Summary Advice on Modelling

TAG Unit 2.4

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Department for Transport

Transport Analysis Guidance (TAG)

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1 Summary Advice on Modelling

1.1 Introduction

1.1.1 The creation of a transport model, along with the collection of the necessary data, is potentially costly and time consuming. Thus, it is sensible to consider whether a model is required at all. The key factor to consider is whether it is possible to make robust decisions without a model. The test for robustness is that there should be a high degree of confidence that decisions would not be different if the analysis was conducted at a greater level of detail or precision; thus, in this context, the issue is whether decisions made without the assistance of a model would be different if a model was available.

1.1.2 In practical terms, the decision to proceed without a model will depend on whether all of the consequences of a transport strategy or plan can be predicted without a model. The Multi-Modal Studies are intended to address the most severe transport problems. The consequences of transport strategies or plans providing solutions to these problems will often be particularly widespread and complex, involving direct and indirect effects, cross-modal effects and, in some instances, effects on land use as well as transport. It is important, that an appropriate level of effort is provided to assess these consequences, to ascertain the extent to which objectives are met and problems solved, and to estimate the value for money of the strategy or plan.

1.1.3 It expected that a computer model of some or all of the transport system will be required in each of the Multi-Modal Studies. Generally, given the nature of the Studies, these models will need to be multi-modal. In some cases, the model of the transport system may need to be linked to or embedded within a wider model of relevant aspects of land-uses and the economy.

1.1.4 It is vital that the scope for using existing models and data is carefully considered and that new models and data are up to the task. Careful consideration should be given, before resources are committed to data collection and model building, to the nature of the options which it is likely to wish to test and the required level of detail of the analyses.

1.1.5 This TAG Unit provides advice on the form of models appropriate to the Studies in summary form only. More detailed advice is provided in *Modelling* (TAG Unit 3.1), which, in turn, contains information about other sources of advice which may be useful.

1.2 General Principles of Transport Modelling

1.2.1 The four fundamental features of a multi-modal transport model are as follows.

- The impedance to travel is measured by the **'generalised cost'** of travel. This usually consists of a linear addition of the elements of journeys, such as time spent walking, waiting and travelling in-vehicle, plus money costs of using private vehicles or public transport, with the various elements weighted to reflect their importance to travellers. It is through the manipulation of these elements of generalised cost that the impacts of transport interventions are represented in a model.

- The elasticity of the demand for travel to changes in generalised cost is modelled through use of a **'demand curve'**. The traveller responses generally represented in multi-modal models are change of mode and destination, with change of frequency and time of travel also being represented in some more sophisticated models. The accuracy of the demand model is also influenced by the extent to which the demand is segmented into separately identifiable and behaviourally distinct groups of travellers. The more such segments are treated separately, the greater the accuracy of the modelling, but also the greater the complexity of the model and the longer the run times. Simple models use aggregate elasticity values, which represent in a single number all traveller responses. More complex models use linked hierarchies of equations which represent individual traveller responses separately and, it is argued, more realistically.

- As travel demand increases, so congestion on the transport system, especially the road system, increases, thereby increasing the generalised cost of travel. Transport supply effects of this kind define a **'transport supply curve'.** They may also occur in other aspects of the transport system, through over-demand for parking or crowding on public transport. The realism with which these effects are represented is usually a matter of detail - the more detail, the greater the realism. The accuracy of the model outputs may be as dependent on the realism of the implied transport supply curve as on the realism of the travel demand curve. The accuracy of the supply model is related to the level of spatial detail at which it operates. The larger the number of zones for any given area, the more accurate are the results likely to be, but the longer will be the model run times.

- The accuracy of the model output, especially the costs and flows which are used in the appraisal, are crucially dependent on the accuracy with which the equilibrium between travel demand and supply is determined. The need for this accuracy should not be overlooked by modellers.

These issues are discussed in more detail in *Modelling* (TAG Unit 3.1).

1.2.2 There is a trade-off between: (a) segmentation of demand, (b) degree of spatial detail, and (c) the accuracy with which equilibrium is found. With models of small areas, compromise may well be unnecessary, but with large study areas, treatment of some elements of the model in an approximate fashion may be inevitable if reasonable run times are to be achieved without compromising the robustness of the model results.

1.3 The General Principles of Land-Use Modelling

1.3.1 Transport models work on the assumption that land uses are fixed, both in location and magnitude. However, it may be relevant to consider the relationship between 'land-use' and 'transport' for three reasons:

- land-using activities and the interactions between them generate the demands for transport;

- those activities and interactions are to a greater or lesser extent influenced by the availability of transport; and

- the linkages between transport and activities may be important to the appraisal of transport strategies - especially when trying to consider whether the transport system is providing the kind of accessibility to activities that people and businesses require, rather than simply providing mobility for people and businesses.

1.3.2 It may be feasible to explore these issues without using land-use models. Different land use inputs can be used to explore the sensitivity of transport models to land use, while the impacts on land use of different transport strategies or plans can be assessed by planners, based on the outputs of transport models. However, these relationships are often complex, thus the use of a formal modelling approach may be valuable in some cases.

1.3.3 **'Land-use/transport interaction models**' represent the influences of transport upon different groups of economic agents (individuals and households, firms and other productive organisations, and national and local government) by modelling some or all of the markets (property, labour, and goods and services) through which they interact. As their name indicates, they model both the transport and land-use systems, and relate the behaviour of residents and firms to physical changes in land-use.

1.3.4 The economic interactions between activities, such as flows of workers to workplaces or of services to consumers, are obviously related to, though not identical with, transport demands. Land-use/transport interaction models can be classified into two broad groups according to their treatment of these interactions, as follows.

- One group consists of models where the economic interactions between activities are used in predicting where land-uses will locate. These are referred to as **'integrated'** models, because the land-use and transport algorithms are inextricably interwoven.

- The other group consists of models where the economic interactions between activities are, in the short term, controlled by the location of land-uses. These are referred to as **'linked'** models, because they can be created by linking a complete transport model (including generation and distribution) to a land-use model.

These issues are discussed in more detail in *Modelling* (TAG Unit 3.1).

1.3.5 A crucial issue to consider is that the Appraisal Summary Table - which is at the heart of the New Approach to Appraisal, *The Appraisal Process* (TAG Unit 2.5) - requires measures of net transport user benefits.

1.3.6 At present, none of the land-use/transport interaction models are capable of producing the required estimates of user benefits. The difficulty is that user benefits are more difficult to accumulate in a rigorous fashion in a land-use/transport interaction model than in a transport model alone, and the required development work has not yet been undertaken.

1.3.7 Models of the 'linked' type imply the development of separate 'land-use' and 'transport' models, which are then run iteratively. This approach automatically provides a transport model from which user benefits can be obtained. In contrast, use of the 'integrated' type of model would require the construction of a separate, parallel transport model for this purpose.

1.3.8 Land-use/transport interaction models need to cover a large area if they are to show how activities will change in response to a transport intervention in a reasonably realistic manner. This and the additional complexity and data requirements of these models means that they will nearly always require greater resources than transport modelling alone.

1.4 Choice of Modelling Approach

1.4.1 There is no simple formula or flow chart which can be used to guide the modeller in making the choice of approach; it is a matter of considering the particular circumstances and requirements of each study and arguing the case for the preferred approach. Bearing in mind all the above considerations, the following paragraphs attempt to show how the arguments for a particular modelling approach should be constructed.

1.4.2 The key questions are:

- what is the nature of the problems at which the study is aimed, what are their likely solutions and the likely transport impacts (direct and indirect) of those solutions?

- should the study output include a 'strategy' as well as a 'plan' or can work proceed directly to the development of a 'plan'?

- is it important to understand the impacts on the scale and location of economic activity in some detail?

- how big is the area to be modelled, bearing in mind that the modelled area should cover the area of influence of any likely solutions and, as a result, may be either smaller or larger than the study area?

- how many options are likely to need to be tested?

1.4.3 In the first instance, the modeller should prepare an outline specification of an appropriate modelling system, leaving on one side for the moment consideration of information about existing data and models and the proposed study timescale and budget, if pre-defined. This outline should consider the extent of the study area, the basic model components required, how they should be linked together and the appropriate level of detail. In parallel with, but separate from, this activity, information should be collated on existing models and data (this could be done after preparation of the outline specification, if time permits). When both strands of work are complete, the specification should be reviewed and developed, taking account of the constraints of timetable and budget and taking advantage of previous work.

1.4.4 As all Studies will aim to produce options for a 'plan', spatially detailed assignment models are likely to be a firm requirement. The issues of size of modelled area and number of options to be tested need to be confronted. Assignment models of large areas will be costly to develop, given their requirement for detailed origin-destination data, unless recently collected data of this kind are already available. Consideration therefore needs to be given as to:

- whether a single model covering most of the study area, or even beyond, is required; or

- whether a series of models covering different parts of the study area will suffice.

The latter approach is likely to be cheaper, but does rely on the absence of significant interaction between the areas to be modelled separately. If there is some interaction between the areas of interest - that is, what is done in one area could have a significant effect in another - then the assignment model should embrace all those areas which interact. In general, single models should be preferred for the smaller study areas.

1.4.5 The question which then follows is: what kind of demand model should be used with the spatially-detailed assignment models? Leaving aside land-use responses for the moment, there are two broad alternatives:

- a demand model which operates with a large number of reasonably small zones (if not exactly at the same degree of spatial detail as the assignment model); or

- a spatially aggregate transport model, which contains both demand and supply elements, and which operates with a relatively small number of quite large zones, and which is used to provide changes in the patterns of demand to the spatially detailed assignment models.

Spatially detailed models

1.4.6 If the area of interest is small, or if a larger study area can be divided into a series of smaller areas which are relatively independent of one another, then the choice of modelling approach is easier than in the case of a large area which has to be modelled. With a small area of interest, the spatially detailed approach is likely to be the most appropriate approach. Given their small size, run times should not provide a practical constraint to the number of options which can be tested.

1.4.7 However, if the area of interest is large, the question of run time becomes more important. It is quite feasible to create a four-stage model for even the largest of the Multi-Modal Study areas; for example, the Central Scotland Transport Model covers much of Scotland from the border to north of Perth. However, models of this size do take a considerable time - a matter of days - to run on even the high specification PCs readily available today, particularly if convergence between demand and supply is to be achieved, and especially with policies which are intended to shift markedly the balance of demand between private and public modes.

1.4.8 Note that this comment applies to the whole model, including the process of iterating between demand and supply to convergence, and then assigning the demands to the detailed networks to convergence, and it applies to models of areas of all sizes. It is quite possible to test individual components using fixed demands and therefore using the assignment models only, with the full variable demand model being used only for combinations of components and the complete strategies or plans.

Spatially aggregate models

1.4.9 A spatially aggregate strategic transport model can be used to forecast changes in the patterns of demand by mode. These changes in patterns of demand would then be fed down to spatially-detailed assignment models. It will clearly be important to ensure that the cost changes forecast by the two tiers of models are consistent.

1.4.10 This spatially aggregate approach would be more suited to those Studies in which it is required to develop a ‘strategy’ first so as to provide the framework within which the development of a ‘plan’ can proceed. Strategic transport models are quicker to run and can therefore be used to test a large number of policy options in a relatively short period of time.

1.4.11 The use of a strategic (spatially aggregate) transport model covering the whole study area may also be useful where it is more convenient to create spatially detailed assignment models for a number of discrete areas within the whole study area. The strategic model would provide a means for forecasting changes in demand which would be consistent between all the areas subjected to more detailed modelling.

1.4.12 In addition to the considerations outlined above, there will be many detailed modelling issues to be considered. These will often arise as a result of the problems which need to be examined, or in order to satisfactorily model specific solutions. Where possible, these issues should be anticipated and accommodated in the development of the detailed specification of the modelling system. However, it may not be possible to anticipate all such issues, and thus the detailed specification should allow for refinements of the model during the course of the study.

Land use/transport interaction models

1.4.13 The question of whether or not a land-use/transport interaction model is required also needs to be addressed. To answer the question, it is necessary to consider whether:

- the potential solutions are likely to cause significant shifts in the scale and pattern of economic activity, including jobs;
- the investigation of alternative land-use policies is a matter of key concern; and
- there is likely to be significant interaction between transport and land-use strategies.

1.4.14 If one or more of these matters are important and more informal methods (see paragraph 1.3.2 above) are not considered to be appropriate, then a land-use/transport interaction model may well be appropriate. However, two features of these models noted earlier are worthy of re-emphasis here:

- they need to cover a large area in relation to the interventions to be appraised; and
- because estimates of economic benefits cannot be derived from these models at present, it must be possible to isolate the transport model from the land use model, or a separate transport model must be available, to enable benefits to be estimated in the usual fashion, as explained in *The Appraisal Process* (TAG Unit 2.5) and *The Economy Objective* (TAG Unit 3.5).

1.4.15 It is worth noting that the use of a land-use/transport interaction model is likely to be more practical at a spatially aggregate level rather than at the spatially detailed level at which the assignment models for 'plan' development are likely to operate.

Specification of Model

1.4.16 Once a conclusion has been reached about the modelling, then, as noted in paragraph 1.4.3, a detailed specification of the modelling system needs to be developed, taking account of:

- the availability of existing data and models;
- the requirements for new data collection and the costs and time involved;
- the time likely to be required to create and validate the model(s);
- any constraints on the study timescale and budget; and
- the views of the study Steering Group.

Some iteration between these issues may be required. For example, it may be that, because of budget or timescale constraints, rather more use is made of existing data and models than might have been envisaged had those constraints not existed.

1.4.17 It may be that some adjustment to the initially preferred approach would be required to take advantage of existing data and models. However, it is crucially important that, in doing this, sight is not lost of the study requirements and an inappropriate modelling approach does not result. For example, it would not be sensible to attempt to develop a transport plan using a spatially aggregate transport model alone.

1.4.18 Of particular importance is the need to take appropriate advantage of the national models (of car ownership and trip ends) and datasets (census journey to work matrix, CAPRI rail trip matrix, and roadside interview data index) created by the Department see *Modelling* (TAG Unit 3.1).

1.4.19 Even if there are no timescale or budget constraints, the cost-effectiveness of the initially selected approach should be considered. It may be that some appropriate simplification in the modelling approach may yield a significantly quicker or cheaper approach while still yielding answers that are sufficiently robust for the required aim of the study.

1.4.20 Getting the technical details of this right relies quite heavily on the judgement of the modeller. However, it is important that the functionality of the proposed modelling system meets the needs of the Steering Group and of those relying on the output of the model. Full use should be made of the documentation available which describes tried and tested modelling techniques, see *Modelling* (TAG Unit 3.1).

1.4.21 In *Modelling* (TAG Unit 3.1), the principles of model selection are explored in greater detail than in this summary. Also provided in *Modelling* (TAG Unit 3.1) is advice on (a) sources of more detailed guidance on modelling, (b) sources of useful data, (c) use of the Department's national models of car ownership and trip ends, (d) the availability of software and (e) the need for specialist modelling knowledge.

2 Further Information

The following documents provide information that follows on directly from the key topics covered in this TAG Unit.

For information on:	**See:**	**TAG Unit number:**
Information Modelling, including datasets and the link with land-use	*Modelling*	TAG Unit 3.1
The Appraisal Summary Table	*The Appraisal Process*	TAG Unit 2.5
Guidance on Appraising options against the economy objective	*The Economy Objective*	TAG Unit 3.5

3 References

DETR (July 1998) *A New Deal for Transport: Better for Everyone*

DETR (July 1998) *A New Deal for Trunk Roads in England*

DETR (2000) *Guidance on the Methodology for Multi-Modal Studies*

4 Document Provenance

This Transport Analysis Guidance (TAG) Unit is based on Chapter 5 of *Guidance on the Methodology for Multi-Modal Studies Volume 1* (DETR, 2000).

Technical queries and comments on this TAG Unit should be referred to:

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