities for vehicles to enter or leave the cohort en route (either by joining or leaving the route, by overtaking the front-of-cohort vehicle or by being overtaken by the back-of-cohort vehicle).

4.10 Although it is theoretically possible to determine link journey times by taking a series of spot-speed measurements, the method is unlikely to be accurate unless speeds are relatively constant along the route - and this is very unlikely to be the case in congested or urban areas.

4.11 Automatic methods of determining journey times are likely to become increasingly important - two particularly interesting developments are the use of automatic image processing techniques to collect registration plates (see above) and the ability to monitor the progress of vehicles equipped with some types of route guidance system (eg, Autoguide).

5 METHODS OF ESTIMATING OD MATRICES

5.1 Origin-Destination matrices can be estimated by means of data on individual vehicle movements derived from interviews or questionnaires or from matched registration plates. Other sources of information which may become significant in due course include data from some types of route guidance and road pricing systems (there is a question, however, as to the representativeness of a self selected sample of this kind and, for the forseeable future, the numbers of equipped vehicles are insufficient to produce statistically reliable information).

5.2 Derivation of OD matrices from interviews or questionnaires is relatively expensive but is the standard technique. A typical survey design would employ household interviews within the main study area with roadside interviews on a cordon around it. The OD information is often obtained via a one day travel diary within the household interviews and questions relating to the current journey within the roadside interviews. These interviews obviously relate to a sample of the complete matrix. The sampling rate is used to factor up to the complete matrix.

5.3 A particular advantage of the interview and questionnaire methods is that information about journey purpose and traveller characteristics can be simultaneously obtained and it thus becomes possible to produce separate matrices

for different journey purposes and person types and to provide disaggregate information suitable for behavioural models. Other advantages and disadvantages are discussed in Section 6 which deals in more detail with questionnaire and interview surveys.

5.4 The use of matched registration plates to estimate OD matrices is dependent on the network structure and zone definitions being such that a flow at a given point on the network can be definitively attributed to a particular origin or destination. The method requires the establishment of a fairly extensive number of survey stations, typically as a series of cordons and the achievement of a fairly high match rate. An example of a recent application of the technique is provided by Wooltorton et al (1989).

5.5 The requirement for a good match rate means that the use of video to collect the data, whether for manual or automatic processing, is particularly attractive and, when the equipment costs reach more reasonable levels, there is little doubt that this technique will become very important.

5.6 It is worth noting that the registration plate matching becomes more attractive if it can simultaneously be used to produce OD information and estimates of journey times.

5.7 Once an OD matrix has been estimated there are various statistical techniques which can be used to update them using information from strategically placed traffic counts. The ME2 method (Van Zuylen and Willumsen, 1980) is the best known but several others have since been developed (see for example, Fisk and Boyce, 1983; Cascetta and Nguyen, 1988; Oh, 1989). Such techniques could, in theory, be used to determine farily cheaply whether the matrix has changed by a given extent. It is not clear, however, that the information theory which underlies these models can cope with the kinds of situation which we are likely to meet - i.e. simultaneous changes in network structure and route choice as well as mode choice, increased trip frequency and redistribution. More work is urgently required to pursue these issues further.

6 INTERVIEWS AND QUESTIONNAIRES DESIGNED TO COLLECT TRAVEL DATA

6.1 Interviews and questionnaires may be conducted en route (at the roadside or while using public transport) or at trip ends (in the household or at some other location). We will consider each of these in turn.

6.2 Roadside interviews involve extracting a sample of vehicles from the stream of traffic and their drivers to answer a series of questions before rejoining the traffic. This is an attractive method of obtaining basic data about driver's journeys but it is quite expensive and can be very disruptive of traffic, even to the extent of influencing the route choice of drivers and thus distorting the very data of interest. Disruption is kept to a minimum by keeping the interview brief, having interview bays in a layby or other convenient location which does not take up road space, and being prepared to reduce the sampling rate if and when congestion begins to build-up.

6.3 The implications of these desiderata are that the interview can only normally contain four or five questions (typically including origin address, origin purpose, destination address and destination purpose) and that the choice of potential sites is very seriously limited. It is particularly difficult to find suitable sites in heavily congested urban areas (where, even if a layby did exist, it would be difficult to

sample traffic from an outside lane into it) on high speed roads without laybys, or on motorways (indeed the potential safety risk involved in conducting such exercises on motorways is such that, as we understand it, permission is never forthcoming).

6.4 Roadside interviews are, in practice, restricted to the hours of daylight (for practical, safety and perceived security reasons) and are not repeated regularly at the same site. Firstly, because drivers will come to expect them and may, therefore, re-route to avoid them and secondly because the public may object to being stopped repeatedly and this may lead to adverse publicity.

6.5 Although the interview itself must normally be kept short, there is no reason why the sample of people extracted from the traffic should not be invited to participate in some follow-up exercise such as a self-completion questionnaire, home interview or panel (see below).

6.6 Information as to the accuracy of roadside interviews is included in an advice note from the Department of Transport (1981).

6.7 Stopline surveys make use of the fact that, at traffic lights, vehicles are required to stop for a number of seconds and can be approached during that period. The stop period (typically under 60 seconds), is rarely long enough to ask more than one or two questions but can be quite long enough to ask the driver to accept a self-completion (post-back) questionnaire. Indeed, given that it is not possible in the UK, as it is in some other countries, for highway authorities to gain access to drivers' names and addresses via their car registration numbers, the stop line survey is often the most efficient way of targeting the questionnaires to a sample of users of particular parts of the network.

6.8 Compared to roadside interviews, line surveys are less disruptive of the traffic and much cheaper and simpler to mount. The main disadvantage is that there is insufficient time to ask many questions and that, unless there are only one or two questions to ask, a self-completion questionnaire will have to be used (for the disadvantages of which see below). Artificial extension the stop time to enable more questions to be asked might be considered but would not be wise if it caused severe traffic disruption - it might, of course, be possible to extend the cycle time and thus increase the stop time for one cohort of vehicles without altering the overall green time.

6.9 Not all traffic lights will be suitable for stop line surveys: there must be convenient refuges for the interviewers and care must be taken to ensure that traffic signal co-ordination does not result in the traffic that stops at the chosen lights being unrepresentative of the flow in which one is interested. In general, however, it is likely that in congested urban areas it will be easier to find sites for stop line surveys than for roadside interviews.

6.10 Interviews conducted on board trains or buses fulfil an equivalent purpose to the roadside interview or stop line survey in that they provide an opportunity to gather information (by direct interview or via distribution of self-completion questionnaires) about users of a particular route at a particular time. The standard procedure involves inspection of tickets and, asking about origin and destination (where these are not shown on the ticket). Questions about journey purpose and size of party are often also asked. Many public transport operators have this data collected routinely via roving enumerators equipped with appropriately programmed data loggers.

6.11 If more information is ought, a self-completion form is often distributed. On long distance journeys the forms can be collected back before the terminus is reached or a postal reply can be arranged.

6.12 In some instances, it may be more economic to conduct interviews or distribute self-completion questionnaires at boarding or alighting points, although the sample design will clearly be different.

6.13 The household interview is the obvious technique by which to collect data in respect of people who live in a given area. The interview can vary from a doorstep interview to obtain simple information (eg, on car ownership and household structure), combined perhaps with distribution of a self-completion questionnaire, to an in-depth discussion lasting an hour or more and involving several members of the household and, perhaps, the completion of travel diaries.

6.14 The exercise can be very expensive, particularly since the survey and sample design will normally require call-back visits to contact people who were not available on the first visit (if people who were absent during the first visit were ignored, the data set would obviously be biassed towards stay-at-homes).

6.15 The household interview is attractive, not only as a means of obtaining information about residents of an area but also as a suitable forum in which to seek information about the complex dynamics of individual behaviour.

6.16 The trip-end interview is roughly equivalent to the household interview, except that it will be based on a sample of people who visit a given location (eg, a work place, a shopping centre or a leisure facility) rather than who live there. As with the household interview, it can take a variety of forms but is typically restricted to the shorter, less complex exercises because the interviewees generally have less time available.

6.17 The sampling and respondent-contact strategies are simpler for trip end interviews than for household interviews. The cost per interview is therefore lower, although the precise cost will clearly depend on the length of the interview and whether or not it can be done there-and-then or whether the interviewee has to be enticed into a special interview room.

6.18 The use of self-completion, mail-back, questionnaires allows questionnaires to be handed out to a target population (eg, users of a particular road in the network or a particular public transport service), they are then completed by the respondent and posted back to the survey team (usually via Freepost). This technique can be used to gather a variety of information:- ranging from postcard surveys seeking only the origin, destination and purpose of the trip being made when the respondent was approached, through to trip diaries, attitudinal and stated preference questions (see below). Their main advantage, compared to face-to-face interviews is that they are less costly (particularly for the more complex questionnaires) but the main problem is the low, and possibly biassed, response rate. Another drawback is that the questions have to be kept simple and there is no possibility for interaction between the respondent and interviewer.

6.19 Response rates of 25% are not uncommon for self completion surveys and, although this can be raised to over 60% by offering incentives and a persuasive initial contact, the problem remains that the response may be biassed. Typically, the bias is towards people who feel that the questionnaire is relevant to them, eg, local people or regular travellers. It is clearly important to ask questions in the questionnaire which, when compared with what is known about the target

population, will enable the nature of the response bias to be quantified. If this cannot be done then the data source cannot be relied on.

6.20 Trip diaries are an established method of obtaining information about travel behaviour. The traditional household interview survey involves a one-day diary, while the National Travel Survey, and many panel surveys, involve one-week diaries. The reason for extending from one day to one week is to pick up within-week variation. It would, of course, be logical to extend beyond one week but this is not generally thought to be practicable.

6.21 A well known problem with multi-day diaries is that mid-period trips are under-reported (10% under-reporting in mid-period has been detected in some cases). The mid-period under-reporting is thought due to the fact that respondents tend to be keen at the beginning of the period and thus record all trips whereas later on they forget and have to fill in the diary from memory, and, since memory decays with time, the mid-period will suffer most from trips being forgotten.

6.22 One method of achieving good reporting rates is to ask respondents to record activities and locations rather than trips and then to deduce trips from changes in location. This method has been shown to increase the apparent number of trips by up to 15%.

6.23 Retrospective questions which invite the respondent to recall his travel behaviour, car ownership and so forth in some previous period can be included in self-completion questionnaires or interviews. The questions can either ask him for absolute values or for values relative to his current situation (eg, "I now make more trips between x and y than I did this time last year"). The potential application of such an approach in a monitoring study is obvious in that it avoids the 'before' study and thus saves resources and avoids abortive work in locations which, because of unexpected exogenous factors occuring at the same time as the scheme, would not warrant an after study.

6.24 Unfortunately, however, there are two major problems with the method. Firstly, there is evidence to suggest that peoples' recollection of previous behaviour cannot be relied on. There is, apparently, a tendency to forget the less frequent trips more quickly than the regular trips. Helpful prompting, by an interviewer, can improve the respondents' recall somewhat but, as of now, this phenomenon is not sufficiently well understood for reliable correction factors to be applied. Secondly, the method cannot detect people who have ceased to travel and have moved out of the catchment area of any household survey.

6.25 "Prospective" (stated intention) surveys involve asking respondents to predict their intended or expected travel behaviour at some future point of time with and without the new scheme. Unfortunately, previous experience with stated intention data suggests that the results are very subject to biases deliberate and otherwise.

6.26 If it were accurate (perhaps after application of suitable correction factors - the literature suggests factors ranging from 0.5 to 0.2), this information could reduce the need for more complex modelling procedures to predict scheme impact. However, given its likely unreliability, it clearly cannot serve as an alternative to before-and-after monitoring as a source of hard evidence on scheme impact.

6.27 Stated preference questions differ from stated intention questions in that, instead of asking respondents directly to predict their behavioural response to a real scheme, respondents' underlying preferences for a range of attributes are determined via a series of carefully designed trade-off exercises. The resulting preferences can

then be entered into a model which can use them to predict behaviour. The questions can be asked in the context of an entirely hypothetical scheme and thus need not be tied, in time or space, to any real scheme.

6.28 There is now a substantial body of evidence to suggest that the resulting predictions are fairly reliable in the context of mode choices, route choices, time of travel choices, and, perhaps, trip-end choices. It is less clear, however, that the technique could deal adequately with choices involving a change in trip frequency. (The problem being that the stated preference question relating to alternative frequency would be difficult to pose and more difficult still to answer).

6.29 The initial attraction of the stated preference technique, as with the stated intention technique, is that it might offer an alternative to before-and-after studies with consequential savings in cost, time and possibly abortive 'before' studies (where due to unforeseen circumstances it is not possible to conduct a useful 'after' study). Unfortunately, however, even if the trip-end and frequency dimensions could be dealt with, the technique does not provide the kind of 'hard' evidence that we perceive to be politically necessary.

6.30 A fuller discussion of the potential role of stated preference methods in studies of scheme impact is contained in a comparison report (Bates and Wardman, 1989).

6.31 Panel surveys involve going back to the same group of people on more than one occasion rather than taking separate samples each time. This avoids the costs of drawing a new sample and reduces variance due to sampling error. Panels have become a popular device for monitoring the evolution of behaviour and have been used on a number of monitoring exercises, notably in the context of public transport service or fares changes. Perhaps the best known panel is the Dutch Mobility panel which has been running for several years (see, for example, Golob et al, 1985). The success of a panel survey depends crucially on retaining the interest of panellists. This is achieved by very careful design, keeping the panellists informed about the progress of the survey, courteous treatment of panellists and, on occasions, financial incentives or rewards. Good practice is demonstrated in the Kontiv technique (see Brog et al, 1983).

6.32 Over and above the question of survey efficiency, panels allow for much more detailed investigation of individual behaviour permitting, for example, inertia effects to be studied in a way that would be quite impossible with repeated cross-section data.

6.33 Analysis of panel data allows and requires some quite different models. A particularly important distinction in the current context would be between changes in individual behaviour (which are picked up directly by the panel and which are obviously fundamental to any understanding of response) and changes in population behaviour (which is of greater significance for scheme appraisal and design).

6.34 Even the best run panels suffer from degradation either because some panellists drop-out (attrition), or, more fundamentally, because as the cohort of panellists ages, it ceases to be representative (for example, it will not contain the appropriate proportion of young people or newcomers to the area).

6.35 A particular problem in using panels to monitor scheme impact would be to determine the appropriate geographical sampling frame. The biggest problem would be how to include people who are attracted into the area to use the scheme but who previously had little or no contact with the area.

6.36 A fuller discussion of the potential role of panels in studies of scheme impact is included in a comparison report (Goodwin and Jones, 1989).

6.37 Indepth interviews can be designed to explore various aspects of respondent behaviour. In the present context there may be a particular role for questions which seek the respondents' views on why they make the trips they do. By this means it is possible to obtain a better understanding of the decision making process and to develop behavioural models. More directly it may be possible, in certain circumstances to ask whether any changes in trip patterns (origins, destination, timing, mode, frequency, route etc.) are due to the scheme, to specified land use developments or to other factors. Questions of this type were recently tested by ITS in the context of their study of the York Bypass and the Rochester Way Relief Road (see Wilcock, 1988). The results were quite promising and suggested that it is possible to include such questions in mail back questionnaires.

6.38 Particular care must be taken in the aggregation of data derived from retrospective or prospective questionnaires and interviews or from panels. This is because the variability in individual behaviour is greater than that of populations and a naive aggregation would therefore lead to an overestimate of responsiveness to changed network conditions.

7 OTHER SURVEYS

7.1 In addition to the surveys outlined above, there may be a role for special surveys to determine the response of freight and commercial vehicles and to examine possible land use impacts. We will deal with each of these in turn.

7.2 Freight and commercial vehicle movements can be picked up along with traffic in traffic counts, registration plate matching and, provided that the bays are appropriately dimensioned, in roadside interviews. If more information is required it is possible to arrange sample surveys of major fleet operators. Operators may sometimes agree to complete logs which monitor their operations, but it will often be necessary to rely on qualitative and anecdotal information. Statistical rigour is rarely achievable even with high sample rates. The purpose of the surveys is rather to help formulate hypotheses which can be tested with such objective data as is available.

7.3 Quantitative information about land use changes and development resides in the Planning Registers (in respect of applications for planning permission), and the Land Registry (for land values). Rather less formally it may be possible to obtain indications of trends in land values and rents from local estate agents. Even if such information is available, it would be desirable to obtain qualitative information from the local planning authority, local estate agents, developers and major land holders - particularly those who are considering, or have just completed, a change in location or scale of operations.

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