**Major Scheme Appraisal in Local Transport Plans**
**Part 3: Detailed Guidance on Forecasting Models for Major Public Transport Schemes**

## 1 Introduction

1 This document sets out the procedures to be followed in developing forecasting models to be used in the appraisal of major public transport schemes. Guidance aimed at ensuring forecasting on a consistent and reputable basis must be linked to appraisal and needs to be set in context. Appraisal requirements drive forecasting outputs so the scope of forecasting is determined by those requirements. This approach already exists in guidance published by the Department, notably Guidance on Full Local Transport Plans, Major Public Transport Scheme Appraisal in Local Transport Plans (Part1: Detailed Guidance on Public Transport Schemes) (Reference 1) and in Guidance on the Methodology for Multi Modal Models (GOMMMS) (Reference 2).

2 The rationale behind the production of this guidance is that, whilst there exist rigorous and widely accepted rules for assessing the performance of highway models, there is limited practical advice or rules for models used in the public transport context. Therefore, there is a need to be able to assess the structure and performance of public transport models used to assess network-based investments.

3 The modelling and appraisal of a major public transport scheme can be significantly more complex, with associated implication on resources, than modelling required for appraising a highway scheme. For a rapid transit proposal, there will almost certainly be a requirement for highway modelling as well as a public transport assignment and mode split models.

4 The type of public transport improvement proposed is an important factor when determining the most appropriate type of assessment. Whilst the appraisal of major public transport schemes will require some sort of modelling, the level and complexity will depend on the scale and impact of the scheme. This guidance aims to offer advice on 'best practice' for major public transport improvements, typically requiring capital expenditure in excess of £25 million. The advice is likely to be most applicable to network based investments such as light rail or guided bus. This guide does not, however, set out guidelines for best practice when evaluating proposals such as bus priority schemes, improvements to bus stations and interchanges or passenger information systems, for which quantified analysis rather than more formal modelling will normally be required.

5 The stage that the scheme has reached is also an important consideration. At an early stage of scheme development, when different options are being considered, less detailed modelling may be appropriate. However, a major public transport scheme included in the Local Transport Plan (LTP), either seeking agreement to apply for a Transport and Works Act (TWA) application or subsequent bidding for funds, will require full and robust modelling. Whilst models will therefore almost certainly be developed in an incremental manner, it is important to ensure that modelling work is not abortive and that each stage of the work builds upon work undertaken in previous stages.

6 The context for forecasting work should be as clear as possible. To expedite the Department of Transport, Local Government and the Regions appraisals process for grant applications, it is essential that inappropriate or premature forecasting work is avoided. Thus, for example, no light rail scheme appraisal should be undertaken without a clear definition of the do-minimum case and an assessment of alternative options; nor should detailed revenue and benefit forecasting be completed without detailed scheme costs. Therefore, this guidance sets out the usual sequence of activities, of which forecasting forms a part.

7 This guidance is intended to be used in conjunction with the guidance issued in both GOMMMS and in Major Public Transport Scheme Appraisal in Local Transport Plans. Indeed, there is commonality between the three sets of guidance and cross reference to these and other guidance, including the Design Manual for Road and Bridges (DMRB) (Reference 3), is made. In particular this guidance on Forecasting Model Assessment seeks to expand on some sections in Part 1: Detailed Guidance on Public Transport and Highway Schemes, namely paragraphs B16 to B30.

## 2. Modelling framework

8 This guidance attempts to provide a framework setting out appropriate model structures, data requirements and model performance.

9 Model structure is important because it determines the functional form of the model, and it is important to ensure that this conforms with good practice.

10 The guide contains advice to ensure the performance of the model is acceptable. For instance guidelines on the extent of segmentation that should be represented in the model.

11 There are several important validation tests that should be carried out and criteria applied to judge whether the model validation is acceptable.

12 The data underpinning the model may have been used to develop the model, calibrate it, or validate it. In each case, guidelines are given to enable the fitness for purpose of the data. A key aspect in developing mode choice models is the use of stated preference and/or revealed preference data, so guidance is issued on this. The data used for values of time (contained within the Departments Transport Economics Note (TEN) (Reference 4) are also critical. Guidance already exists on the use of local planning data to produce trip ends that are consistent with the National Trip End Model (NTEM), (Design Manual for Road and Bridges,12.2.3, Reference 5) and its associated data access programme TEMPRO (www.dft.gov.uk/roadnetwork/heta/hetagen). In addition, advice on stated preference and economic valuation are given in the Departments "Summary Guide on Economic Valuation with Stated Preference Techniques" (Reference 6) and in the "Manual on Economic Valuation with Stated Preference Techniques" (Reference 7).

13 The final appraisal should be presented in a single and complete document, with annexes as necessary; a separate annex should be included which covers all aspects of model development and forecasting, as discussed above. Earlier working papers or reports covering base year validation and forecast results may be included, but the derivation of the numbers and the analysis should be clear from the final document without any need to refer back to earlier papers.

14 For larger schemes, the Department may appoint its own consultants to carry out technical audits of appraisals. These consultants may be used at an early stage of the scheme development to assess the quality of the data and the robustness of the modelling methodology. Promoters will be expected to provide access for such consultants to all relevant analysis, including possible access to base data and forecast models.

## 3. Process

15 Promoters should discuss the forecasting models to be used in scheme appraisal with the Department at an early stage. It is anticipated that promoters will need to liase closely with the Department at a number of stages during model development. The broad stages envisaged are:

- Method statement setting out model methodology in general terms including, inter alia, demand data to be used, use of any existing models, model structure, level of validation anticipated, forecast years and assumptions on growth in demand;

- Validation stage, where the validation of the public transport and highway elements of the model will be presented;

- Forecasting stage, where the more detailed forecasting methodology and the results of the central forecast and any associated sensitivity tests will be presented; and

- Appraisal stage where the appraisal assumptions and the results of the appraisal will be presented.

## 4 Structure of Annexes to the Guidance

16 The remainder of the guidance comprises a series of Annexes. Annex A provides a summary of useful guidance already available. Annex B offers advice on possible model structure, whilst Annex C describes the methodology to collate demand data from new and existing sources. The Model Calibration and Validation requirements are described in Annexes D and E respectively, whilst Annex F outlines the forecasting procedures needed to produce future year estimates. Annex G describes the requirements for reporting the appraisal assumptions and the outcome of this assessment, although it should be noted that advice on appraisal are set out in other Departmental guidance such as Major Public Transport Scheme Appraisal in Local Transport Plans. Annex H describes the references.

# ANNEX A - SUMMARY OF CURRENT GUIDANCE

A1 A significant number of documents have been produced in recent years containing advice, recommendations and guidelines for modelling. Whilst the emphasis of the more detailed guidance relates primarily to highway modelling (Design Manual for Roads and Bridges), there is still a large amount of advice available for public transport demand forecasting. This section reviews, in a broadly chronological manner, those documents which contain relevant advice.

### *Guidelines for Developing Urban Transport Strategies, The Institution of Highways and Transportation, May 1996*

A2 These Guidelines (Reference 8) were prepared by the IHT to assist those charged with developing transport strategies in urban areas and to encourage a "balanced" approach to the provision of urban transport. The guidelines cover a wide range of topics including strategy development, appraisal, consultation and implementation and describe the modelling issues in some detail. The section on Models for Transport Strategy Development and Appraisal describes in detail the need for and use of transport models for testing urban transport strategies and provides advice on the appropriate types of models for a range of situations.

A3 Areas of particular relevance for the modelling of major public transport schemes include guidance on modal and sub-modal choice, public transport assignment, over-crowding, time periods, use of survey and Electronic Ticket Data (ETM) data, generalised cost components and calibration, including use of stated preference data and validation data. The guidance provides much relevant general advice, particularly with reference to the appropriateness of different approaches to different types of scheme or urban area.

### *Guidance on the Methodology for Multi-Modal Studies, DTLR, March 2000*

A4 This document (Reference 2) provides advice on the technical conduct of the Multi-Modal Studies announced by the DTLR in March 1999. The aim of the studies is to investigate problems on or with all modes of transport and to seek solutions to these problems. The Guidance provides an overview and guidelines on modelling, data collection and level of detail of analysis.

A5 The Guidance points out that the creation of a transport model, along with the collection of the necessary data is potentially costly and time-consuming and that the scope for using existing models and data should be carefully considered. The Guidelines describe in some detail the trade-off between segmentation of demand, degree of spatial detail and the accuracy with which equilibrium is found. It includes a recommendation to segment the demand model by a **minimum** of by three purposes and two car ownership categories and suggests the level of spatial disaggregation needed for both broad transport strategies and more detailed plans.

A6 The requirements of a model for assessing an urban public transport scheme in isolation differ from those of a multi-modal study testing a wide range of transport policies. Indeed, the Guidance states that even with complex, detailed multi-model models, individual components can be tested using fixed demands with full variable demand models only being used for combinations of components and complete strategies or plans.

### *Major Scheme Appraisal in Local Transport Plans. Part 1: Detailed Guidance on Public Transport Schemes, DTLR, June 2001*

A7 This document (Reference 1) sets out the procedures to be followed in the appraisal of major schemes. And supersedes Guidance published by the Department in May 2000 together with Annex A to the former Department of Transport Circular 3/89 on grant applications for public transport projects under Section 56. Much of the material in the note is taken directly from GOMMMS.

A8 The note identifies the requirement for a detailed transport cost benefit analysis (CBA) forming part of a wider NATA (New Approach to Transport Appraisal) assessment covering the governments five over-arching criteria of Environment, Safety, Economy, Accessibility and Integration. The CBA requires an explanation of the calculation of traveller and non-traveller benefits and a comparison of benefits with the costs of investment, maintenance and operation. The CBA should be supported by an explanation of the modelling and forecasting of travel demand, with and without the option to be appraised. Annex B of the Guidance covers the modelling framework, parameters, data sources, and the outputs and assumptions for patronage, revenue and benefit forecasts.

### *Stated Preference (SP) Guidelines*

A9 There are a number of publications dealing with guidelines for stated preference. Of particular note is the DTLR "Summary Guide on Economic Valuation with Stated Preference Techniques" (Reference 6) and the "Manual on Economic Valuation with Stated Preference Techniques" (Reference 7). Courses run by PTRC together with associated literature and guidance published by Hague Consultancy Group and Steer Davies Gleave as part of the ALOGIT software (Reference 9) also give detailed advice. In addition, the Guidelines for Developing Urban Transport Strategies, IHT, May 1996 contains a section on SP. This advice tends to be highly technical in nature and it is clear that there are a limited number of practitioners with the necessary specialist knowledge to undertake and analyse SP surveys.

### *Design Manual for Roads and Bridges (DMRB)*

A10 The recommended practice for appraisal of trunk road schemes in England is set out in the Traffic Appraisal Manual (TAM) – Volume 12 Section 1 of the DMRB. (Reference X). However, the predominant emphasis in TAM is on rural and inter-urban trunk road assessment. The current best practice for urban traffic appraisal techniques is contained in Traffic Appraisal in Urban Areas (TAUA) (Volume 12 Section 2 of DMRB) which is relevant because of the urban nature of light rail schemes. Whilst this gives detailed guidance on model structure, time periods, trip purposes, base and forecast years, calibration, validation acceptability criteria and forecasting methods, the advice relates specifically to "urban traffic appraisal techniques in the context of trunk road assessment". Although the advice on model structure, time periods and forecast years is largely relevant and is referred to later in this guidance, the emphasis on a single mode means that the criteria for validation are perhaps too stringent for the assessment of models designed to appraise light rail schemes.

### *Strategic Rail Authority Planning Guidelines*

A11 The Strategic Rail Authority (SRA) provide guidance, first developed by OPRAF, on bidding for Rail Passenger Partnership (RPP) funding and "Planning Criteria – A Guide to the Appraisal of Support for Passenger Rail Services" (Reference 11). The Planning Criteria guidance are aimed at business case preparation and procedures for changes to supported rail services for anyone putting a proposal to the Franchise Director that affects the Passenger Service Requirements or new proposals requiring financial support from the SRA. The core advice concerns business case preparation for which a sequence of actions is recommended including a clear statement of objectives, projects of costs, benefits and NPV. It does not contain specific forecasting guidelines other then to recommend:

- an appraisal period corresponding to contractual liabilities and infrastructure asset life;
- categories of costs and benefits to be presented;
- the context of the business case; and
- a NATA-based checklist of information for the base and one forecast year.

A12 The RPP Bidding Guidance is to be read in conjunction with "Planning Criteria" in making a case for finance for SRA for new or enhanced rail services that cannot be commercially justified, but contribute to wider government objectives. This includes capital and revenue support for stations and services. A pre-qualification is needed including value for money, policy criteria, the prospect of significant user benefits. Following this, SRA provides guidance particular to each scheme and a business case is required indicating the costs, benefits and other information on the same general basis as in the Planning Criteria. The guidance also calls for a methodology statement. For smaller schemes only, qualitative indicators are required. However, no specific guidance on forecasting methods or models is provided.

## ANNEX B - MODEL STRUCTURE

B1 Determining the model structure is one of the most crucial elements in an assessment. Therefore, the model specification and structure should be determined at an early stage of the assessment.

B2 The model will need to satisfy a number of requirements for use. These will include the need to forecast demand by section of the proposed scheme, with demand identified separately according to its source. It should also take account of variables such as speed, frequency, fares, and access on both the scheme being assessed and competing modes and routes. In order to obtain an accurate representation of the costs involved by different journey options it will be necessary to code the highway network and public transport network and services in some detail implying the use of detailed network models using specialist transport planning software in preference to a spreadsheet based approach. Moreover, DTLR's standard appraisal model, Transport Users Benefit Appraisal (TUBA) requires, as input, demand and cost matrices supporting the need for a formal network model. The complexity of the model is likely to be influenced by the stage that scheme development has reached.

B3 In considering model structure it is necessary to decide whether a full "four-stage" multi-modal model is required or whether a simpler corridor based approach will suffice. Many urban light rail schemes have the characteristics suitable for a corridor model, being basically linear in nature serving a major destination at one end, such as a city centre. With this approach, the elements of the model can be considerably reduced to the forecasting of fixed future matrices of travel demand which are then input to mode choice and assignment sub-models. This is similar to guidance in GOMMMS that individual components of a policy can be tested using fixed demand, with full variable demand models only being used for combinations of components and complete strategies or plans.

B4 A full multi-modal four-stage transport model of an urban study area is not necessarily required for the assessment of a light rail or similar scheme. Although such a model might be desirable it would not normally be reasonable to expect the scheme's promoters to fund the considerable model development required. However, more complex models may well be required if a scheme is part of a wider package of measures such as congestion charging or other traffic restraint measures where it will become more important to assess complex behavioural responses other than mode choice, such as trip suppression and change of destination.

B5 A comparison may be drawn with the advice contained in Traffic Advice in Urban Areas which states that higher tier models are not usually suitable for direct use in scheme appraisal, although they may provide useful inputs to the traffic forecasting process, especially where they reflect trip re-distribution and multi-modal effects. For trunk road appraisal, emphasis is placed on observed, rather than synthesised, movements and traffic forecasts are based on local growth factors applied to those observed movements as far as possible.

B6 With the addition of the mode choice element, the Department suggests a similar approach for major public transport schemes, unless a scheme is expected to have a wider impact on the pattern of travel demand.

### CONVERGENCE

B7 Models developed to date for appraising light rail schemes have not generally dealt with model convergence. In other words, such models do not incorporated feedback by which new costs were extracted, with light rail included, and fed back into the mode split model in an iterative fashion until a pre-defined level of convergence was achieved.

B8 Historically, where an iterative approach was adopted, the effects of even large schemes were within the "noise" of convergence, more particularly for large models. Generally, the approach has been to cordon down the model to incorporate the area of influence of a particular scheme, in an attempt to minimise external impacts that may affect the results.

B9 There is no additional guidance on public transport model convergence currently available. However, the Department is currently undertaking research known as DIADEM (Development of Integrated Assignment and Demand Modelling) to develop better methods; this research should be complete by Summer 2002.

## STUDY AREA AND ZONING

B10 The modelled study area should include all the specific area of interest of the scheme to be tested and the area affected by re-routeing and modal transfer to the proposed scheme. This may include a wider area than the corridor served directly. There is a close relationship between the definition of the study area, the zoning system and the modelled network, and these should be considered together.

B11 It is important to recognise that it is seldom possible to define an ideal zoning system for a particular alignment. In many cases the zoning system will have been defined before details of a particular alignment are known. Frequently, particularly where use of an existing highway model of the area is made, practical considerations mean that a less than optimal zoning system is adopted. Ideally, zones should be defined that offer similar walk access times to public transport, but these zones may be bisected by major roads. This creates potential conflicts with zoning systems suitable for highway modelling. Although this is frequently the case, care needs to be taken that the zones used are suitable for the purpose. In particular that, wherever possible, they:

- are consistent with administrative and planning data boundaries;
- group areas of similar land use;
- do not in general span transport corridors;
- are not ‘severed’ by main roads or railway lines;
- have the necessary detail to model differences in access times where appropriate, for existing public transport (bus and/or rail) and the proposed new mode from the same zone;
- have the ability to model traffic restraint policies;
- do not group together areas with different levels of public transport provision; and
- allow new development areas to be distinguished.

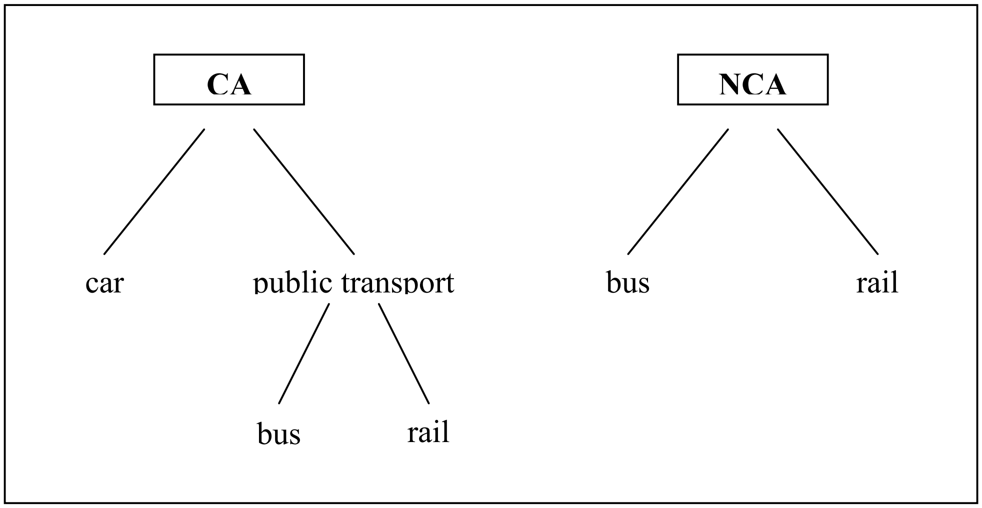
B12 Advice on zone size in Traffic Appraisal in Urban Areas is to ensure that, typically, zones are large enough to generate 200 trips per hour across the screenlines or cordons, although it is acknowledged that some will need to be smaller than this to allow loading to be represented with sufficient accuracy. As a guide it is suggested that between 50 and 200 zones will be required for an urban traffic model for the appraisal of a road scheme. However, due to the importance of walk access and egress in urban public transport modelling, a finer zone system may be appropriate.

B13 The zoning system should be developed to take account of the spatial detail needed for accurate appraisal of the proposals being assessed, with smaller zones used in the key parts of the study area. For a light rail scheme zones should be defined at around the level of one zone per stop, with zone sizes set to correspond approximately with the expected walking catchment area for each stop. A further set of zones would be defined of similar size further from the rail alignment to cover the immediate area of influence in sufficient detail to distinguish different potential access routes to the scheme.

## MODE CHOICE MODEL STRUCTURE

B14 The typical mode choice model for the car available segment is frequently of a hierarchical nature, with a higher level choice between car and public transport use and a lower level choice for those trips forecast to use public transport, between individual public transport modes. The choice model for the non-car available segment would allocate between public transport modes. Typical structures for car available (CA) and non-car available (NCA) segments are shown in Figure 3.1.

**Figure 3.1 Typical mode choice model structures**




B15 Complex public transport models may employ a hierarchical logit model structure where public transport demand may be split initially into bus and "rail" with rail further subdivided, for example, into metro, light rail and heavy rail. Alternatively the sub-mode choice for public transport can be undertaken by assignment rather than a formal sub-mode choice model and this is also an acceptable approach.

B16 The choice between a sub-mode choice model or an assignment based approach is largely a matter of personal preference as each approach has been successfully used on a number of occasions and each has advantages and drawbacks. General advice would be to consider how different the public transport modes are, particularly in terms of their perceived quality. If each mode has markedly different characteristics, we suggest a formal sub-mode choice model which will allow, for example, the commonly observed preference for rail over bus, particularly from car available segments, to be explicitly represented, and generally offers more control than an assignment based approach.

B17 However, where a wide choice of public transport modes is available it is more difficult to distinguish precise boundaries. For example "quality" bus, guided bus, street-running tram and segregated light rail represent a fairly continuous range of public transport improvement, and any divisions imposed will be somewhat arbitrary. Moreover, the possibility of 'mixed mode' trips such as bus feeder to light rail can make the definition of sub-mode choice models difficult and present problems in extracting appropriate sets of costs by mode. The presence of an integrated fare system, which removes one of the key differences between public transport modes, also might imply an assignment based approach. It is still possible to include allowances for the qualitative benefits of different modes within an assignment with, for example, weighted in-vehicle times to reflect passenger preference, although the details of the assignment algorithm are important.

B18 Other more complex approaches might include Park and Ride as a separate mode, or in particularly complex urban situations with a wide range of travel options, the use of formal sub-mode, station choice and route choice sub-models at difference stages.

B19 A further point to consider is the use of pivot-point or incremental logit models. These can be used to forecast the *change* in demand based upon changes in cost from a base situation and have the advantage that data are only needed for those attributes that change. They also tend to give greater weight to the base observed travel demand matrices, which is often seen as desirable. New modes, for which no observed data exist, can be included in an incremental model structure by using an absolute logit model at a lower level to forecast probabilities by say, bus and light rail within the public transport nest, under an incremental main mode choice (car versus PT) model based upon existing demand by each mode.

## MODEL TIME PERIODS

B20 All appraisals should be based on models with at least two time periods; one peak period and an inter peak period. There may be a need to model both the morning and evening peak periods if these demonstrate particularly different characteristics in the pattern of demand. The inter-peak time period should be covered to reduce the reliance on factors to calculate daily and annual patronage and revenue forecasts from a single peak period, and because the inter-peak can show very different levels of benefit and revenue per passenger. Moreover, the pattern of demand and its sensitivity to changes can be very different across time periods.

B21 We recommend that a two or three hour period should be modelled rather than a single hour for public transport models. This reduces the error associated with annualisation factors based on a single hour as it allows for peak spreading and longer journeys that span the peak hour. Trip data could be collected for a longer period and adjustments made to the calculation of service capacities if a crowding function is included. Where over-crowding is an issue, adjustments will need to be made to determine peak period public transport vehicle capacity requirements which are not indicated by two or three hour periods. The adoption of two or three hour modelling periods is generally not suitable for highway models.

## MODEL SEGMENTATION

B22 The extent to which a demand model should be segmented by journey purpose and car availability is inevitably a trade-off between the theoretical ideal and pragmatism. GOMMMS includes a recommendation to segment the demand model by a **minimum** of three purposes, with a preference for five, as well as by car ownership.

B23 This level of segmentation is not necessarily appropriate for assessing an urban public transport scheme in isolation as opposed to a multi-modal study testing a wide range of transport policies and strategies. Although there are strong arguments for retaining a high level of segmentation where the base demand data support this, this is frequently not the case. In particular, where use is made of existing highway models, or demand has been updated using matrix estimation, market segmentation is frequently not available.

B24 However, segmentation should be retained if suitable demand data are available and appropriate behavioural relationships can be calibrated. The minimum GOMMMS segmentation of home based work, employers' business and other is appropriate and we would not envisage that any further level of segmentation is required. This will also improve the inputs for appraisal as benefits can be extracted separately for trips in work-time and non-work time, which correspond to the standard purposes used in TUBA. A segmentation between car available and non-car available segments, undertaken either on a household basis or for the current journey, is essential as these will exhibit very different characteristics in travel choice.

## PUBLIC TRANSPORT SUPPLY MODEL

B25 The main requirements of the public transport model are to provide generalised cost inputs for the mode split model, undertake mode split by assignment if appropriate, provide plots of scheme link flows and provide input into operational, economic and financial appraisals.

B26 In most public transport software packages, the ***bus network*** is merely a subset of the highway network and does not require any additional coding, except in the case of bus-only links. Bus services should be coded from current timetable information and include details of route specification and headway. Journey times should be taken from the highway assignment, if available, to ensure interaction between bus and highway journey times. Several highway assignment models can simulate both the effect of prevailing traffic on public transport speeds, together with the contribution that public transport vehicles themselves make to congestion. It is standard practice to include an allowance for deceleration/acceleration at bus stops, together with a dwell time to represent setting down and picking up passengers. This may be done using dwell times for each public transport stop or by adjusting highway times to represent these delays through an 'add-on' factor.

B27 ***Rail/LRT networks*** can be coded from appropriate scale plans (or from GIS data). Interchange between rail lines and between rail and bus should be coded explicitly to facilitate extraction of interchange flows. Rail/LRT services should be coded from timetable information, or from run time models in the case of new modes. Data requirements generally include route specification, stopping pattern, vehicular capacity, headway and journey time. Because journey times are not generally influenced by other modes, with the exception of street running LRT, journey times can be coded directly by link or "segment" (a section of an individual service running on one link) where services offer a combination of stopping patterns.

B28 In urban areas with complex bus and rail networks, ***multi-routeing*** is a common feature, both within and between public transport sub modes. This is due to adjacent bus corridors serving similar catchment areas, competition between orbital and radial routes for cross-city trips and competition between bus and rail. In order for a model to realistically reproduce base year public transport conditions, a public transport assignment model should be used to reflect multi-routeing opportunities.

B29 In large urban areas, passenger demand may exceed capacity leading to ***crowding*** on the system. Applying crowding techniques is non-trivial and requires algorithms within the software or additional macros. In general terms, crowding can be represented by application of a crowding factor to in-vehicle time. This is based on the relationship between demand and capacity by public transport service. An iterative procedure is used between the assignment and calculation of the crowding factors. The initial assignment produces a series of crowding factors by service. These are then applied to the in-vehicle time of the "crowded" service and a further assignment undertaken. The journey time of the initially crowded service is increased by the application of the crowding factor making the service relatively less attractive. The process is complete when a level of convergence is reached.

B30 There are various practical considerations when crowding is explicitly modelled, in particular the calculation of economic benefits based on savings in crowded time. Further research is needed into the behavioural responses to crowding before it can be accurately incorporated into a forecasting model. This is a difficult area, particularly with a new mode where direct research is not possible. For consistency, both the costs associated with delay on the highway network and the inclusion of crowding penalties should be incorporated into both the mode choice and assignment models. Otherwise, the comparisons of mode share between car, existing public transport and the proposed public transport may be spurious.

B31 When crowding is not explicitly modelled, checks should be made on forecast public transport line loadings to ensure that crowding does not become an issue in later years, and that forecast demand levels are in line with available capacity. Capacity analysis should concentrate on the peak hour within the full modelled peak period.

B32 ***Fares*** are required as an input to the mode split stage of the model. Because most other elements of public transport generalised cost are matrix based (in-vehicle time, wait time, access time, etc.), it follows that fares should follow the same convention. Most public transport software packages are capable of replicating a wide range of fare systems (distance based, zonal, etc.). An alternative approach is to apply a suitable fare per kilometre function to a skimmed distance matrix.

## HIGHWAY SUPPLY MODEL

B33 The structure of the highway element of any model used in major public transport scheme appraisal is set out in considerable detail in DMRB Volume 12A (Section 2.3 and 4.1). Whilst this guidance is not reproduced here, we draw attention to the points overleaf.

- it is important to decide on the model structure (link versus junction based) at an early stage;
- traffic models should normally be sub-divided into separate time periods with separate network definition and matrices for each period; and
- the model should deal with the key features of the study and should not be unduly complex.

B34 Highway network data can be derived from a number of sources including existing models, by measurement from scale plans, or using GIS data. The latter approach has the benefit of greatly enhanced accuracy. However, additional data such as junction geometry and signal timings, may be available from the relevant local authority. Speed flow relationships should be taken from the latest version of COBA.

## SOFTWARE REQUIREMENTS

B35 There are several network based software packages available that are appropriate for forecasting the effects of major public transport schemes. Although there is a wide range of highway traffic assignment packages available, the choice of suitable public transport assignment packages is more limited.

B36 The requirements for highway models are generally well understood and detailed guidance is given in DMRB Volume 12A (Section 4.1.4). Whilst all of these features may not be required in each case, the following requirements are preferable:

- link and junction based modelling;
- elastic assignment; and
- matrix estimation.

B37 There is much less clear guidance on public transport software. However, the following are basic software requirements:

- multi routeing;
- detailed route representation;
- extraction of individual trip and generalised cost matrices for input to TUBA;
- sub modal choice by assignment or logit model;
- matrix estimation;
- representation of fares.

B38 In addition, the ability to represent crowding may be a useful capability in some instances together with the capability of interacting with the highway model so that traffic speeds can be fed into the public transport model and bus flows can be pre-loaded as fixed flows on the highway network. However, this may not always be feasible where use is made of an existing highway model.

# ANNEX C - TRAVEL DEMAND DATA

## INTRODUCTION

C1 The availability of existing travel demand data and the practicalities and costs associated with collecting new data for both private and public transport may influence the structure and specification of the model.

C2 Establishing base travel demand by public transport and car is of key importance for modelling any major public transport scheme. Whilst best use should be made of any existing data (and models), scheme promoters should discuss the appropriateness of such data with the Department an early stage. Significant attention should be paid to the robustness of the data collection methods. The collection of travel demand data tends to be a very expensive exercise where large scale travel surveys are required and alternative approaches have been developed. These are discussed below.

## PUBLIC TRANSPORT DEMAND DATA

*Public Transport Survey Data*

C3 There is no formal guidance equivalent to DMRB for public transport surveys, although the key issues are outlined in GOMMMS. The approaches listed include in-vehicle or at stop/ station interviews and counts. With in-vehicle surveys there will be a tendency to interview those passengers who remain longer on the bus or train. Care should be exercised and techniques for avoiding bias such as issuing questionnaires to all passengers at the same time, enumerator assistance and postal returns should be considered. The LT bus origin and destination surveys (BODS), employ self-completion questionnaires with independent logging of stop to stop movements. Data collected in public transport surveys might include the following:

- origin purpose;
- origin address;
- origin stop/station;
- access mode;
- destination purpose;
- destination address;
- destination stop/station;
- egress mode;
- car availability for journey;
- household car ownership;
- gender/ age;
- employment type;
- time of trip; and
- ticket type.

C4 It is recognised that issues of survey time and model design may limit the amount of background data collected. If roadside interviews are also being undertaken, public transport purpose categories should correspond to the standard categories used in roadside interview surveys. As well as offering generally consistent data sets, this also enables logic checks to be carried out in order to screen illogical journey purpose combinations.

C5 Questionnaire design should adhere to a number of simple "rules", namely:

- questions should be simple and direct;
- difficult or personal questions should be left to the end of the interview;
- open questions should be minimised;
- for on-board and station/bus stop interviews, all interviewees should be over 16 years old.
- self completion questionnaires should be clear, straightforward and relatively short.

*Public Transport Surveys*

C6 There are a number of methods of data collection generally employed to collect the information set out above. Reference 12 gives a good summary. Methods include household interview surveys, questionnaire surveys, including in-vehicle surveys and surveys at interchange locations and simple volumetric counts.

C7 Household interview surveys present a snapshot of travel patterns on a particular day. The interview comprises simple, closed questions that include any trip exceeding a pre-defined travel distance. Key household information including car availability and age/gender characteristics should also be collected. Household interviews usually involve extensive resources due to the need to undertake sufficient data collection to obtain a representative sample. For example, recommended sample sizes range from 1 in 5 for towns and cities with a population under 50,000 to 1 in 25 for cities with a population exceeding 1million.

C8 Surveys targeted at collecting specific origin-destination data include on-board surveys and surveys at railway stations or bus stops/stations. For these types of surveys, it is impractical to survey all passengers, so a sample of passengers should be interviewed. For on-board surveys, the number of survey enumerators required is dependent on vehicle occupancy, but on-board interviews can be problematic if the vehicle operates close capacity.

C9 Once data have been collected, it is necessary to expand them in order to reflect the total "population". For household interviews, this will involve expanding the dataset by the ratio of the households sampled in each zone to the total number of households in that zone. For roadside interviews, this will comprise expanding the interviews to a suitable control count, calculated from ideally a fortnights count data which corresponds to the time of the survey. The approach is similar for in-vehicle or at station/stop interviews; the sample will be expanded to the number of passengers on board or the number of alighting passengers respectively. For on-board surveys, there is usually a further expansion factor. If not all services are surveyed, the data needs to be expanded by the ratio of the number of services surveyed by the total number of services.

*Electronic Ticket Machine (ETM) Data*

C10 An alternative source of bus patronage data, subject to agreement from operators, is ETM data. This has the advantage that data can be made available for the whole area of interest and that all passengers can, in theory, be included in the data set. It also offers the possibility of using information for a longer time period removing the variability associated with a survey carried out over a limited period, and avoids possible bias in survey design and implementation.

C11 The disadvantages of using ETM data are identified in both GOMMMS and the IHT Guidance, and are summarised below:

- origin and destination are identified in terms of fare stage and a complex series of assumptions can be required to allocate these to individual stops and to model zone;
- fare stages may differ between services operated by different companies;
- absence of segmentation (journey purpose, car availability);

- trips involving interchange can be recorded as two separate trips as ticket sales data are recorded for each journey leg rather than the whole journey;
- concessionary travel and pre-paid tickets are often poorly recorded.

C12 It is therefore recommended that ETM data is used to supplement or update survey data rather than the primary source used for trip matrix building. However, this could change as ETM data becomes increasingly sophisticated and analysis software is further developed.

## HIGHWAY DEMAND DATA

C13 The Design for Roads and Bridges, Volume 12a, Traffic Appraisal in Urban Areas (Reference 3), describes in detail the stages required for developing an urban traffic model and includes a section on data requirements and availability. It is not proposed to repeat this advice here, although it is worth highlighting the key points identified, namely:

- maximum use should be made of suitable existing data provided they are sufficiently up to date and their source is sufficiently well documented;
- if the use of an existing traffic model is considered, its suitability for appraisal of the present scheme must first be checked in detail; and
- the use of unsuitable models solely for the purpose of saving time and money is not acceptable.

C14 In many cases a validated traffic model may already be available for the study area and this can lead to considerable savings in both survey costs and time spent developing base year travel matrices. Although this can be of significant benefit, a number of points should be noted when using an existing highway model:

- the model should be validated against recent data
- the model should be updated if necessary;
- the zone system should be sufficiently detailed in the corridor of interest; and
- car occupancy factors should be verified with local data when converting vehicles to person trips.

C15 One issue in using an existing highway model is that any segmentation of demand by journey purpose which might have been recorded in the original survey data is generally lost at the matrix development stage. Although this is a limitation, it may be less significant when assessing a major public transport scheme in an urban environment.

C16 The discussion of highway demand data in this context has historically been based on a ‘fixed demand’ matrix with the application of high or low traffic growth for the forecast year. In practice, the introduction of a new scheme could change travel costs that may encourage some people to travel more frequently, or further. The additional journeys resulting from the change in costs is known as ‘variable demand’. A range of research and other studies have been commissioned to understand its impact. Simple elasticities are usually applied to calculate variable demand, but the prediction of changes in the overall pattern of demand is complex. Given the focus of this report, it is not intended to discuss variable demand further. For further information on variable highway demand, readers should refer to “User Friendly Multi-Stage Modelling Advice, DTLR, 2001. (Reference 13).

## OTHER SOURCES OF DEMAND DATA

C17 The DTLR maintains a database of surveys, originally set up to cover roadside interview surveys, but which has been extended to cover both household interview and public transport surveys

C18 The DTLR have developed a set of national passenger rail matrices. These are based on CAPRI (Computer Analysis of Passenger Rail Income) data and are available by trip purpose. Use of the national passenger rail matrices must be cleared with DTLR on a case-by-case basis. Some care should also be taken when deriving matrices from CAPRI data for a detailed network model due to the level of spatial detail which may require plausible assumptions to ensure that journeys are distributed in a reasonable manner.

C19 Data from the 1991 Census, in the form of Census Matrix Tools (CMT) can form a useful source of demand data for both highway and public transport. Although this relates to journeys to work, it can form a useful starting point for peak period trip matrices, particularly for the early stages of scheme development

## MATRIX ESTIMATION

C20 A distinction should be made between *matrix infilling* where unobserved elements of a trip matrix are in-filled, generally by a partial matrix technique, and *matrix updating* where a trip matrix is converted to a new base year using count data. The former is generally undertaken at the time of the original development of the trip matrix and should be carried out by vehicle type/trip purpose. Matrix updating techniques include global factoring, factoring by sector or matrix estimation techniques. The latter approach is usually adopted, assuming count data are available. Because matrix estimation cannot be carried out by trip purpose, it "***is not considered a suitable technique for infilling a trip matrix***" (DMRB Volume 12A, Section 4.3.18). A thorough description of the partial matrix technique is given in DMRB Volume 12A, Sections 4.3.17 to 4.3.27.

C21 Matrix estimation techniques can be used to make the best use of existing data and to reduce the need for expensive surveys. The validity of such an approach is heavily dependent upon the quality of the information input by the user and the weight placed on the different elements of data. However the technique is well suited for updating existing matrix information with more recent count data. Care should be to avoid generating matrices that provide a good match against observed count data, but bear little resemblance to actual trip patterns.

C22 Where matrix updating includes the incorporation of new roadside interview data together with matrix estimation, care must be taken to ensure that the fully observed data from the roadside interviews are not updated. Care must also be taken to ensure that counts on adjacent links and at junctions (if junction count data are used) are consistent in terms of survey dates and the continuity of the count data.

C23 Matrix estimation can be carried out with both highway and public transport trip matrices using the same basic principles, although the format of count data will vary. Highway count data tends to rely on link-based traffic count data and are probably more accurate than that available for public transport which rely more on road side volumetric observations or boarding and alighting counts

# ANNEX D - MODEL CALIBRATION

## INTRODUCTION TO MODEL CALIBRATION

D1 There are several fundamental issues regarding model calibration that require practical guidance. There are five main questions.

- Where should revealed preference data be used?
- Where should stated preference research be carried out?
- If primary SP is not required, under which circumstance can model coefficients be imported from other areas?
- What range of values of time is acceptable?

D2 When SP research is carried out, what procedures should be followed? In line with the general principles articulated by GOMMMS (Volume I section 5.2), we assume that all mode choice models will have a generalised cost formulation, though the way in which the components are combined may be specific to the study. Given a definition of generalised cost, as discussed below, the critical aspect of the calibration is to set the scale parameters.

D3 As discussed in Annex A, most models of mode choice are based on a single level logit choice model formulated as:

$$P_i = \exp(-\lambda C_i) / \Sigma_j [\exp(-\lambda C_j)]$$

where $C_i$ is the generalised cost of option i and $\lambda$ is the scale parameter. Hierarchical choice models can also be used where $C_i$ is the result of an earlier choice such as destination, in which case, there will be a separate scale parameter at each level in the hierarchy. These must increase in (absolute) size as the hierarchy is descended. Models can also operate incrementally and predict the change from the base situation resulting from changes in generalised cost, or in part of the assignment routines (for example, highway route choice or the choice between different public transport modes).

D4 The definition of generalised cost usually relates only to the ‘level of service’ (LOS) variables (in-vehicle time, frequency etc) but it is invariably found that these in themselves are not sufficient to establish the pattern of mode share, and that ‘alternative-specific constants’ (ASCs), usually referred to as modal constants or penalties in this context, are required. The notation is often ambivalent as to whether these are included within the Ci terms or not, but they will need to be present in the model formulation.

D5 Choice model calibration requires:

- the setting of the generalised cost component weights;
- the setting of the modal constants; and
- the setting of the scale parameter(s).

These are described in detail in the following sections.

## GENERAL PRINCIPLES OF CALIBRATION

D6 Ideally, all the elements of the calibration would be obtained by a maximum likelihood estimation using revealed preference (RP) data, using the general principles of discrete choice analysis (for a straightforward introduction, see Ortúzar & Willumsen, Chapter7 (Reference 12)). It will be rare, however, to have RP data of sufficient scope and quality to allow this to be done and therefore it becomes necessary to make use of values from other sources, relying on principles of ‘transferability’.

D7 This topic is also usefully discussed in Chapter 9 of Ortúzar & Williumsen. Model transferability can be considered as a practical approach to model estimation for a study area with limited resources and is based on the idea that parameters from one study may provide useful information for estimating a similar model in a different area, though they may need to be scaled.

D8 Stated Preference (SP) data may be useful for providing some of the calibration elements. However, it is essential to note that models developed entirely from SP data are not usually appropriate as **demand** models. In general, SP is of most use for the setting of the generalised cost weights, of doubtful use for the setting of the modal constants and of almost no use for the setting of the scale parameter(s). Although techniques exist for the **combined** analysis of RP and SP data in a particular study area, this remains a difficult technical area. Further advice can be found in Wardman & Shires, "Comparison of within-mode revealed preference and stated preference choice models, AET, 2001, Reference 14)

D9 In many cases there should be sufficient RP data to allow the last two elements (constants and scale parameters) to be acceptably estimated, after setting the generalised cost weights (either by default assumptions or from SP data). If this is not the case, then the best recourse will be to adjust the scale parameters to reproduce plausible elasticities. Provided care is taken with units for generalised cost, experience has shown that mode choice scale parameters tend to lie in a reasonably narrow range, generally 0.02 to 0.09, when the units are "in-vehicle time per one-way trip". (Appendix B "Traffic Impact of Highway Capacity Reductions: Report on Modelling", MVA Ltd., March 1998, Landor Publishing) (Reference 15). No satisfactory rules for transferring modal constants have been devised as they tend to vary between calibration areas. However, for the reasons explained later in this annex, such constants are not required with incremental models except for new zones..

D10 Section 6.5 of the IHT Guidelines for Developing Urban Transport Studies gives general advice on model calibration. Ideally a disaggregate approach to calibration (estimation) should be taken in which each observation is analysed separately: this will certainly be most efficient when different 'segments' of the travelling population need to be distinguished.

D11 It is unlikely, however, that the LOS variables will be available at a disaggregate level of detail - typically, they will be zone-to-zone averages. When the number of segments that are required or feasible is small, then an aggregate calibration at the level of the O-D pair will be acceptable. In this case the 'observation' is the proportion using different modes for each separate O-D pair. A good example is the Heathrow Surface Access Model (HSAM) which used RP data from the Gatwick Express to calibrate a mode choice model for the Heathrow Express.

D12 Regression techniques are not generally suitable for calibrating discrete choice models, though in certain circumstances a linearising transformation may be used. Recourse is normally necessary to specialised software which is not available in standard spreadsheet applications. While this software is primarily directed at disaggregate estimation, most packages can also be used with aggregate (ie. grouped) data.

D13 Nevertheless, aggregate RP calibration is unlikely to be very satisfactory in terms of establishing appropriate weights for the generalised cost components: the most that is normally expected is that the values obtained are reasonably in line with expected default values. It is very often necessary to 'force' plausible values into the estimation.

D14 We therefore go on to discuss how best to set up the generalised cost weights in the normal case, where the RP data is of insufficient quality to determine them.

## GENERALISED COST COMPONENTS

D15 The standard assumption is that generalised cost is a linear combination of money and time components, plus penalties for interchange etc. Clearly, the specification for public transport is inherently more complex than that for the car mode, although car journeys may involve some walking, and some proposals have been made for valuing parking search time or time spent in queues, more highly than time spent freely moving in the vehicle.

D16 It is convenient to deal first with the combination of in-vehicle time and money, and then to relate other non-money components to in-vehicle time. For reasons discussed in GOMMMS (Volume 2 Appendix A, paragraphs 2.90 to 2.93), it is recommended that generalised cost be measured in units of in-vehicle time. Thus we have, in broad terms:

$$C = M/v + [t + k_{wt}\ wt + k_{wk}\ wk + ......]$$

where v is the 'value of time' (converting between money M and in-vehicle time t), wt and wk are respectively waiting and walking time, with appropriate weights $k_{wt}$ and $k_{wk}$ relative to in-vehicle time.

## VALUE OF TIME

D17 There is a large corpus of evidence relating to the value of time and the DTLR makes periodic recommendations most recently in its 'Transport Economics Note', although these values relate primarily to appraisal rather than behavioural values for modelling. A useful review of the literature and the results is given in Wardman (1998a) (Reference 16). Typically, separate values are used for business and leisure purposes. The topic is under investigation by the Department and further recommendations will be forthcoming which should provide more detail on the variation in values according to traveller characteristics, including income.

D18 As a default, it should be acceptable to use the national values for working and non-working time given in the Transport Economics Note: note that these are in 1998 values and price levels and should, therefore, be adjusted for later years. However, a case can be made for using local values, either by adjusting the national values to reflect known variations in the local population, such as different average income, or by conducting SP studies as discussed below. Alternatively, results from existing SP studies for comparable areas can be used.

## GENERALISED COST WEIGHTINGS

D19 It is standard practice in calculating the total generalised cost of travel to weight the different components of a public transport journey to reflect passengers' preference or dislike for each element. This is generally done by weighting walk and wait time in relation to in-vehicle time (IVT) and by use of an interchange penalty to represent the inconvenience of having to change services.

D20 Section 6.11.10 of the IHT Guidelines for Developing Urban Transport Studies states: *"indication of the relative valuations of travel time that have been derived from transport modelling studies and surveys is shown below:*

- *walk time 1.5 to 2.0 times in-vehicle time*
- *wait time 1.5 to 2.5 times in-vehicle time*
- *interchange penalty 5.0 to 10.0 minutes of in-vehicle time".*

D21 There is also a large corpus of evidence also reviewed by Wardman (1998b) (Reference 17). This review of evidence of service quality valuation using values from behavioural choice models estimated on either RP or SP data suggests that walk and wait time are valued less than the conventional rate of twice IVT, and that, if a single weight is used, a value of around 1.6 would be more appropriate. It also suggests that the same weighting of walk and weight time relative to IVT for business travel as for non-business travel is appropriate.

D22 Work undertaken on behalf of DTLR by Wardman at the University of Leeds (Reference 18) provides up to date estimates of generalised cost weightings.

D23 In addition, in the rail context, substantial recommendations have been made by SDG (2000) in the Rail Industry Forecasting Framework (Reference 19) . However, a case can also be made for deriving local values by conducting SP studies or using existing SP studies.

D24 It may be noted that there is very little evidence relating to the influence of socio-economic variables on these relative weights: in general, therefore, socio-economic variables are held to influence the value of time but not the relative weighting of different time components. The broad range of weightings quoted is reasonably consistent and values corresponding to these ranges would be expected. It seems logical that car available segments are likely to have a greater resistance to walk and wait time and this should be reflected in the weightings applied.

D25 There are thus a variety of options available for setting the generalised cost weights when a full RP calibration is not practical. The choice between these alternatives will depend essentially on convenience, resources and the extent to which the local area is considered to be different from the national picture.

D26 The LTP guidance states that although SP can *"often provide useful inputs to the modelling process, the Department will not insist that primary stated preference research is carried out, providing some suitable alternative can be identified"*.

## SETTING THE MODAL CONSTANTS AND SCALE FACTORS

D27 The theoretical property of the modal constants is that they ensure that the overall mode shares are reproduced over an area which the user may define. This normally implies that the aggregate mode shares for smaller areas will not be perfectly reproduced, though they may not be known anyway.

D28 If not even the overall shares are known, then it is very unlikely that a useful model can be constructed: some data relating to modal shares is essential. However, in better circumstances much more information may be available and the issue is how this may be used.

D29 In the best circumstances, base modal matrices are available, representing the number of journeys made by each mode between each O-D pair. In this case the best course of action is to use these matrices directly and build an incremental model. In effect, this is equivalent to having separate modal constants for each O-D pair (though it is not necessary to estimate them). With the exception of 'new modes', discussed below, the setting of the modal constants can then be dispensed with.

D30 In intermediate cases it might be useful to estimate modal constants separately for different movement 'sectors' - for example, between movements within the centre and movements from the centre to outlying areas etc. Clearly, this will depend on the amount of data available and the extent to which the implied modal constants vary from the overall average.

D31 It is important to note that the modal constants and the scale factors are inter-dependent so that it is not possible to change one without changing the other. Typically, a simultaneous or sequential adjustment process is required. Section 9.4.4 of Ortúzar & Willumsen outlines the procedure.

D32 As already noted, a scale parameter is required for each level in the hierarchy: for modal constants it is necessary to estimate one fewer constant than the number of available modes - arbitrarily, one of the modes should be selected as the 'base', having a zero constant. This choice has no impact on the model predictions, merely on the interpretation of the constants.

D33 In certain cases it might be acceptable to 'borrow' values of the scale parameters from other studies. It is never acceptable to borrow the modal constants. If the scaling parameters are borrowed, more weight must be put on the validation, particularly in relation to the elasticities, discussed below.

D34 Ortúzar & Willumsen (section 9.4.3) note, in relation to transferability, that "differences in the mean values of the error distribution will be relatively large, the differences in the standard deviation will be smaller, and the differences in the parameter estimates the smallest". Hence they recommend that "efforts to improve model transfer should emphasise adjustment of constants first, parameter scale second and relative values of the parameters last". Note that this relates to the amount of effort put into these three aspects, rather than the order in which it is done.

D35 In practical terms, therefore, the procedures to adjust parameters involve local re-calibration using RP data. The Manchester Metrolink Monitoring Work (Reference 20) has resulted in the development of demand models calibrated from data in a context where light rail (LRT) is operational. This is the only instance of such models in the UK, and the report suggests that *"serious consideration"* should be given to RP models for both car available and non-car available market segments to form an appropriate basis for the appraisal of LRT elsewhere.

## STATED PREFERENCE STUDIES

D36 Ortúzar & Willumsen provide a useful introduction (section 3.3.4) to SP data collection and also discuss the analysis (section 8.6). More detailed texts are available: SDG and HCG have produced the joint publication 'Stated Preference Techniques: A Guide to Practice', while a recent thorough theoretical treatment is available in Louviere, Hensher & Swait (2000), 'Stated Choice Methods' (Reference 21).

D37 For this reason detailed discussion is not given here. However, Ortúzar & Willumsen note that the design and analysis of SP experiments is demanding *"in terms of survey design, ... the requirement for trained survey staff and quality-assurance procedures should be designed to ensure realistic responses."* They also stress the need to ensure realistic responses in terms of:

- the need to identify and present all key attributes with plausible and realistic 'packages of options';
- easy to understand option presentation within the respondent's experience and constraints;
- the need to ensure a 'rich and representative' data set - general good practice is that:
    - at least one pilot survey is required to test the suitability of the experimental design, the adequacy of the way in which it is presented and other practical management issues. At least 15 to 20 interviews are necessary;
    - respondents will need to be 'segmented' by, eg. trip purpose, car ownership etc. The number of interviews per market segment is recommended at between 75 and 100. Hence, an SP survey with a segmentation of work/ non-work trips and car ownership would require at least 300 interviews and preferably 400;
- appropriate survey conduct and quality assurance; and
- the need to ensure appropriate model estimation techniques.

D38 The analysis of SP data is invariably done at a disaggregate level by means of discrete choice modelling techniques, almost always logit. Since pairwise presentation of options is now the industry standard, the use of the binary logit does not suffer from some of the theoretical objections that are often raised to the use of the logit model in more complex choice situations.

D39 For choice based SP, the choice made for each set is treated as an independent observation. The estimating program will need to know:

- the alternatives in each choice set;
- the attributes of those alternatives; and
- the alternative actually chosen.

D40 On this basis the maximum likelihood (ML) estimates of the utility coefficients can be estimated.

## INTRODUCING NEW MODES

D41 The introduction of 'new modes' (or, more generally, new options within a discrete choice framework) remains a difficult area where little progress has been made. A review of the general issues is given in Bates (1992) (Reference 22). The first question to be addressed is: under what circumstances should an alternative be recognised as a 'new' mode? This relates to the similarity of and key differences between alternatives and the identification of modal constants within the utility function. A further question is the position of a new mode within the model hierarchy . For example, for a simple binary choice case, to which a third alternative is introduced, there are three possibilities:

- C enters at the same level as A and B;
- C is nested with A; and
- C is nested with B, and that choice is considered before B enters the choice sets.

D42 It can be shown that, for a given utility for C, there is considerable variation in the market share prediction depending on the hierarchical assumptions. The number of possible hierarchical structures will increase, of course, combinatorially with the number of alternatives.

D43 It is difficult to provide advice on the preferred hierarchical structure without calibration data, which can only be obtained when the new modes have been installed. Of course, the parameters must obey the rules that there must be a separate scale parameter at each level of the hierarchy which must increase as the hierarchy is descended.

## MODAL CONSTANTS FOR NEW MODES

D44 The above discussion showed that even if we are confident about measuring utility for the new mode, the predictions are still uncertain because of alternative hierarchical possibilities. But, in reality, we cannot be in any way confident about the utility of the new mode because a major element in the utility of existing modes is the modal constant relative to the most closely related existing alternative.

D45 There are three methods for consideration:

- revealed preference studies in situations where the new mode has actually been introduced;
- attempting to 'decompose' existing modal constants into attribute effects and thereby to deduce the likely value for the new mode; and
- stated preference approaches which describe the new mode to existing travellers.

All these methods involve considerable difficulty.

D46 In principle, the revealed preference approach offers the most reliable way forward, as with the Manchester Metrolink case described above. As well as providing a direct estimate of the modal constant for the new mode, it also provides evidence about the appropriate hierarchical structure, as discussed earlier. However, there are major impediments. In the first place the new mode may not actually have been introduced anywhere, or at least not in a form sufficiently close to the proposed introduction to offer reasonable guidance. Even if it has been introduced, the expense of surveying in a different area may be prohibitive. In addition, there are well known requirements for successful revealed preference studies of discrete choice (in particular those relating to the proportion of 'genuine' choices relative to cases where one alternative is clearly dominant) which require careful design and are not easy to satisfy.

D47 Finally, even after overcoming these problems, the fundamental issue remains of the interpretation of the modal constant and its scope for transferability. Thus, while such studies need to be encouraged, it would be unwise, without a major improvement in goodness-of-fit, to expect them to solve the problem. The same applies to the other methods proposed.

D48 In cases where no such revealed preference information for the new mode is realistically available, some researchers have attempted to 'explain' modal constants for existing modes. It may be argued that if these modal constants have actually been calibrated for the population who will experience the new mode, then the method has some additional validity because a certain amount of the population-specific aspects of the modal constants may be netted out.

D49 Nonetheless, the exercise involves a considerable amount of judgement as a paper by Bates, Ashley & Hyman (1987) (Reference 23), in the context of mode choice to Heathrow Airport, makes clear. Here RP analysis had produced a modal constant for London Underground relative to main-line rail services. It was then hypothesised that this ‘utility difference’ was due to the different incidence and importance of various quality factors (comfort, provision for luggage, information etc.) and the overall difference was disaggregated among these factors. For the new mode (in this case an express rail service to the airport), the relative levels of these quality factors were also estimated and these then made corresponding contributions to the modal constant.

D50 Since Stated Preference methods address themselves directly to the problem of presenting hypothetical options, they would seem to be well suited to the problems of estimating the "inherent disutility" of a new mode. Typically, such studies are applied to users of existing modes who are then presented with a choice between their current mode and the new mode while a limited number of design variables, like cost and time, are varied. In simplified form, it is then possible to estimate a model along the lines of:

$$\Delta U = a + b_t \Delta T + b_c \Delta C$$

in which a is the required modal constant.

D51 There are, however, a number of problems quite apart from those relating to the ‘presentation’ of the new mode. In the first place an examination of such models calibrated at the individual level indicates a very high degree of variation in the value of ‘a’ and, more seriously, a strong tendency for individuals to show a bias towards their current mode and towards any hints about the improvements being considered in the survey design (Reference 14).

D52 Secondly, the implicit relationships between the SP constants calibrated for different mode users cannot be reconciled with the RP-based constants required to account for the market shares of existing modes. For example, if users of mode A produce an average utility difference of $\Delta_A$ between mode A and mode C, while users of mode B produce a corresponding value of $\Delta_B$ between mode B and C, there is an implied modal constant between A and B of $\Delta_A$ and $\Delta_B$: this difference cannot normally be related to RP values. This does not mean that the SP values are necessarily failing to provide an estimate of the modal constant, but it does imply that such values are not suitable for use within standard RP-based mode choice models.

D53 Thirdly, SP surveys tend to be carried out on choice-based samples and are rarely corrected for representativity. Given what is known about the properties of coefficient estimates under choice-based samples, uncorrected modal constants can be expected to be particularly vulnerable to bias.

D54 Finally, the range of model specifications tested on SP data is usually limited and often constrained by the design itself. It would certainly be generally wise to allow for mode-specific effects to interact with the in-vehicle (and possibly other) time coefficients as well as with the constant: alternative hypotheses could be tested in the usual way.

D55 The safest approach is to define a ‘reference’ mode which is the existing mode considered to be ‘most similar’ to the new mode. As a default, the constant for the new mode is assumed to be the same as that for the reference mode - any departures from this would need to be specifically justified such as a 5 minute advantage on grounds of comfort, reliability, image and so on.

## VALIDATION

D56 The calibration procedures set out earlier should ensure that the model ‘fits’ the base data. It will be necessary, however, to check its forecasting performance and the simplest way is to investigate the implied elasticity, ie. the proportionate change in market share divided by the proportionate change in some key cost variable. This approach can also be used in the case where no market data are available and it is necessary to select scale parameters without recourse to calibration.

D57 The most reliable elasticities are those related to money components: further, while some evidence on cross-elasticities is available, the values tend to be highly context-specific. Although, almost by definition, all elasticities will depend on context, 'own' elasticities are generally more transferable. It is recommended that scaling be carried out relative to fuel price (for car) and fares (for public transport modes). The simplest approach is to increase the relevant cost component by, say, 10% globally. The decrease in total market share for the mode in question allows the model-implied elasticity to be calculated, which should then be compared with published data. The scale parameters of the choice model should then be adjusted in a proportional manner. It is normally straightforward to achieve an acceptable result by a few 'trial and error' iterations.

D58 If a single-level model is being used, there is only one scale parameter to be adjusted. If two separate elasticities are tested (eg. car and public transport), some judgement will be required as to the best compromise. If an hierarchical model is being used and the relative parameter has been determined with some confidence, it is probably safer to keep this fixed and to carry out a single adjustment. For a more complex model, however, when elasticities are being tested for a number of modes, it should be possible, with care, to improve the modelled elasticities by changing the scale at different levels.

# ANNEX E - MODEL VALIDATION

## INTRODUCTION TO MODEL VALIDATION

E1 The base year model, comprising the base year network and demand models, will need to reproduce base year conditions on both the highway and public transport networks in order to form a sound basis for forecasting demand. In addition, if a mode split model has been developed, and this is used to explain primary mode choice between car and public transport, there will be a need to demonstrate that this is reproducing the observed year modal choice for key movements within the corridor.

E2 The main elements of model validation are set out below. Highway model validation is covered in significant detail in a number of guidelines, most notably DMRB Volume 12 Section 2 Part 1. Appendix B of DMRB sets out the reporting requirements for urban traffic models and describes the structure of the Local Model Validation Report (LMVR) required. No formal requirement currently exists for public transport models and it is important to ensure that adequate reporting of validation is provided, following the same structure as the highway LMVR. This is set out in DMRB as follows:

- a description of the model used and its development (including evidence of the fit achieved to the calibration data, and a description of any sensitivity tests undertaken, and their results);
- a description of the data used in building and validating the model;
- evidence of the validity of the network employed;
- a validation of the trip matrices employed;
- a validation of the trip assignment;
- a validation of any other special features (e.g. higher tier model inputs, trip end models, modal choice models, etc) employed; and
- a present year validation, if appropriate.

## NETWORK VALIDATION

*Highway Networks*

E3 There are two main types of highway model currently in use in the UK, link based and junction-based models. Link based models employ link based capacity restraint by means of speed flow curves and tend to be used for strategic, inter-urban or all day models. In urban areas, capacity restraint tends to be effected through the explicit modelling of junctions taking account of turning capacities, signal timings ant the interaction of adjacent junctions.

E4 The majority of major public transport schemes to be assessed will be in urban areas and it is therefore possible that most models will be junction based. However, link based models may be appropriate, particularly for the preliminary stages of a public transport project, or when use is made of a strategic or regional highway model.

E5 Highway network validation is covered in DMRB Volume 12A (Section 4.2.9) and will normally include:

- comparing link distances from the model with crow fly distances;
- checking the routes through the network; and
- comparing observed journey times with accumulated travel times from the model.

*Public Transport Networks*

E6 Network validation carried out for the highway model is also appropriate for bus and rail networks. In addition, the following validation checks are suggested:

- comparison of modelled bus journey times with scheduled bus timetable information which generally has some inbuilt allowance for traffic congestion;
- careful checking of rail and light rail routes in terms of frequency and stopping patterns;
- checking whether routeing through the network appears realistic;
- comparison of modelled rail/light rail journey times with scheduled timetable information. Where a new mode such as light rail is included in the do something forecast year network(s), journey times should be derived from an appropriate run-time model; and
- careful checking of the plausibility of rail or LRT service patterns to ensure that there is sufficient line capacity available to cater for the proposed service level. This will usually involve an analysis of operating patterns together with a run-time simulation model.

## MATRIX VALIDATION

E7 Demand matrices for both highway and public transport should generally be validated against screenline and cordon counts and observed trip movements. DMRB Volume 12A (Section 4.3.42) sets out procedures for assessing the accuracy of highway trip matrices based on ***"estimating the sampling error inherent in the original interview data and keeping a track of it throughout the matrix construction, infilling and updating process."*** However, it is recognised that matrices developed for assessing major public transport schemes are often based on fairly old interview data and have been successively updated using matrix estimation techniques over a number of years.

E8 DMRB Volume 12 (Sections 2.2 and 11.4) states that the maximum use must be made of suitable existing data, wherever possible, provided that they are sufficiently well documented. If the (highway) demand data are greater than 6 years old, validation should be carried out as a "forecast" of the present day and that the validation must demonstrate that the model is suitable for purpose. These procedures are equally applicable to public transport models and data. The implications of the age of the demand data should probably be considered on a case-by-case basis. Study areas which have experienced significant change in land use or economic activity since demand data were collected, with possible re distributive effects, will require more up to date data than areas where this has not occurred. Certainly, where the demand data are more than 6 years old, the case for using these data must be fully justified.

E9 Whilst the use of recent interview data for matrix construction is to be encouraged, it may be that the matrix validation techniques espoused in DMRB Volume 12A are overly stringent. Therefore, the following validation checks may be more appropriate for both highway and public transport trip matrices.

- comparison of the original highway roadside interview site matrices (if available) with model select link matrices on those links where the interviews took place; and
- comparison of sector to sector movements from the trip matrix with observed cordon/screenline counts or link loads.

## ASSIGNMENT VALIDATION

*Highways*

E10 Validation of highway models is well covered in most guidance, in particular in DMRB Volume 12A (Section 4.4.34 and Table 4.2). This is extremely useful and highly relevant guidance and is not repeated here. The major question that arises is the appropriateness of the DMRB criteria to the type of model used for major public transport scheme appraisal rather than the detailed assessment of a highway scheme. The best starting point is to attempt to validate the highway model to the same standard as if it were to be used for a traffic appraisal. However it is appreciated that this is generally a resource and time intensive task, and there may be cases where certain of the validation criteria can be relaxed. This should be discussed on a case by case basis with the Department.

E11 The following guidance on validation is offered:

- validation should be presented on an hourly basis, irrespective of the length of the time periods modelled;
- validation should be against independent data on screenlines and/or cordons;
- independent observed data should ideally **NOT** include observed data used for matrix estimation;
- validation should be presented on a link basis – the validation of junction turning movements is not appropriate to the appraisal of major public transport schemes;
- the choice of links to be validated is important and should include links that carry movements critical to the public transport scheme, i.e. adjacent competing routes;
- validation should be presented in terms of absolute and percentage differences as well as the GEH statistic, as advocated in DMRB Volume 12A (Section 4.4.42); and
- a selection of routes should be chosen for comparing modelled and observed journey times. As with link validation, it is important that routes adjacent to the public transport scheme are compared to ensure that observed conditions are reasonably well reproduced.

## PUBLIC TRANSPORT

E12 Public transport assignment validation involves comparison of observed and modelled flows on links and across screenlines and cordons. This should be done at least at the level of sub-mode (i.e. by bus, by rail, etc). However, if individual observed route count data are available, this can be done at service level. In some instances, rail census data may be available which will give station to station flows along the route of a particular service; comparison against model station to station flows is valuable if these data are available.

E13 We would expect that across a modelled screenline, public transport modelled flows should be within +/- 15% of observed, with individual links within +/- 25% on the majority of links, unless the flow is particularly low (say, <150). It may also be appropriate to supplement that information by the GEH statistic as used in highway validation.

E14 One difficulty is that the level of variation in public transport link flow data is likely to be greater than equivalent highway data due to the difficulty of accurately assessing passenger volumes. Automatic traffic counts carried out over a period of time allow traffic flows to be assessed to a relatively high degree of accuracy compared with, for example, a count of bus passengers undertaken by a roadside observer. This can lead to a high margin of error within public transport survey data and could affect the degree of validation achieved. We are aware of surveys where permission is sought from the public transport operator to stop the bus and undertake an internal on-board count. If this is possible, accuracy is greatly enhanced.. It is more usual, and probably more accurate, to have data relating to station entry and exit counts on rail and on and off flows on bus. Comparison of these data with modelled boarding and alighting should also be undertaken.

E15 We recommend, if possible, a check of implied annual patronage against recorded annual statistics, generally derived by operators from revenue. Although this will often be difficult because the study area may not coincide with the public transport operating areas, it is nevertheless a very useful basic check on the scale of patronage.

# ANNEX F – FORECASTING

## INTRODUCTION

F1 In order to produce flows on the system and provide inputs into the financial and economic appraisal, it is necessary to develop a forecast year model. The basic building blocks of the forecast year model are:

- choosing the forecast year;
- forecast year do minimum and do something supply models;
- forecast year demand matrices; and
- forecast year assignments.

F2 These are discussed below, along with the treatment of generated trips and sensitivity tests

## FORECAST YEARS

F3 For major public transport scheme assessment, it has been usual practice to develop one forecast year, generally related to the year of opening with passenger journeys, passenger revenue, user and non-user benefits extrapolated from this year onwards using growth assumptions. GOMMMS states that at least one forecast year is required to generate streams of costs and benefits, although it states that this should be typically 10 to 15 years after the opening year. Whilst appraisal at 15 year intervals is often quoted, the Department would ideally like to see appraisals at 10 year intervals.

F4 Whilst relating primarily to highway models, DMRB Volume 12A (Section 5.2.1) states:

> ***"As an absolute minimum, forecasts should be prepared for at least two years, and these should be within one or two years of the anticipated opening and of the 15$^{th}$ year."***

F5 The development of two forecast years should apply to models used to provide forecasts for major public transport schemes. Development of a second forecast year reduces the level of uncertainty, particularly with respect to the effects of traffic congestion and the level of transfer from car. Other issues, such as increasing car ownership and changes in real values of time can be more explicitly addressed as model inputs and should lead to a more robust forecast, which is to be preferred to simply factoring the model outputs from a single year. It must be stressed, however, that the forecasts are only as good as the assumptions that underpin them.

F6 DMRB argues that additional forecast years are needed to take account of:

- inaccuracies introduced into economic appraisal by interpolating/extrapolating for more than 10 years;
- years in which network constraint may occur. This may apply to both highway and public transport models; and
- years in which significant changes to demand, such as the introduction of new developments, are expected to occur.

F7 Although developing two forecast years increases the level of complexity, the DMRB recommendation of at least two forecast years should be followed. Whilst the alternative approach of applying growth factors to the benefits and revenues is simple and facilitates simple sensitivity testing, the benefits of two forecast years outweighs any disbenefits. Forecast years should be as close after the opening year as possible, and 15 years after opening to give a forecast mid-way through the appraisal period. When two forecast years are used, consideration should be given to the robustness of the changing underlying assumptions, including land use, socio-economic and transportation considerations.

## DO MINIMUM NETWORKS

F8 The do minimum network should be based on the validated base year network and should include all transport proposals that could reasonably be expected to be in place by the forecast year. The list of do minimum schemes should be discussed with the relevant local authorities with reference to their LTP and agreed with the Department. The do minimum network for the first forecast year could, therefore, be different to that for the second forecast year i.e. 15 years after opening. Proposals that could reasonably be expected to be in place generally relate to committed schemes for highways, public transport infrastructure and service proposals. Clearly a judgement will need to be made on the scale of schemes that need to be included; minor traffic management schemes may not have a material effect on traffic flows and associated modal shift.

F9 Fares should be projected with care. It may not be appropriate to assume constant real fares. Evidence of trends in real fares should be presented together with a reasoned argument for the do-minimum projection, taking account of policies and market trends likely to operate over the forecast period. The same issues also apply to highways costs such as fuel, tolls, etc.

## DO SOMETHING NETWORKS

F10 The do something network will be based on the equivalent do minimum network such that the only difference between the two networks will be the scheme being appraised and associated changes such as a competitive bus scenario different to that in the do minimum. If the reaction of bus operators to, say, a LRT scheme is uncertain, it may be appropriate to test with and without a competitive bus scenario. It will be crucial to accurately represent the journey times on the scheme being proposed. For segregated LRT systems, or sections of systems, a run time simulation model should be used, capable of including the effects of stop spacing, vehicle performance (acceleration and deceleration), gradient and curvature in general terms. For street running LRT sections, the interaction of highway vehicles and the proposed system, should be represented.

## VALUE OF TIME

F11 Both Gross Domestic Product (GDP) and the value of time are forecast to grow in real terms over the timescale likely to be covered by any forecasts. Forecasts for real GDP growth and growth in the value of time are given in the DTLR's TEN. HM Treasury produces forecasts of real GDP per head. It is assumed that the real value of time will grow in line with these and forecasts for population growth produced by DTLR, and these should be the basis of the forecast assumptions used.

## FORECAST GROWTH IN DEMAND

F12 Forecast demand matrices are required for both forecast years, for each mode being modelled and for each time period being modelled, segmented as appropriate. In the past, the approach to growth has tended to be different for highway and public transport demand. Each of these is dealt with in turn below.

*Highway Demand*

F13 Growth in highway demand is generally based on the application of growth factors to the validated base year matrix. Unless local forecasts are available from a local strategic higher tier model, factors should be derived from the National Trip End Model (NTEM) or the TEMPRO software at district level. Growth factors by district should be applied to the base year zonal trip ends and the matrix furnessed. NTEM provides growth factors for different trip purposes which will result in different growth in demand in different time periods.

F14 NTEM provides growth factors for high and low growth. Paragraph 5.17 of the Multi Modal NTEM (TEMPRO 4.2) Guidance Note suggests an equivalent allowance for uncertainty as a range about the central forecast of +/-2.5% for forecasts one year ahead, 5% four years ahead, 7.5% nine years ahead, 10% sixteen years ahead and 12.5% twenty five years ahead. It recommends supplementing those national factors by estimates of local economic and planning uncertainty drawn up in consultation with local planning authorities and this provides a possible source to derive similar scenarios for growth in public transport demand.

F15 In congested urban areas, assignment of the peak period do minimum demand may lead to unrealistic high levels of highway congestion. Guidelines for Developing Urban Transport Strategies suggests a number of responses to this including reallocation of parking demand against supply, investigation of low cost highway improvements and spreading of demand into the peak shoulders (peak spreading). These initial responses are also recommended in DMRB Volume 12A (Section 5.6) which states:

> ***"It is important that these initial adjustments to demand are made, and that steps are taken to adjust the capacity of the road system to realistic levels before more comprehensive constraints are considered."***

F16 However, where problems still persist, the application of growth constraint techniques may be required. DMRB summarises these as:

- user determined factors and cut-offs;
- matrix capping techniques;
- elasticity techniques;
- incremental loading; and
- shadow network techniques.

F17 A thorough description of these techniques is given in DMRB Volume 12A (Section 5.7) and is not repeated here. However, this is a crucial area because if constraint is not considered, the implication is that congestion and hence modal shift (particularly to segregated or largely segregated public transport schemes) could be over-predicted. It should also be stressed that the method must be applied consistently to the do minimum and do something scenarios.

*Public Transport Demand*

F18 Whilst economic performance indicators have traditionally been used to calculate underlying growth for rail trips, there has been an absence of guidance and recognised techniques for calculating growth in bus trips. Application of recent historic trends is one method, although the continuation of these trends needs careful consideration as the experience of the last few years points to a halt or reversal of downward trends in many areas. The effects of policy initiatives, such as TravelWise campaigns, as well as infrastructure improvements, such as Quality Bus Corridors, are difficult to predict but should have a positive impact on future bus patronage.

F19 Increase in highway trips, predicted by NTEM and TEMPRO, are largely a function of increases in car owning households, the proportion of which is predicted to increase over time. The corollary of this is that non-car owning households will decrease over time. Any claimed increases in public transport growth should be offset by reductions in the non-car available demand matrices, suggesting a potential decline in public transport demand, and this should be addressed when calculating trends. Care should be exercised when considering areas with significant regeneration proposals, which may or may not be included in NTEM. Clearly if proposals are excluded from NTEM, local growth may well exceed that forecast by NTEM. Scheme promoters should consult with the department before deciding on local growth factors.

F20 If a higher tier model is available, or if the public transport model is part of a four-stage model with trip generation and attraction sub-models, growth can be taken directly from these models. However, it will be important to ensure that any predicted growth is realistic and that the public transport modes are not merely being used as a "sink mode" for over capacity or constrained highway trips. This can be the case where the highway network model employs capacity constraint whilst the public transport model does not. Such a model structure should be avoided if it is likely that the highway network will become seriously congested in future years.

*Multi-Modal NTEM*

F21 The Department has developed the National Transport Model (NTM) which provides growth factors for both public transport and highways for use in local models. This is a way of ensuring a degree of consistency between the forecasts used for project appraisal in different studies in different parts of the country. The NTM is of a modular structure with data held at different levels of detail in the different components. In particular, travel demand, in the form of all-mode trip ends, is held at ward level (by applying a base-year split of zonal level data into constituent wards).

F22 The model works through a logical sequence from trip ends, to trips by different modes, to a detailed synthetic car trip matrix, to background traffic on different types and locations of road, to predicted outturn traffic taking account of congestion.

F23 TEMPRO 4.2 was released in December 2001 and presents trip ends at sub-district level – each local authority district, metropolitan borough or unitary authority is divided as appropriate into a number of named urban areas and a rural remainder.

F24 TEMPRO 4.2 calculates trip end growth factors split by time period and trip purpose, based on a fixed allocation of different trip purposes between time periods with an option of splitting trip ends by car availability, which is important for multi-modal modelling. It also includes the underlying planning and car ownership data.

F25 TEMPRO 4.2 includes a “reference case” modal split, obtained by applying a base year modal split to each market segment. This therefore includes changes in modal split over time resulting from demographic change. It does not take account of changes in the generalised cost of any mode, or the effect of increasing income (which gives any fixed monetary cost a declining behavioural impact over time). These reference case trip ends therefore form a suitable input for local models which reflect the impact of changes in modal costs, speeds and other characteristics and is an appropriate starting point for assessing major public transport schemes.

F26 It is important to note, however, when using growth from TEMPRO 4.2, that the demand assigned to the highway network should represent a “with congestion” situation rather than a pure growth of highway demand. If an unrealistic level of highway demand is assigned, this will start the forecasting process with an unrealistic set of costs for input into mode choice modelling. If an unrealistic set of costs is generated by a highway assignment, advice on growth constraint techniques given in the advice note ‘Traffic Appraisal in Urban Areas’ (DMRB Volume 12a Section 2 Part 1) should be followed. Although some of the excess highway demand could transfer to public transport, other behavioural responses to congestion are possible, such as trip suppression, change of destination or re-timing. In the absence of formal models of all these complex behavioural options. We recommend the use of a simple elasticity model or other methods given in paragraph 5.7.3 of ‘Traffic Appraisal in Urban Areas’ (DMRB Volume 12a Section 2 Part 1).

F27 In conclusion, increases in public transport demand have, in the past, been predicted with reference to recent growth trends, likely policy and network changes, increases in car ownership and other demand forecasting models. The release of TEMPRO 4.2 by the Department provides a level of consistency with highway growth not previously available. However, whatever the source, it should be stressed that growth should be examined closely over the appraisal period to ensure that it appears plausible.

*Demand from New Developments*

F28 It is likely that trips from major new developments will be included in the forecast demand. This is a complex area and needs careful treatment. On a general level, it appears prudent only to include those committed developments for which planning permission has been granted, although sensitivity tests based on less firmly committed land use should be undertaken. Committed developments should have been included in the district level forecasts from NTEM. Therefore, whilst the ***distribution and scale*** of these trips can be explicitly included in the forecasts, the resultant District level growth totals should be ***constrained*** to NTEM. However, whilst this is certainly the case for the peak periods, where trips to most developments will be for employment purposes, it may not be strictly correct for the inter peak and off peak periods for certain land uses. For example, it has been argued that trips to leisure facilities in the inter peak could be additional to those included within NTEM. Where there is a possibility of double counting, clarification should be sought from DTLR/ITEA (Integrated Transport Economic Appraisal).

## FARES AND CONCESSIONS

F29 The do-minimum projection should also provide a reasonable view of the public transport market in the absence of the scheme to be tested. This should recognise the growth in car ownership, the related fare and level of service trends on public transport and, if appropriate, any major demographic trends. Given the importance of labour costs in bus operation and the usual assumption that real incomes will continue to increase, bus operating costs are likely to increase. If at the same time average passenger loads are decreasing whilst operators maintain frequencies, fares will increase. Outside London, these trends have been present for forty years. Therefore, the do-minimum case should be defined with care to take explicit account of likely trends to establish the probably scale of the public transport market, taking account of relevant policies.

## GENERATED OR INDUCED TRIPS

F30 Evidence exists that the introduction of a major public transport scheme will result in generated trips, that is trips will be made that previously were not made. It is acknowledged that this is an extremely complex area and additional research is required.

F31 The justification for including generated trips usually comes from before and after or monitoring surveys such as the Manchester Metrolink Monitoring Study and the Midland Metro Line 1 surveys. (References 20 and 24). Monitoring work is also being undertaken for Croydon Tramlink and is due to be completed by Spring 2002.

F32 The Manchester Metrolink Monitoring Study surveys of Phase I Metrolink passengers showed that peak period trips are generally not discretionary. For off-peak period trips, a certain amount of travel was identified that would not take place if Metrolink did not exist. This traffic varied by corridor and by movement type and is shown in Table 7.1.

**Table 7.1 Phase I Metrolink Passengers who would not Travel if Metrolink were Not Available**

| Time Period | Movement | Percentage of Passengers |
|---|---|---|
| AM Peak | Bury Corridor – Central Manchester | 3.2% |
| | Altrincham Corridor – Central Manchester | Less than 1.0% |
| Off Peak | Bury Corridor – Central Manchester | 7.0% |
| | Altrincham Corridor – Central Manchester | 2.6% |
| | Within Bury Corridor | 2.1% |
| | Within Altrincham Corridor | 2.1% |
| | Cross City Centre Trips | 17.8% |

F33 The proportion of trips which could be considered as new trips for Phase I was 4.3% of total Metrolink off-peak patronage. The MMS report notes that this is a complex issue that cannot be determined through passenger surveys alone and also uses an alternative method to consider generated trips. This was to consider growth in overall demand across all modes for trips of interest, defined as those for which Metrolink was a competitive alternative. Household surveys undertaken in the pre- and post-Metrolink situations showed an increase in the number of trips of 9.2% between 1991 and 1994.

F34 The Midland Metro Line 1 surveys indicated the percentage of trips not made before Line 1 opened were 23% in the AM peak period and 26% in the inter peak period. This appears high for a short run effect compared with Manchester. There are a number of factors that could contribute to the higher proportion of generated trips in the West Midlands, including:

- changes to home or work location may be a contributory factor in the higher proportion of trips using Midland Metro Line 1 who had not made the trip previously. A proportion of these trips could be unrelated Midland Metro Line 1 but due to other effects including land use changes;
- Midland Metro offers a new service for part of its alignment, whereas Manchester Metrolink was a replacement of an existing service, albeit with frequency and accessibility advantages;
- Midland Metro offers a lower fare structure compared to Manchester Metrolink and the West Midlands scheme is also within an area offering an integrated ticketing system.

F35 In the absence of any corrobatitive evidence we believe that the projections for generated trips reflect other things over and above pure generation and could therefore be an over estimate.

F36 Unless other evidence is presented, we conclude that peak generated trips should not be allowed. There is a practice of applying a factor of 15% of trips forecast to transfer from other modes in the off peak. Whilst the source of this factor is uncertain, it does at least act as a proxy for some of the effects grouped under generated or induced traffic and is consistent with the finding from the Manchester Metrolink Monitoring Study. Therefore, in the absence of new primary research, local evidence or a forecasting model capable of predicting generated demand, the inclusion of a factor of 15% to represent off peak generated travel is permissible. No generated travel should be assumed for the peak periods.

## SENSITIVITY TESTING

F37 Sensitivity tests around a central case should be undertaken to assess the impact of the forecasts to a range of different assumptions. The definition of the central case is important here; we recommend that it include the do something model, together with:

- an allowance for generated trips;
- average growth in demand;
- an allowance for disruption during construction; and
- an allowance for the effects of induced traffic.

F38 DMRB (12.2.2) provides guidance on the recommended approach to calculate induced traffic. The guidance recommends different elastcities should be used to calculate induced traffic, dependent on journey purpose and time of the day.

F39 A number of standard tests can be readily undertaken, some of which are relatively simple financial exercises based on goal seek analysis of key variables and do not require that the transportation model be re-run. These include sensitivity tests to;

- assess the level of demand necessary for the net present value to be equal to zero; and
- assess the level of demand necessary for the operating ratio (i.e. the ratio of annual revenue to annual operating cost) to be equal to zero.

F40 Given the simplicity of these tests, they should be undertaken in order to assess the robustness of the forecasts. However, there are a number of additional sensitivity tests that could usefully be undertaken and which give additional comfort. Although the list is not exhaustive, the major types of test are summarised overleaf.

- Changing the profile of build up of the benefits during the early years immediately after the opening of the scheme.

- different highway decongestion values or unit rates;
- an assessment of the impact of complementary schemes (such as congestion and workplace parking charging);
- a competitive response by other public transport operators. Note that this depends largely on the assumptions in the central case;
- sensitivity to different central case assumptions such as public transport fare levels or journey times; and
- different planning or economic growth assumptions.

F41 Depending on the nature of the forecasts and benefits produced by the model and the appraisal, the Department may also wish to see additional sensitivity tests. For instance, if it is felt that the level of transfer from car to the proposed public transport scheme is high, there may be a need to undertake sensitivity tests assuming a lower rate of transfer from car.

# ANNEX G – APPRAISAL ASSUMPTIONS AND FORECASTS

## INTRODUCTION

G1 Major public transport schemes will generally be submitted to the Department as part of the LTP process. The Department expects the appraisal of the major public transport scheme to include an annex setting out in detail any demand and revenue forecasting work undertaken. Details of the minimum the Department would expect to see in the annex are set out below.

## DEMAND DATA

G2 The Department will require a clear description of the sources and basis of any data used to develop the forecasting model. This should include sample rates for both highway and public transport survey data and a commentary on how these relate to existing guidance on sample rates (for example in Chapter 6 of DMRB, 12.1.1). If data from existing models are used, details should include the base year at which data for these models was collected, the degree of validation of these models and any adjustments to the base year data such as factoring or matrix estimation.

## BASE YEAR VALIDATION

G3 A clear description of the highway and public transport model validation should be provided. This should include details of the source and base year of the independent validation data set, together with tabulations showing modelled data, observed data, percentage differences and the GEH statistic. The validation should be presented on screenlines and/or cordons relevant to the scheme being examined. The implications of any areas of validation outside the guidelines to the scheme forecasts should be explained.

## MODEL STRUCTURE

G4 An explanation of the model structure should be given with justification of any structure outside existing guidance. All model parameters, including modal constants, scaling parameters and weights attached to out-of-vehicle times should be set out, together with a description of how these parameters were derived and how they were applied in the mode choice models. If sub-mode (public transport) choice by assignment is used, a description of the assignment procedure and any other assumptions should be provided.

## GROWTH

G5 The basis of growth should be clearly described with tabulations provided on growth by market segment. If differential growth over time is assumed, growth factors by year should be provided. The total growth over the appraisal period must be provided. Use of different growth to the Departments' TEMPRO 4.2 predictions must be fully justified. Assumptions on trips from developments must be clearly set out and clarification sought from the Department to ensure that there is no double counting of these trips by applying growth over and above TEMPRO 4.2.

## FORECASTS

G6 Forecasts of patronage for the scheme should be provided for the two model years, one of which should be as close as possible to the scheme opening year. Forecasts should be broken down by source and by model time period in order to identify the proportions of trips diverting from car and from other public transport modes, trips associated with new developments together with any newly generated trips. Annual patronage should be presented, together with the source and basis of the factors used to convert model time period forecasts to annual forecasts. Finally, the implications of patronage growth on rolling stock should be presented and any capacity problems identified.

## APPRAISAL

G7 The requirements of the appraisal are covered elsewhere, particularly in Guidance on Full Local Transport Plans, Major Public Transport Scheme Appraisal in Local Transport Plans (Part1: Detailed Guidance on Public Transport Schemes). However, it is worth re-iterating a number of requirements here.

G8 Assumptions on patronage build up over the early years of the scheme should be presented. The values of time used in the economic appraisal should be set out and be consistent with TEN. A clear explanation of the derivation of non-user benefits should be provided. If a congested highway assignment model is used to derive decongestion benefits, the implied pence/vehicle kilometre removed from the highway network should be reported. If a highway model is not used to derive decongestion benefits, the rates used should be based on the range suggested by the Department in the LTP Guidance and should relate to the level of highway congestion. The economic appraisal should be based on a willingness to pay approach advocated by the Department. The algebra and values of time used should be clearly explained. If a modal constant is included as a user benefit, to represent for example quality and reliability benefits, the present value associated with this should be separately identified to user travel time savings.

## ANNEX H – REFERENCES


1. DTLR (2000): *Major Public Transport Scheme Appraisal in Local Transport Plans: Detailed Guidance: Version 1*
2. DTLR (2000): *Guidance on the Methodology for Multi-Modal Studies*
3. DTLR (1996): *Design Manual for Road and Bridges, Volume 12 Section 2 Part 1: Traffic Appraisal in Urban Areas*
4. DTLR (2001). Transport Economics Note.
5. DTLR (1996): *Design Manual for Road and Bridges, Volume 12 Section 2 Part 3: ????*
6. DTLR, 2002. Summary Guidance on Economic Valuation with Stated Preference Techniques.
7. Bateman, et al., 2002. Manual on Economic Valuation with Stated Preference Techniques.
8. The Institution of Highways and Transportation (1996): *Guidelines for Developing Urban Transport Strategies*
9. Hague Consultancy Group and Steer Davies Gleave (1992) *Stated Preference Techniques. A Guide to Practice*
10. DTLR (1996): *Design Manual for Road and Bridges, Volume 12 Section 1 Part 1: Traffic Appraisal Manual*
11. Strategic Rail Authority Planning Criteria: *A Guide to the Appraisal of Support for Passenger Rail Services*
12. Ortúzar, J de D and Willumsen, L G (1994): *Modelling Transport (Second Edition)*
13. Bly B, P Emerson, T Van Vuren & N Paulley (2001) *User-friendly multi-stage modelling advice,* Transport Research Laboratory.
14. Wardman & Shires, "Comparison of within-mode revealed preference and stated preference choice models, AET, 2001
15. "Traffic Impact of Highway Capacity Reductions: Report on Modelling", MVA Ltd., March 1998, Landor Publishing
16. Wardman, M (1998a), *The Value of Travel Time: A Review of British Evidence*, Journal of Transport Economics and Policy 32 (3), pp 285-316
17. Wardman, M (1998b), *A Review of British Evidence on the Valuations of Time and Service Quality*, Working Paper 525, Institute for Transport Studies, University of Leeds.
18. Wardman, M. 2001. Public Transport Values of Time. Working Paper 564. Institute of Transport Studies, University of Leeds.
19. Steer Davies Gleave (2000): *Rail Industry Forecasting Framework*
20. Oscar Faber (1996): *Metrolink Monitoring Study*
21. Louviere J J, D A Hensher and J D Swait (2000): *Stated Choice Methods: Analysis and Application*, Cambridge University Press

22. Bates J J (1992), Developing Choice Models to Deal with New Transport Alternatives, 6th World Conference on Transport Research, Lyons, France.

23. Bates J J, D J Ashley and G Hyman (1987), The Nested Incremental Logit Model: Theory and Application to Modal Choice, PTRC Summer Annual Meeting, Seminar C.

24. Midland Metro Passenger Services Director (1999): *Midland Metro Line 1 User Surveys*, Report to Management Team Meeting