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URBAN ROADS APPRAISAL

Report to the:
Standing Advisory Committee on Trunk Road Assessment

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PART ONE

1.1 INTRODUCTION

This note is our response to SACTRA's invitation to submit suggestions for desirable and practicable improvements in methods for assessing options for the strategic improvement of urban roads. We understand that SACTRA's emphasis is on the economic and environmental appraisal of a range of options from traffic management to major road construction. Our note reflects this. It draws on our experience in research into a wide range of urban transport problems and solutions (Kirby, 1984), our recent review of procedures for policy formulation and appraisal in the provincial conurbations (May et al, 1984), our close working relationship with West Yorkshire MCC, and the local government experience of some of our members, particularly with the GLC.

This note serves to highlight some of our concerns about the appraisal process. Part one considers in turn:

- Necessary extension of the appraisal process.
- The style of the appraisal process.
- The need for consistency between the forecasting and evaluation procedures.
- The need for improvement in the analysis/forecasting techniques used in appraisal.
- The scope for technical discretion and its influence on results.

Part two gives more detail on some of the topics discussed in part one - references to it are embedded in the text of part one - but does not detail our specific proposals for dealing with the issues raised. Further information on our ideas on these topics could be provided on request.

A central concern, which lies behind many of our comments, is that the currently recommended procedures for appraising inter-urban road schemes would be quite inappropriate to urban road schemes. They are, we believe, surpassed by procedures currently in use in some of the larger local authorities let alone by the latest technical developments and research findings which have yet to become standard practice.

1.2 NECESSARY EXTENSION OF THE APPRAISAL PROCESS

1.2.1 Identification of problems.

The appraisal frameworks developed by ACTRA and SACTRA were designed to contribute to three important stages in the appraisal process:

* identification of design modifications and alternative options

* prediction of the full range of potentially important impacts and the provision of the necessary analytical tools for this process
* comparison of options based on the full range of relevant impacts.

There is however one important stage before these which it appears that present Department procedures do not address at all:

* the identification of problems to be tackled and the determination of priorities for doing so.

The Department's approach to trunk road appraisal through the application of formal procedures on a project by project basis implies either that a broad strategy exists to determine the nature of the individual projects to be appraised or that the strategy is no more than the selection of the best set of projects that have been submitted (often for reasons of historic or political inertia) into the selection process. This contrasts with the apparently more systematic way in which problem identification procedures have been used by some metropolitan authorities to set the bounds of the design and appraisal processes.

<u>We recommend that urgent consideration be given to the development of monitoring procedures which would ensure that scarce resources were being devoted first to the most serious problems</u>. Such a review should obviously draw on the experience with procedures developed by local authorities.

1.2.2 Consideration of a wider range of impacts.

When compared with rural areas, urban areas are characterised by a greater complexity of issues and of interaction between different elements of the transport system and between the transport and non-transport systems. We believe that the techniques and procedures currently advocated for the appraisal of major inter-urban schemes fail to recognise many of these issues and interactions.

We would highlight the need to deal more explicitly with the impact that schemes might have on specific groups of users and non-users of the transport system; cyclists, pedestrians, public transport users, residents and traders being prime examples. It is also crucial to estimate and appraise the impact of schemes on other agencies in the transport system - most particularly public transport operators and the enforcement authorities. Proper assessment of these various impacts would clearly require the development of more detailed forecasting/analysis tools than are currently in use (though relatively minor enhancement of existing techniques is possible in some cases) and the use of more sophisticated multi-criteria assessment techniques.

The MEA approaches this issue by identifying 5 impacted groups and for the first three it provides tables which serve as a checklist of impacts that should be included in an appraisal. Our belief that these checklists are incomplete is perhaps best illustrated in our tables 1 2 and 3, which are based on those in MEA but with our suggested additional items shaded in. We recommend that the MEA tables 1-3 be expanded for urban appraisal to include the items shaded in the attached versions.

Several of the items which we have added into the original MEA tables are considered in greater detail in part two of this document. Thus impacts on public transport operators and passengers are discussed in section 2.3, impacts on pedestrians and cyclists are discussed in Section 2.4 and environmental impacts in Section 2.5. The importance of variability in travel time is discussed in section 2.6, parking and access time are dealt with in section 2.7, and development effects are considered in section 2.10. The impacts of policy on enforcement agencies are included in section 2.8.

1.2.3 Treatment of development and land use effects.

Development and land use effects are not included in the formal appraisal of inter-urban schemes and ACTRA clearly envisage their also being excluded from the appraisal of urban road schemes. We are concerned firstly that there is evidence of development and land use effects and secondly that currently recommended procedures are theoretically flawed when linked with the fixed trip matrix assumption (see Sections 2.9 and 2.10). We recommend that further attention be paid to this contentious issue.

1.3 THE STYLE OF THE APPRAISAL PROCESS

There are a number of aspects of current inter-urban procedures where we would suggest improvements irrespective of whether the appraisal is of an urban or inter-urban scheme. We have aleady discussed the need for extension of the appraisal process to include problem identification and scheme selection. We would add to this list the treatment of uncertainty and multi-criteria assessment:

We do not regard the current method of dealing with uncertainty (the high growth/low growth technique) as adequate. We would advocate the use of an approach which appraises option against a small number of plausible, qualitatively distinct scenarios, which embrace a range of possible future patterns of development. Choice between options based on the cost of being "wrong" and/or robustness of performance against all scenarios appears more appropriate attractive than the conventional (expected value) criterion used in isolation (see Section 2.2).

We believe that a multi-criteria basis for evaluation, similar to that recommended by the Leitch Committee for trunk road appraisal, is essential for urban roads appraisal. But, as we have argued earlier, it would be necessary to broaden the range of impacts explicitly recognised. It is also necessary to explore the development of more effective means of applying and experimenting with different sets of weights for the various elements of the matrix. This development might well make use of the latest software from the field of expert systems (see Section 2.1).

1.4 THE NEED FOR CONSISTENCY BETWEEN THE FORECASTING AND EVALUATION PROCEDURES

We are concerned that the inconsistencies between the assumptions and procedures used in traffic models and in the Department's present methods of estimating economic benefits may bias the appraisal process. The main issues are as follows:

i) COBA advice is heavily rated towards adopting the "fixed matrix" assumption, in which a scheme assumes to have no affect on origin/destination patterns. Such advice is particularly suspect in urban areas, where changes in both modal split and trip distribution can occur as a result of the schemes, as well as longer term changes in location/land use. The Department's advice for "variable matrices" is inadequate for this situation (see Sections 2.9, 2.10). Notwithstanding inadequacies in transport models (see Sections 1.5, 2.12), results are likely to be less biased if mode change/redistribution affects are modelled than if they are ignored.

ii) Presuming that the fixed matrix assumption is replaced, and that a user benefit measure (such as consumers' surplus) is to be used, it is important that the benefit measure be consistent with the traffic models used (see Section 2.12).

iii) There are major differences in the level of detail at which flows and travel times are modelled and between the traffic model and COBA. Details are given in Section 2.11. The main point to emerge is that, for the appraisal of alternative schemes, it is more appropriate to have one process aimed at getting the product of flows x travel time about right than it is to have two processes aimed at getting flows and travel times separately about right.

The recommendations that follow from the above are:

(a) that mode split and redistribution affects be modelled (in a consistent way)

(b) that consumer surplus measures consistent with these be used

(c) that an integrated modelling approach (aimed at getting the product of flow x travel time about right) be evolved.

1.5 THE NEED FOR IMPROVEMENT IN THE FORECASTING/ANALYSIS TECHNIQUES USED IN APPRAISAL

We are concerned that some of the techniques currently in use do not reflect an adequate understanding of user response. We believe that currently used techniques would be severely stretched when applied to schemes in urban areas because of the wide range of response options available to urban travellers. Some more suitable techniques already exist while others are still in need of development. We would highlight the following problems:

i) conventional link based assignment techniques combined with area or link specific speed flow relationships do not provide an adequate representation of urban traffic conditions particularly given the increasing use of sophisticated signalised junction control. More advanced techniques such as SATURN, and CONTRAM are already available and ought to be the norm for detailed urban road appraisal. Their use at a more strategic level merits further investigation (see Sections 2.14 and 2.15).

ii) on a related point we are concerned that the practice of using coarse or skeletal networks will obscure the effect that schemes might have on the alleviation (or causation) of rat running.

It is desirable to assess the extent to which strategic-level appraisals might understate potentially important effects like this that would be identified in more detailed appraisals.

iii) conventional techniques do not have a good representation of the dimensions of user response to changes in the urban network. Examples include changes in the time of travel and the destination of trips (particularly non-work trips). We suggest that there is sufficient evidence of the importance of these effects to warrant their urgent investigation and the development of techniques to replicate them (see Sections 2.7, and 2.13).

iv) conventional techniques do not give a good representation of user response to such aspects as uncertainty/variability in travel time and access costs particularly parking search costs). Again we suggest that there is already sufficient evidence of the importance of these influences on traveller behaviour to warrant their urgent further investigation and the development of techniques to represent them (see Sections 2.6 and 2.7).

v) conventional techniques pay no regard to the effects of transport investment on trip rates, land use or development. We suggest that the use of model based techniques (e.g. land use-transport interaction models) be considered in this area. We do recognise that they might require further development before being used in this context.

1.6 SCOPE FOR TECHNICAL DISCRETION - ITS INFLUENCE ON RESULTS

Guidance on the appraisal of urban road schemes, as currently set out in TAM, MEA and the COBA9 manual, emphasises the desirability of matching the scale and comprehensiveness of the appraisal to the specific circumstances of the schemes to be appraised.
There seems to be considerable discretion as to the circumstances in which particular techniques are to be used or in which particular effects are to be investigated. Examples of this discretion include: the size of area over which reassignment should be considered, the treatment of possible changes in the mode, distribution or number of trips and the separate treatment of peak and off-peak conditions. The documents also suggest that more complex effects such as variability in journey timing may be significant in certain circumstances but do not give guidance on what these circumstances are or how the effects might be represented.

We are concerned that the decision as to whether to represent these and other effects and if so by what method may have a determining influence on the results of the appraisal. Not only may the predicted benefits change in absolute terms (perhaps causing critical thresholds to be passed) but, perhaps more significantly, the relative benefits of competing schemes may be altered.

We suggest that the Department ought to provide clearer advice on the circumstances in which a particular procedure would be appropriate and in which it would be potentially misleading. A code of practice could be developed quite rapidly by drawing on the accumulated experience of local authorities, consultants and academics but we recommend that advice be based on the results of a model based analysis of the infuence that the inclusion/exclusion of potentially important effects has on the appraisal of typical schemes (see Section 2.16).

In providing this advice particular regard should be paid to consistency in respect of :

1) treatment of different kinds of schemes
2) forecastings and evaluation procedures (see sections 2.11 and 2.12).

1.7 CONCLUDING COMMENTS

We are convinced that the techniques currently advocated by the Department for the appraisal of inter-urban trunk roads would be quite inappropriate for the assessment of schemes in urban areas. If the starting point of SACTRA's deliberations were to be the COBA/TAM/MEA system we would suggest that several changes are desirable, some are procedural others technical. Some could be introduced immediately while others call for more extensive research.

PART TWO

FURTHER DETAILS ON SOME ISSUES RAISED IN PART ONE

C O N T E N T S

2.1 MULTI-CRITERIA DECISION MAKING

Project Evaluation and Choice Decisions on urban road projects cannot be based on COBA alone. As the Leitch Committee argued for trunk roads, elements of benefit and cost which cannot be evaluated in monetary terms must be considered alongside those which can, for example, in some sort of framework. An appraisal methodology founded on COBA costs and benefits and without adequate treatment of environmental and social consequences will no longer stand up to public scrutiny. This is particularly true in the urban context because such issues are relatively more important and complex.

Local Government Re-organisation We believe that an approach analogous to be Leitch framework is required for urban road appraisal. The need for this has been made more urgent by the prospective changes in local government in the Metropolitan areas. Under the present arrangements, Metropolitan Counties act as a filter, ranking their own projects in some order of merit, according to their own criteria. While creating problems of comparability between authorities, this does at least ensure that priorities are assessed somewhere in the process. Under the new regime, the 36-metropolitan districts will be operating much more as promoters of schemes. Given the current level of resources, they will all wish to promote their favoured schemes so that the Department will be faced with a pressing need for a ranking device. We believe that some form of framework approach will inevitably be required if the process is to command respect and assent from officers and politicians alike.

Research and Development An ESRC - financed research project, "Priority Assessment Techniques for Local Transport Improvement Projects" is scheduled to commence in the Institute for Transport Studies in July 1985. It will be concerned to evaluate and improve upon existing practice as implemented by local authorities in the U.K. The Leitch Committee, in the context of inter-urban roads, has (rightly) rejected existing multi-criteria methods which might be used formally to decide which of a series of options to implement. This is not, however, a reason for rejecting the multi-criteria approach altogether. Recent research (notably in regional planning) has concentrated on the presentation of information about projects with multiple impacts. This can involve graphics, computer systems for the rapid re-organisation of information to present it from alternative viewpoints, etc. There is important work to be undertaken with an emphasis on modern computational technology, providing something which is akin to a management information system. The emphasis should be shifted away from black-box decision rules, towards using multi-criteria thinking to present difficult data sets in as comprehensible way as possible.

2.2 THE INFLUENCE OF UNCERTAINTY ON PROJECT DESIGN, EVALUATION AND CHOICE

Current Position Neither COBA, nor as far as can be ascertained any locally implemented appraisal procedures, satisfactorily deal with the implications of uncertainty for project design, evaluation and choice in the context of urban roads appraisal. There is a general recognition among transport planners of the importance of uncertainty, but the absence of a fully developed and tested methodology for handling the uncertainties encountered in the circumstances of typical road appraisal exercises has militated against endeavours to modify the essentially deterministic *status quo*. The correct position should be viewed against a background of growing Treasury interest in uncertainty and investment appraisal, and significant steps forward in parts of the public sector, notably electricity supply.

The Problem Allowing for uncertainty will make the evaluation and choice process a more time-consuming one, and possibly more complex. Superficially, it may appear also that it will make decision-making less clear-cut and hence might be administratively undesirable. This is probably *not* the case, in that attempts to impose solutions based on a *single* view of the future are likely to attract considerable criticism in public debate. It is arguably more effective (as well as more honest) to be open about the uncertainties which exist, and to develop an evaluation procedure which permits them to be thoroughly explored in an analytical way, rather than let them emerge as debating points.

The urban context emphasises uncertainties over and above those usually encountered in an inter-urban appraisal. Essentially these stem from the much finer level of aggregation at which appraisal must take place. Much greater uncertainty exists about items such as route choice, journey times, traffic growth, local development effects, etc. There is also a wider range of possible actions - traffic management, local improvements and major improvements - with markedly different characteristics in terms of their response to uncertainty, notably in terms of the opportunity costs of incorrect final decisions.

Existing Approaches The COBA approach of simply evaluating against high and low traffic growth projections seems quite inappropriate to the circumstances of urban appraisal. So, too, because of the complex interdependencies which exist, is any type of one-variable-at-a-time sensitivity testing. The systematic sensitivity testing procedure developed for DTp by MVA (but not implemented) allows for interactions between variables, but at a cost of some quite severe assumptions about the nature of the interactions. Moreover it is probably true that the exploration of deviations from a central trend is not the most effective means to uncover the truly important, policy-influencing uncertainties which exist in urban road appraisals. It may be more important to look *at* a series of qualitatively distinct, plausible "scenarios" which embrace a range of possible patterns of future development, to evaluate proposals against each scenario, and to choose between alternatives on the basis of the cost of being wrong or the robustness of their performance against this range of possible futures, as much as on traditional economic expected return criteria.

Suggested Course of Action A series of case studies of UK urban roads appraisals should be undertaken, emphasising: the identification and characterisation in practice of the range of uncertainty faced; implications for data collection and traffic modelling procedures; effective means of presentation to interested parties; guidelines for project choice; and, the potential importance of future uncertainty for initial project design.

2.3 TREATMENT OF PUBLIC TRANSPORT

Current practice

Within the Leitch framework, there are two elements which relate directly to public transport operators and users:

- o under road users directly affected, time and operating cost savings to bus operators and users are evaluated
- o under other transport operators and users, effects on rail, air and waterways are described.

In general, in its application to inter-urban schemes, the Department has considered that changes in mode-split, with their consequent implications for public transport fares and service levels, would be too small to warrant explicit consideration, although on a number of occasions (for instance at the M40 enquiry) this view has been challenged. Similarly, public transport alternatives to the road scheme under consideration have not been evauated by the Department.

Problems in urban areas

When appraising strategic options in urban areas, it is clear that public transport considerations must be dealt with much more fully. This is because:

- o public transport still plays a very important (in the case of London, dominant) role, particularly in peak-hours on corridors to the city centre
- o recent experience of public transport fares policies in London and of investment in public transport (e.g. Liverpool, Birmingham) confirms that such strategies can have a significant effect on mode-split and need to be tested against strategies which concentrate on road-building
- o where new road capacity is created in heavily congested conditions it is likely to result in significant diversions of traffic between modes. In particular, surveys suggest that generally 30-50% of rail commuters have a car available for the trip in question, whilst - particularly post-deregulation - diversion to express bus services may also be substantial.

Necessary Developments

In applying the Leitch framework to urban road appraisals, therefore, it will clearly be necessary to have:

- o a traffic model which adequately captures changes in mode
- o a public transport supply model which incorporates reactions

of public transport operators to changes in traffic and revenue, both in the context of planned response of monopoly operators and of market equilibrium in cases of competitive supply. If this response involves changes in fares and service levels or availability, interaction with the traffic model is necessary to establish the final equilibrium

- an evaluation framework which incorporates net changes in public transport operators' profits or subsidies, and in public transport users' benefits (as a result of fares and service level changes) in the new situation.

2.4 IMPACTS ON PEDESTRIANS AND CYCLISTS

Background: Road traffic conditions experienced by pedestrians (and probably cyclists) are rated highly as problems more so than nuisance reported in the home (Morton-Williams et al, 1978). Urban road design and appraisal gives less emphasis to pedestrians and cyclists than to other groups. Consequently new schemes may have a greater impact on pedestrians and cyclists than is revealed by conventional analysis.

The issue: New roads may create a physical or psychological barrier to walk or cycle trips and resultant traffic changes might cause sufficient changes in environmental conditions to distort travel behaviour or increase anxieties and frustrations on trips still made. Available evidence does not allow us to forecast how pedestrian/cyclist journey behaviour or reported annoyance might change with changes in environmental conditions. The most comprehensive study of pedestrian nuisance/annoyance and delay considered only reaction to existing conditions (Crompton et al, 1978). Cumulative problems experienced on a journey and possible synergism between effects have not been evaluated in any studies found. These effects are likely to evoke different response than replies to instantaneous events.

Problem identification: Current techniques for evaluating effects on pedestrians and cyclists, based on journey time and amenity changes, as recommended in MEA, are unlikely to be able to identify supressed journeys (latent demand). Surveys and statistical analysis of factors (such as journey categories, individual characteristics and environmental factors) accounted for variations in the propensity to walk or cycle are required to pin-point and place priority on problems encountered on journeys (Waldman, 1977).

Measurement and evaluation: The criteria used in MEA for evaluating the significance of changes in journey time and amenity are not empirically validated, do not discriminate between the important sub groups (in particular the elderly, young and infirm) and fail to address the wide range of problems identified in (Morton-Williams et al, 1978). A finer graded set of evaluation criteria is required.

To overcome these deficiencies, we see the need to measure attitudinal and behavioural response for different groups of individuals experiencing different levels of the same environmental factors.

2.5 ENVIRONMENTAL APPRAISAL

The issue: Environmental appraisal of urban trunk road schemes is likely to become more important for two reasons:

i) Capital schemes are more likely to fail to meet economic criteria but at the same time could achieve greater net environmental gains; hence it will be the more important to determine the balance between economics and environmental.

ii) Environmental disruption and conflict between different groups will be more pronounced in urban areas than inter-urban areas.

In both instances environmental appraisal will be required to stand up to close public and political scrutiny.

Problem identification: It is clear from the 1972 National Environment Survey that, whatever the physical or physiological effects, psychologically danger, difficulty crossing the street and fumes are of as much concern to the pedestrian as noise, while noise is 'clearly the main cause' of concern for building occupants. Since, arguably, more pedestrians than residents are exposed to traffic in urban areas, it is important that the assessment be extended to cover these effects. We are currently carrying out a short review for TRRL of pedestrians' perception of amenity as an input to this process.

Forecasting, anlaysis and data handling: One of the major problems with urban environmental analysis is that the problems arise on roads whose flows are rarely adequately modelled. This strengthens the case for more detailed models of the SATURN/CONTRAM type, and we are currently investigating the extension of these to provide predictions of pollution levels. A second problem is the scale of the data to be handled, bearing in mind the numbers of locations, properties and people affected. Neither of the two comprehensive environmental evaluation tools of which we are aware (developed by GLC and WYMCC) overcomes the data handling problem, and both make arbitrary vaue judgements to simplify the presentation. This is an area which requires urgent study if manageable, comprehensible and objective assessment methods are to be developed.

Evaluation: On a related point, more information is needed on the ways in which the information in environmental appraisal is used by decision makers. In particular there is a need for a post-audit of evaluation frameworks using Leitch/MEA guidance to establish:

o the implicit valuation (if any) placed on individual environmental factors

o the environmental factors identified as important and how these are treated in the design procedure

- the consistency in the treatment of groups/impacts in different contexts

- the relative emphasis given by decision makers to numerical and descriptive information. This relates to our comments elsewhere on multicriteria appraisal.

2.6 VARIABILITY OF TRAVEL TIME

Problem identification

Variability is rarely measured, but such surveys as have measured it have indicated its importance in urban areas. For example:

- o unreliability is generally accepted as the source of greatest passenger complaint with urban bus services
- o our study of the transport problems of inner city firms (May and Patterson, 1984) found that about half inner London employees experienced over 10 minutes' variation in journey times by public and private transport, and that employers lost about one hour per employee per month as a result
- o our study of urban congestion on radial roads in Leeds (May and Montgomery, 1984) found ranges in in-vehicle travel times at the height of the peak which were greater than the difference between the best peak travel time and off peak conditions, suggesting that benefits from reducing varability could equal those from improving average peak travel times
- o a related MSc dissertation (Foster, 1982) found that almost half of those working fixed hours who used public transport had to allow an extra 10 minutes or more for variability

Our urban congestion study (May and Montgomery, 1984) has developed statistical guidelines for surveys to measure both the mean and distribution of travel times on radial roads. They need to be tested elsewhere and extended to cover travel time surveys on city centre road networks.

Impact groups

It is clear from our work that travel time variability is of importance to both private and public transport users; hence their inclusion in Table 1.

Forecasting, analysis, and evaluation

Because variability has rarely been measured, little is known about its detailed causes, effects on user behaviour or costs to the user. In particular we see the need for

- o before/after studies which incorporate travel time variability measures
- o the incorporation of variability estimates in traffic management models
- o surveys of the response, particularly of employees on fixed and flexible work hours, to variability, to include the impact on choice of mode, route and time of travel

- the application of utility analysis as a basis for evaluating the costs of variability

Despite already having a PhD student working on these issues, we see this as an extremely important area for yet further research and one which is likely to identify substantial hidden benefits from urban road improvement.

2.7 PARKING AND ACCESS COSTS

Problem identification

Time spent reaching one's destination having travelled to the vicinity is rarely adequately estimated in existing transport modes. Yet it is a cost which can be significantly affected by parking controls and by traffic management schemes which ban frontage parking (e.g bus lanes) or impose tortuous routes (e.g. banned turns). Several recent ITS studies have demonstrated that it is a source of considerable annoyance. Our recent work on parking enforcement in Central London (May and Turvey, 1984) has indicated that the costs can be substantial. For example in Mayfair, where meter occupancy reaches a peak of 98%, the average time, after reaching the destination, to find a vacant meter, walk to one's destination and wak back exceeds 20 minutes. This represents an area for substantial cost saving: it also provides a major incentive to illegal parking, which in turn reduces the benefit of traffic management schemes.

The two survey methods developed for the ITS parking enforcement study provide possible means of measuring access time costs and the proportion of users who are incurring them. They need further development and testing. There is also a need to refine existing interview survey techniques designed to identify frontages' and suppliers' perceptions of these costs an their reactions to them.

Impact groups

The direct costs clearly arise particularly for private transport users, and are included as such in Table 1. However, they can in turn give the rise to indirect costs to frontagers in the form of loss of trade, changes in working hours and increased operating costs. We suggest identifying these effects under Table 2.

Forecasting, analysis and evaluation

We see the need particularly for

- o design tools which identify the effects of traffic and parking management measures on these costs.
- o a better understanding of users' response to such costs in terms of changes in mode, time of travel or destination.
- o more detailed measurement of the indirect effects on frontages.

Our current contributions in this area inclue a parking model which includes representation of the effect of access costs on choice of parking location, mode and journey timing (Bonsall, Gunn and Williams, 1982; Heydecker, 1985), a study of ways to measure the effects of parking costs on destination choice (May and Bonsall, 1983) and a technique for measuring the affect of traffic management on trade.(Weaver, 1984).

2.8 ENFORCEMENT

Problem identification

The level of non-compliance with traffic and parking management regulations is fairly well known, but recent data for parking in London indicate that the extent can be dramatic: between 0.3m and 0.5m parking offences in central London per day, with 40% of meter parkers and 80% of yellow line parkers committing offences. The effects are less well understood, but the same study suggested that speeds fall by 0.1 km/h for every car parked illegally per km.

Forecasting, analysis and evaluation

To aid the design of urban traffic management schemes of all kinds, a clearer understanding is needed of the level of non-compliance expected, the costs of that level (in terms of congestion, accidents and access problems) and ways of increasing compliance. To this end we see the need for

- more studies of non-compliance levels and their resultant costs.
- more experimentation with different enforcement levels and methods.
- a clearer understanding of drivers' perception of the risks and costs associated with non-compliance and with different types of enforcement action.

A recent ITS MSc study (Mendelsohn, 1984) has piloted a survey method which could contribute usefully to the last of these areas.

It will be important to ensure that future coverage of enforcement issues is treated in full social cost-benefit terms, rather than simply as a financial matter of costs and revenues to the police.

2.9 THE NEED FOR CHANGING THE FIXED TRIP MATRIX ASSUMPTION (1) DISTRIBUTION AND MODE SPLIT EFFECTS

The employment of fixed passenger and commercial vehicle trip matrices for appraising transportation schemes has long been a contentious issue, although it is generally recognised that alternatives would involve a considerable increase in computational complexity, and the justification for so doing is uncertain. There is thus a need for considering that justification further in conjunction with appropriate forecasting models, and ensuring that the evaluation framework (and in particular the computation of user benefits) is consistent with the demand response predicted by models which relax the fixed trip matrix assumption. Two issues are of interest: the effect of matrix changes on the trip costs themselves computed through the supply functions; and the contribution to consumer surplus changes associated with mode and location switching and with trip generation/suppression effects.

The first issue is readily dealt with by exploiting recent results on transport equilibrium methods and employing standard evaluation procedures set out in COBA 9 (Section 1.7).

The significance of the second issue is more directly related to the form of the demand function chosen. The problem of redistribution is in fact mentioned in TAM (and COBA 9) where it is proposed that

> "... in the few trunk road cases where a significant redistribution of trips change in modal split or generation is expected when the proposed scheme is built, a variable trp matrix traffic and economic evaluation model should be used. Possible candidates include ... major schemes in congested conurbations ..."

It is further remarked in the manual

> "Past evidence suggests that benefits attributable to redistribution are unlikely to add to the benefits derived from a fixed trip matrix evauation by more than about 10% in most cases."
>
> (para 14.3 Traffic Appraisal Manual DTp, 1981)

Research in an urban context (Senior and Williams, 1977) has shown that for typical highway investment schemes in urban areas, the contribution of redistribution effects derived from models, to the total benefit of a scheme is indeed of the order of 10%, but that it may be considerably higher for localized restraint policies, the range depending on the nature and extent of the restraint scheme imposed and the detailed model form used to assess response. In addition, the local effects of all schemes may well produce contributions much greater than 10%. Whether any bias exists in the comparison between schemes will of course depend on the nature of the schemes themselves and of the evaluation indicators, but these restraint policies are considered in conjunction with infrastructure development, the assumption of a fixed trip matrix does give some cause for concern.

2.10 THE NEED FOR CHANGING THE FIXED TRIP MATRIX ASSUMPTION (2) LAND USE AND DEVELOPMENT EFFECTS

The Issue It is standard practice to ignore land use and development effects in the formal appraisal of road schemes. This reflects the methodological problems involved in doing otherwise and the lack of consensus as to whether any such effects are other than marginal and whether, if they are substantial, they are properly associated with the road scheme or with the planning policies that accompany it.

In the context of individual road project appraisal the issue reduces to that of whether the measurement of the vehicular road user benefits is a satisfactory proxy for the total economic benefit of the project. For that to be the case it is necessary to be satisfied *either* that the measured user benefit is a close approximation to the total economic benefit *or* that the divergence between the two is of a consistent order and that any variation in the ratio between them is small and unbiassed.

Theoretical demonstration of the nature of the conditions which would need to hold for there to be a national income increment substantially in excess of the *ex post* observed user benefit has suggested that the first of these conditions holds in the case of inter-urban roads in developed countries. (Gwilliam, 1970) That theoretical argument has also been supported by the empirical evidence that for most commodities transport costs represent a small proportion of total delivered costs and hence the effect of road transport cost reductions on the location and activity decisions of firms are likely to be equally small. The Leitch Committee accepted this line of argument and did not recommend that any specific modification should be introduced within COBA to allow for development effects. It is important to note, however, that the theoretical argument takes as its basis the *ex post* observed traffic levels. It is thus assumed that the traffic effects are accurately forecast. Such an assumption would appear *prima facie* to be inconsistent with the "fixed matrix" characteristic of COBA, which only provides for re-assignment of traffic within the designated corridors. The M.62 study showed that for a major motorway investment the majority of the apparent trip generation could be explained in terms of reassignment. But it did also show that there was a residue which could not be so explained, and in any case the corridor over which reassignment took place was much wider than that normally adopted in inter-urban road appraisal (Judge and Gwilliam, 1976).

The implications of this for the use of COBA for urban roads could be very extensive. In a context in which system interactions are widely regarded as being not insignificant, and in exactly the circumstances of micro-location where the evidence suggests that variation of transport costs might be most telling in determining activity locations, the validity of the fixed matrix assumption is most suspect.

We have suggested in Sections 1.6 and 2.16 that the fixed trip matrix assumption should be subject to tests in which the results of an appraisal of a typical urban scheme are tested for robustness.

2.11 CONSISTENCY BETWEEN FORECASTING AND EVALUATION METHODS: (1) JOURNEY-TIME AND FLOW ESTIMATION

The Issue. The net monetary value for journey-time savings is a major component of the Department's methods of appraising road schemes. The Department'measure for this is Net Present Value, and the tool that the Department uses for calculating it is COBA9. This takes as its input the output of a traffic model. The separation of the traffic modelling component from the evaluation component of traffic appraisal is an inherent weakness of present DTp methodology, and leads to inconsistencies in procedure and assumptions that are serious for urban applications.

Problem Specification. A major shortcoming is the inconsistent treatment of speeds and flows as between the traffic model and COBA. This arises as follows. COBA calculates travel-times in a much more detailed way than is usually used in the traffic model. And the traffic model calculates flows in a much more detailed way than is used in COBA. Particular features reflecting this are as follows.

(i) Disaggregation of flows by trip purpose, vehicle type, time of day are, in COBA, based on overall (perhaps national) average proportions; more detailed local values estimated in the traffic model are ignored.

(ii) Specifications differ. For example, traffic models are usually developed for a 12 or 16-hour day, yet COBA requires a 24-hour day estimate; COBA may use a network that is different from that in the traffic model; and does use speed and delay assumptions that may be markedly different from those used in the traffic model, particularly at junctions.

Some Questions. The above raises the following questions.

(A) What level of detail/disaggregation is strictly necessary for (a) flow estimates (b) travel-time estimates for the evaluation of costs and benefits for road schemes? What difference does it make to the NPV calculation if diasaggregated flows derived from the traffic model are used instead of COBA-based diasaggregation? What difference does it make to flow estimates if the travel-time assumptions in COBA are used in the traffic model? (Or vice-versa where the latter's specification is better.)

Such a question implies some sensitivity analyses would be useful; this is discussed further in Section 2.16. But more fundamental is the need to question the forecasting/evaluation process as a whole; we would suggest that:

(B) The basic problem is that the traffic model is trying to get the flows about right; the COBA model is trying to get the travel time about right; whereas what is needed for evaluation is to get the product, flow x times (ie travel) about right. It is recommended that such an approach be investigated.

2.12 CONSISTENCY BETWEEN FORECASTING AND EVALUATION METHODS: (2) TRIP DISTRIBUTION AND BENEFIT MEASURES

In the relaxation of the fixed trip matrix assumption there is a need to reconsider the formulation of passenger and commercial vehicle demand models to ensure that the elasticities implicit in calibrated forms are consistent with those derived from other sources. If resort is taken to traditional urban travel demand models, there is serious concern that the measures of response and user benefit will be subject to large errors. Indeed in some cases it has been shown that trip response will be totally unacceptable (Williams and Senior, 1977; Hawkins, 1978).

We believe that there is a need to establish a consistent and generally applicable methodology for relating consumer surplus changes to suitably specified demand functions. In this process it will be necessary to go beyond the 'Variable Trip Matrix Economic Methodology' described in COBA 9 (Section 1.7), and adopt an economic framework which decomposes travel response benefits into components related to changes in accessibility and changes in rent, so that the spatial distributional effects will be fully exposed in the appraisal process (Williams and Senior, 1978). The numerical significance of a divergence from a fixed trip matrix assumption are then made <u>explicit at a disaggregate level</u>.

A further advantage of relaxing the fixed matrix assumption is that it would enable one to drop the simplistic COBA assumption that the year-by-year growth of traffic takes place at the same rate at all links and junctions (over the 30-year life-span of a scheme). Such an approach may be quite adequate for a limitd number of links, but is very questionable when applied to larger areas with hundreds of links, especially for urban areas where congestion and other constraints will severely limit such growth. Given a future year flow and the base-year flow, a simple remedy would be to interpolate between them for intermediate years, giving in effect an individual growth rate for each link and junction. But it would not be necessary to calculate and use these growth rates explicitly; a formula can be used to give the discounted net benefits in the base year solely in terms of the base-year and future-year benefit levels, presuming an even growth for that link between the two years.

2.13 CHOICE OF JOURNEY TIMING

The issue

It is well known that one response to peak period urban road congestion is for users to alter the time at which they make journeys. The extension of Londons' peak period from a 'rush hour' to the present situation of almost unrelieved congestion through the working day is evidence of this. The increasing adoption of flexible working hours is part of this trend. Against this background it is likely that a network improvement which relieves peak period congestion will attract some travellers to the peak period who had previously been dissuaded from travelling at that time.

This dimension of response is not normally included in the appraisal process or even in the models that feed into it. Indeed it is not unknown for appraisals to pay no regard to the difference between peak and off-peak conditions. Failure to treat peak and off-peak conditions separately will tend to underplay the benefits of schemes whose main purpose is to relieve peak period congestion. Failure to represent the possibility of users changing the time at which they travel will tend to work in the same direction (although it is not bound so to do).

Approaches to a solution

There is an increasing body of evidence as to the extent to which travellers will change their time of travel, much of it relating to response to traffic management measures or parking shortage (e.g. the Singapore peak period supplementary licence scheme, our own work on flexitime - Montgomery and May 1983; and on car pooling - Bonsall, 1980). There have also been a number of approaches to the treatment of this dimension of response varying from the qualitative (HATS approach - Jones, 1982) to the quantitative (Small, 1982; Bonsall, Gunn and Williams, 1982), and the use of stated intentions to calibrate response models (e.g. our own work on modelling car sharing and parking behaviour on MVA's model of user response to road pricing in Hong Kong).

We believe that this work should be pursued so as to produce reliable methods of representing this dimension of user response. We suggest that this should be done along with a renewed study of the appropriate valuation of small time savings and a consideration of the value to be put on 'dead' time since both of these issues are intimately tied up with the temporal dimension of travellers' response to changes in system conditions.

2.14 ROUTE CHOICE MODELLING

We strongly support the recent trends towards the use of "micro assignment" models in urban areas with their greater emphasis on delays at intersections as opposed to the "conventional" link-based assignment models. We refer to both purpose-built models such as SATURN and CONTRAM as well as models such as TRIPS, JAM and HINET which have, essentially, extended the range of applicability of existing program suites.

However we see a number of aspects of route choice in congested arrays which are not adequately represented and whre we feel improvements could be made. In particular we would mention:

- o Day-to-day variations in both demand (variations in the trip matrix) and supply (e.g. changes in junction capacities due to rain or darkness) are inadequately catered for. It is common practice to test an "average" matrix on an "average" day and to ignore what may happen on "bad" days.

- o The interaction between route choice and signal settings policy is treated, if at all, on a fairly crude level.

- o The use of network graphics to display and to analyse output is less common than it ought to be - the inch-thick wadge of line printer output is still very much the norm. We feel the major problem lies with the "users" who generally are unaware of the capabilities of computer graphics despite the fact that there is good software available. We would like to encourage the DTp to take more of a lead in encouraging the use of graphics.

- o There has been a recent surge in theoretical work on capacity-restrained traffic assignment, in particular for "asymmetric" networks (where the cost of travel on a link can depend on the flows on other links, not just its own flow). Unfortunately very few of these new ideas have been incorporated into existing program suites. We feel that there is scope for developing models of complex networks with more reliable theoretical underpinnings.

- o Equally there has been a large amount of empirical work devoted to identifying those factors which explain observed route choice but relatively few of these factors tend to be included in assignment programs. For example no operational programs consider the effects of sign posts on route choice.

2.15 SPEED/FLOW RELATIONSHIPS

Certain key components of the calculations used in traffic appraisal merit further investigation. These comments on speed/flow relations are borne out of Institute experience under Department of Transport contracts on COBA (Gunn, 1982; Murchland, 1982) research into travel-time variability (May and Montgomery, 1984) and recent involvement in specifying area speed/flow relationships in Hong Kong.

i) For detailed urban schemes it is clear that congestion is better accounted for by modelling delay at junctions (cf Section 2.14) rather than speeds on links. For more strategic schemes or where there are long stretches of road the use of link-based or area-wide travel-time/flow formulae (incorporating junction-delay effects) might still be adequate, and simpler. Advice on the circumstances in which these different approaches are appropriate is needed. For this purpose, it is recommended that an evaluation be made of how one approach may be represented by another (viz, junction-delay simulations/relationships being built up into link-based relationships; link-based relationships being built up into area-wide relationships), in an extension of the approach adopted by Manheim et al (1982).

ii) There are major problems in identifying speed/flow relationships on urban/suburban streets, but few studies have been directed to that end. Consequently urban speed/flow relations in COBA have been based on studies not suited to that purpose, and use peak/off-peak speed/flow relationships for an area to depict speed/flow relationships within each time period for the links. Institute work has demonstrated biases in such a procedure; and further investigations of the validity of such an approach would be desirable.

iii) It is recommended that any further studies on these issues be on travel-time/flow (or slowness/flow) relationships rather than speed/flow relationships. This is in part because this is the quantity directly of use in route-choice decisions and in the evaluation of benefits; and in part because travel-time is an additive quantity, so its use is more consistent when the effects of several links are aggregated.

2.16 SENSITIVITY ANALYSIS

The issue. As was suggested in Section 1.5, we are concerned that the use of different techniques to assess given schemes may materially affect the results of comparative appraisals. This is clearly important when alternative schemes are bidding for limited resources. It would be regrettable if the need for a common approach to the assessment of alternative schemes were to stifle the development and application of some of the more sophisticated techniques for which we call elsewhere in this document; the case for consistency is weakened if the result is merely that all appraisals are consistently wrong in an inconsistent way!

The approach

We see great value in a model based study to highlight the areas where appraisal results are most sensitive to the forecasting and analysis techniques used. This would incorporate tests on the concern expressed in Section 2.9, 2.10, 2.11 and 2.12 re the consistency between evaluation and forecasting methods. The idea is not a new one - we have ourselves been involved in similar work some years ago (Bonsall et al, 1977; Senior and Williams 1977) - but we believe that the approach has yet to be applied to the specific problems that arise in the selection of techniques for urban road appraisal.

Using one or two schemes as case studies, the sensitivity of the appraisal results could be tested as follows:

- i) allowing reassignment over a larger or a smaller area
- ii) using junction-simulation rather than link based models for the reassignment of trips
- iii) allowing for change of mode following scheme implementation (rather than assuming a fixed matrix)
- iv) allowing for change in distribution following scheme implementation (rather than assuming a fixed matrix)
- v) allowing for changes in trip rates following scheme implementation (rather than assuming a fixed matrix)
- vi) allowing for possible changes in land use for which the scheme might be a necessary if not a sufficient condition
- vii) assigning and evaluating separate peak and off peak matrices rather than assuming a 16 or 24 hour average
- viii) assigning matrices in disaggregated form rather than leaving the disaggregation until the evaluation stage
- ix) allowing for changes in trip timing following scheme implementation (rather than ignoring this effect)

Of these tests all but v), vi) and ix) could be based on established techniques. The remainder could be achieved using conventional sensitivity analysis methodology as could tests of the effect of incorporating various of the other enhancements to appraisal techniques and procedures which we have recommended elsewhere in this document.

REFERENCES

Bonsall, P.W. (1980) A survey of attitudes to car sharing. T.R.R.L. SR 563

Bonsall, P.W., Gunn, H.F. and H.C.W.L. Williams (1982) A model of the combined parking location mode split/journey timing decision. PTRC Summer Annual Meeting, University of Warwick, July 1982.

Bonsall, P.W., Champernowne, A.F., Mason, A.C. and A.G. Wilson (1977). Transport modelling: sensitivity analysis and policy testing. Progress in Planning 7.3

COBA (1981) [Cost benefit analysis] Assesments Policy and Methods Division, Department of Transport, London.

Crompton, D. et al. (1978) Pedestrian Delay, Annoyance and Risk. Transport Section, Department of Civil Engineering, Imperial College of Science and Technology. (Unpublished.)

Foster, N. (1982) A study of travel time variability for the journey to work. MSc Dissertation, University of Leeds (unpublished).

Gunn, H.F. (1982) Urban speed/flow effects and COBA. Technical Note 108, Institute for Transport Studies, Univ. Leeds.

Gwilliam, K.M. (1970) The Indirect Effects of Highway Investment. Regional Studies, vol. 4, 1970.

Hawkins, A.F. (1978) Some anomalies due to misspecification in transport models. PTRC Summer Annual Meeting, University of Warwick 1978.

Heydecker, B.G. (1985) Development of a travel model which includes car parks. UTSG Annual Conference, University of Birmingham, January 1985 (to be presented).

Jones, P.M. (1982) HATS Education Manual; studying travel in the context of Household Activity Patterns. TSU publication 193. Transport Studies Unit, Oxford University.

Judge, E. and K.M. Gwilliam (1976). Economic impact of primary roads - what kind of evidence? Regional Studies, vol. 10.

Kirby, H.R. (1984) Transport research at the University of Leeds; report for 1983. Traffic Engineering and Control, 25(3), 133-138.

Manheim, M.L., Arnaud, R., Moisi, F. and Raison, M. (1982) Analysis of short-range transportation policies for the Paris region. PTRC Summer Annual Meeting, Univ. of Warwick, July 1982.

May, A.D., Bonsall, P.W. and K.M. Gwilliam (1984) Transport in the metropolitan conurbations; current performance and future prospects. Vol. 2, evidence, University of Leeds, 1984

May, A.D. and P.W. Bonsall (1983) The effects of parking control on destination choice. Unpublished project proposal Institute for Transport Studies, University of Leeds.

May, A.D. and F.O. Montgomery (1984) A comparative assessment of alternative travel time monitoring methods. Proc. IEE Conference on Road Traffic Data Collection, London.

May, A.D. and N.S. Patterson (1984) Transport problems as perceived by inner city firms. Transportation, 12(2), 225-241.

May, A.D. and I.G. Turvey (1984) The effects of wheel clamps in central London: comparison of before and after studies. Working Paper 184, Institute for Transport Studies, Univ. of Leeds.

MEA (1984) Manual of Environmental Appraisal. Assessment, Policy and Methods Division, Department of Transport, London.

Mendelsohn, A.J. (1984) The perception of the risks and costs associated with illegal car parking in central London, MSc Dissertation (unpublished), University of Leeds.

Montgomery, F.O. and A.D. May (1983) Work journey rescheduling: model development and analysis. Working Paper 167, Institute for Transport Studies, University of Leeds.

Morton-Williams, J., Hedges, B. and Fernando, E. (1978) Road Traffic and the Environment. Social and Community Planning Research, London.

Murchland, J.D. (1982) Accuracy of the urban congestion factor. Technical Note 106, Institute for Transport Studies, Univ. Leeds.

Senior, M.L. and H.C.W.L. Williams (1977) Model-based transport policy assessment. (1) The use of alternative forecasting models. Traffic Engineering and Control 18(9), 402-4.

Small, K.A. (1982) The scheduling of consumer activities: work trips. The American Economic Review, 72, pp 467-479

TAM (1981) [Traffic Appraisal Manual.] Assessments Policy and Methods Division, Department of Transport, London.

Waldman, J. A. (1977) Cycling in towns. A quantitative investigation. LIR1 Working Paper 3, Department of Transport, London.

Weaver, P. M. (1984) Measuring the impact of traffic management measures on retailing activities. Phd. thesis, University of Leeds. (Unpublished.)

Williams, H.C.W.L. and M.L. Senior (1977) Model-based transport policy assessment. (2) Removing fundamental inconsistencies from the models. Traffic Engineering and Control 18(10), 484.

Williams, H.C.W.L. and M.L. Senior (1978) Accessibility, spatial interaction and the spatial benefit analysis of land use-transportation plans. In: Spatial Interaction Theory and Planning Models (Eds. A. Karlquist, L. Lundquist, F. Smikaro, and J. Weibull), North Holland.

TABLE 1

GROUP 1 TRAVELLERS - SUMMARY OF IMPACTS TO BE CONSIDERED

	Impacts to be considered							
Component Sub Groups	Time Savings or Delays (2)	Variability in travel time (4)	Parking and access time (4)	Changes in Vehicle Operating Costs (2)	Accident Reductions (2), (3)	Driver Stress	View from the road	Amenity and Severance
Private Vehicle Drivers and Passengers	x	x	x	x	x	x	x	
Public Transport and Passengers	x	x	x	x	x	(x)	(x)	x
Cyclists (1)	x				x			x
Pedestrians	x				x			x(5)

The more important impacts are denoted by x.

NOTES

1. This sub group to be included only where an appreciable flow of cyclists is expected.

2. Although normally expressed in monetary units and discounted to a stated base year, it may be useful to detail time savings (of different magnitudes) in time units as well as in monetary units.

3. Supplemented by assessments of the numbers of casualties prevented.

4. These could be incorporated in column 1, but need to be separately identified.

5. These effects would be dealt with in greater detail for shopping centres and other major generators in Table 3.

TABLE 2

GROUP 2 - OCCUPIERS OF PROPERTY - SUMMARY OF IMPACTS TO BE CONSIDERED

	Impacts to be considered							
Component Sub groups - Occupiers of:	Demolition No.	Noise Change dB(A) L_{10} 18 hr (1)	Visual Effects	Severance	Frontage access problems	Disruption during construction	Landtake hectares	Developmental Effects (2)
Residential Property Including Farmhouses	x	x	x	x		x		x
Industrial and Commercial Property	x	x	x	x	x	x		x
Schools and Hospitals	x	x	x	x	x	x		
Public or Special Buildings	x				x			
Recreational Space							x	
Agricultural Land				x		x	x	

The more important impacts are denoted by x.

NOTES

1. Public Inquiry frameworks will express this impact in terms of the numbers of properties experiencing noise changes within stated ranges of decibels. Public Consultation frameworks will not use decibels. Instead the properties affected will be classified by their distance from the central line of the proposed new road in bands up to a normal maximum of 300 m. For existing roads, the numbers of properties likely to experience at least a doubling or halving of the present traffic flow during the fifteen years after opening will be deemed to indicate the comparative effect of noise change.

2. Although development effects are dealt with in a separate section (group 5 impacts) they are usefully included here to demonstrate linkage with other effects on residential, industrial and commercial property.

TABLE 3

GROUP 3 - USERS OF FACILITIES - SUMMARY OF IMPACTS TO BE CONSIDERED

	Impacts to be considered				
Component Sub groups - Users of:	Vehicle/ Pedestrian Conflict/ Danger	Noise	Visual Intrusion (1)	Severance (2)	Pollution
Shopping Centres	x	x	x	x	x
Public Buildings such as Churches Libraries or Community Centres		x		x	
Recreational Areas and Facilities	x	x	x	x	x
Other major generators (eg. terminals)	x	x	x	x	x

The more important impacts are denoted by x.

NOTES

1. The component sub groups are general examples only. For each schemne, the facilities likely to be affected and the relevant effects must be identified from local data.

2. The boundary between groups 2 and 3 is not well defined and in cases of doubt, the effect on the people concerned should be entered in the group containing the most relevant impacts. Care must be taken that double counting does not occur inadvertently.

(1) Of structures, traffic, parked vehicles.
(2) From structures, traffic.