

Variable Demand Modelling – Preliminary Assessment Procedures

TAG Unit 3.10.1

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Department for Transport

Transport Analysis Guidance (TAG)

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1 Variable Demand Modelling – Preliminary Assessment Procedures

1.1 Background

1.1.1 TAG units 2.9 and 3.10 explain why variable demand modelling needs to be considered and provide guidance on how to carry out such modelling. This unit forms the first stage in the process and explains how to establish whether there is a need for variable demand modelling in a particular application. Assuming that there is a need, it then goes on to give preliminary advice on the scope of the model, with a view to developing a model which is appropriate for the complexity of the interventions that it will be used to test. Finally, it describes the additional simplifications to the demand model that may be appropriate for schemes under £20 million.

1.2 The Importance of Variable Demand Modelling

1.2.1 Any change to transport conditions will, in principle, cause a change in demand. The purpose of variable demand modelling is to predict and quantify these changes.

1.2.2 The Standing Advisory Committee on Trunk Road Appraisal (SACTRA) considered all these effects in 1994 and **emphasised the importance of establishing a realistic scenario in the absence of the scheme or strategy, the extent of travel suppression in the "without-scheme" case, and the extra traffic induced in the "with-scheme" case.**

1.2.3 Although the modelling effort needs to be proportionate to the scale of the scheme, the need to consider variable demand is **not** simply a question of the size of the scheme. Since both demand changes and benefits tend to scale with the size of the scheme, changes in demand can have similar proportionate effects on benefits for both large and small schemes. Thus changes in demand can seriously undermine the economic efficiency justification for schemes of any size.

1.2.4 There may be wider effects of the scheme, on the environment, accessibility or safety, for example, which will also be affected by changes in demand: these must be judged separately from the economic efficiency of the scheme. Any reduction in any type of benefit can undermine the justification for the scheme, since this depends on the balance between the benefits and the costs of the scheme.

1.2.5 Any response in the demand for transport of **freight** is not considered here, as often it is sufficient to assume that total freight traffic is fixed, but susceptible to re-routeing.

1.3 Assessment of the Need for Variable Demand Modelling

1.3.1 It may be acceptable to limit the assessment of a scheme to a fixed demand assessment if the following criteria are satisfied:

- The scheme is quite modest both spatially and in terms of its effect on travel costs. Schemes with a capital cost of less than £5 million can generally be considered as modest; **or**
- There is no congestion on the network in the forecast year (10 to 15 years after opening), in the absence of the scheme; **and**
- The scheme will have no appreciable effect on competition between private and public transport in the corridor(s) containing the scheme.

1.3.2 Under congested conditions, the without-scheme forecasts may be affected by peak spreading, or diverted or suppressed traffic. It will often be

- the case that such suppression in the without-scheme situation will have a greater impact on the scheme benefits than any induced traffic from the scheme itself. It is however expected that where a variable demand model is used for forecasting, then that model will be used to derive forecasts for all scenarios, both with and without the scheme.
- 1.3.3 It should be remembered that the benefit from schemes can be substantially reduced by changes in demand arising from the scheme, and that any scheme potentially encourages more trips and affects congestion levels over the entire journey distances travelled by the traffic through it. Indeed, where the link speed-flow relationship of the scheme itself is nearly flat under the expected operating conditions, induced traffic may have little effect on speeds on the scheme, but there may still be substantial reductions in speeds on roads leading to and from it due to induced traffic. Those extra induced trips and longer trips are the key components of induced traffic.
- 1.3.4 In order to establish a case for omitting fully specified variable demand modelling for schemes above £5 million, it is strongly recommended that preliminary quantitative estimates of the potential effects of variable demand on both traffic levels and benefit are made. An existing variable demand model of the area should be used for this purpose if one is available. Otherwise this can be done by means of an elasticity-based demand function, and, as discussed further in Appendix 1 of **VDM Key Processes** (TAG Unit 3.10.3), the Power formulation is generally considered appropriate for this. Note that the estimated generalised cost elasticities (and associated parameter values if an exponential model is used) may need to be adjusted so that the fuel cost elasticity estimate from the model reflects the national overall estimate of -0.3 (see **Variable Demand Modelling - Convergence Realism and Sensitivity** (Unit 3.10.4)).' An elastic assignment procedure can give an initial indication of the effects. This procedure should only be used to ascertain whether variable demand modelling is required and for nothing else.
- 1.3.5 It is expected that for all schemes covered by this advice an assignment model would be developed as a minimum requirement. Note that some assignment software allows this simplified kind of demand model to be integrated within the assignment – so-called “elastic assignment”. Where available, this is recommended on grounds of ease and computing effort.
- 1.3.6 Where preliminary calculations using variable demand modelling are carried out, it is recommended that the following additional criteria are satisfied to provide a robust case for carrying out a fixed-demand assessment:
- Traffic suppression without the scheme does not impact significantly on the reference case forecasts such that the time saving benefits of the scheme will not reduce by more than 10% in the opening year and 15% in the forecast year (10 to 15 years later), and
 - Extra traffic induced by the scheme is unlikely to reduce the time saving benefits of the scheme by more than 10% in the opening year, or 15% in the forecast year (10 to 15 years later).
- 1.3.7 These calculations may convince you that it is safe not to model variable demand and thus provide a useful justification for restricting the assessment to fixed trip matrix.
- 1.3.8 The environmental and other wider effects, and the possible superiority of alternative schemes, including improvements to public transport, also need to be considered.

1.3.9 Taking into account the qualitative aspects discussed above, if you decide that variable demand modelling is required then you need to establish the scope of the variable demand model, see **VDM Scope of the Model** (TAG Unit 3.10.2) and build one, see **VDM Key Processes** (TAG Unit 3.10.3).

1.4 Preliminary Assessment of the Scope of the Variable Demand Model

1.4.1 Having concluded that a variable demand model is required, it is necessary to take a view on the scope of the modelling system. Typically, the demand model should address the responses of frequency, mode choice and destination choice, as well as, in some instances, time of day, and should be applied on a “Production/Attraction” [P/A] basis. However, while for large and complex schemes, a full multi-modal approach is likely to be required, not all schemes will require this, and it is important that the model is appropriate for the interventions which it will be used to test.

1.4.2 This section provides some initial discussion of the issues. For ease of illustration, it begins with an outline structure of the full multi-modal model with appropriate segmentation and representation of demand responses generally envisaged. This is represented in Figure 1.1 (the dashed lines represent functions which are rarely used).

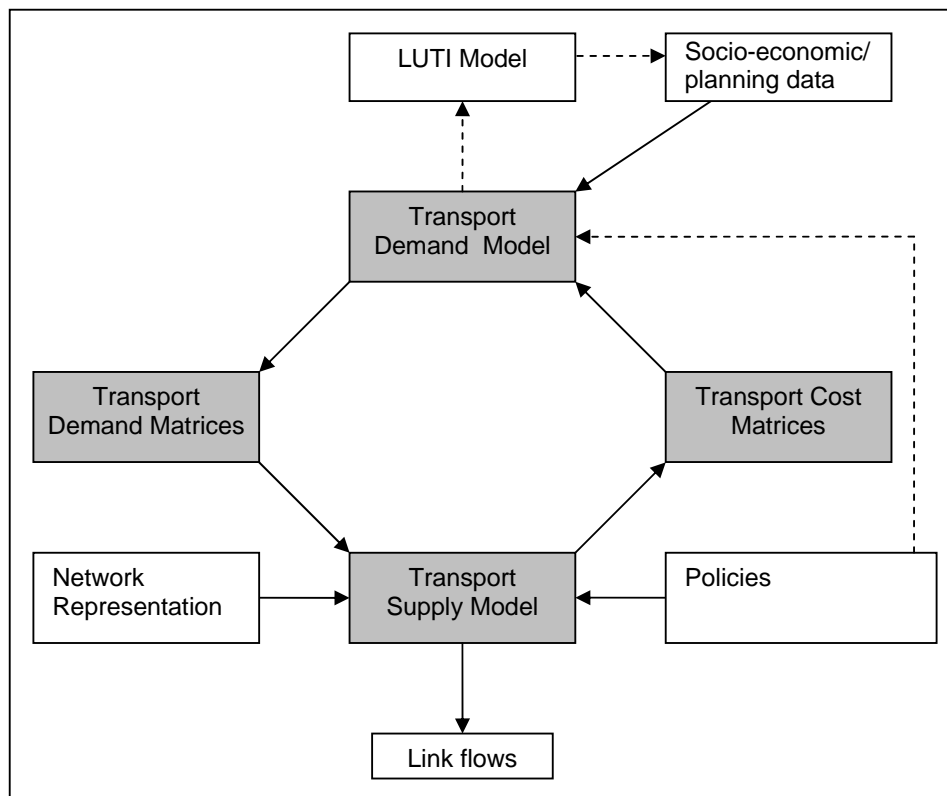


Figure 1.1: General Outline of Transport Model

- 1.4.3 It should be noted that, while this structure in itself is not excessively complicated, each of the model boxes contains substantial additional detail. The supply model is, in principle, represented by both a highway network model and a public transport network model. Because network conditions typically vary by time of day, it will usually be necessary to run the supply models separately for each time period that is represented in the model (typically AM, PM peaks and interpeak). The demand model normally represents a number of linked “choice” responses (choice of mode, choice of destination, choice of when to travel) which need to be separately and consistently calibrated.
- 1.4.4 In addition, the demand model is run separately for different “demand segments”, relating to combinations of journey purpose and different types of traveller. Some of these segments may also be separately represented in the supply models. For the highway supply model, it is also usually necessary to represent different vehicle types (e.g. goods vehicles as well as cars).
- 1.4.5 In practice, therefore the level of complexity is very much greater than is implied in the outline figure. Many of the additional dimensions are specified in the Guidance, as, in particular, the requirements for segmentation in section 1.7 of **Variable Demand Modelling – Scope of the Model** (TAG Unit 3.10.2).
- 1.4.6 Of course, once a model has been satisfactorily constructed, it will actually greatly facilitate the testing of options and the calculation of the items necessary for the AST table. Hence, if a model for the area already exists, even if it requires some adjustment, it will usually be worth using it, whether the scheme is “small” or not. However, where there is no existing model, the analyst must ensure that the effort in constructing a model to appraise an intervention is proportionate.
- 1.4.7 Note that, regardless of any possible modelling simplifications, it will always be necessary to construct a description of the base year demand (for guidance on this, see section 1.6 of **Variable Demand Modelling – Scope of the Model** (TAG Unit 3.10.2), together with more specific information for highway demand in Chapter 8 of DMRB Vol 12.1.1 and for public transport demand in Section 12 of **Road Traffic and Public Transport Assignment Modelling** (TAG 3.11.2)). Indeed, there may be considerable advantages in having a model to assist with this, as well as for problem identification – see **The Steps in the Process - Overview** (TAG Unit 2.1). Of course, the base levels of demand for interurban rail (and to a rather lesser extent, for local bus and rail) may be readily available, but some local data will always be required for highway demand.
- 1.4.8 The main possibility for simplification relates to the treatment of mode. A particular issue is the extent to which public transport needs to be represented in connection with highway schemes, and highway in connection with public transport schemes. In fact, the two aspects are rather different.
- 1.4.9 TAG Unit 3.11.1 (**Model Structures and Traveller Responses for Public Transport Schemes**) has some discussion of the possible cases where there might be no need for a highway network. Correspondingly, for some highway schemes, the amount of likely diversion to or from public transport may be considered very limited. If this is so, there is a strong case for a) restricting the demand model segmentation to car users only, b) dropping the mode choice function in the demand model and c) not representing public transport supply at all. See also **Variable Demand Modelling - Key Processes** (TAG Unit 3.10.3), Section 1.6.

1.4.10 For the purpose of discussion, it is helpful to expand the essential part of Figure 1.1, given earlier. The critical issues are represented by the items in bold in this diagram (Figure 1.2), described below.

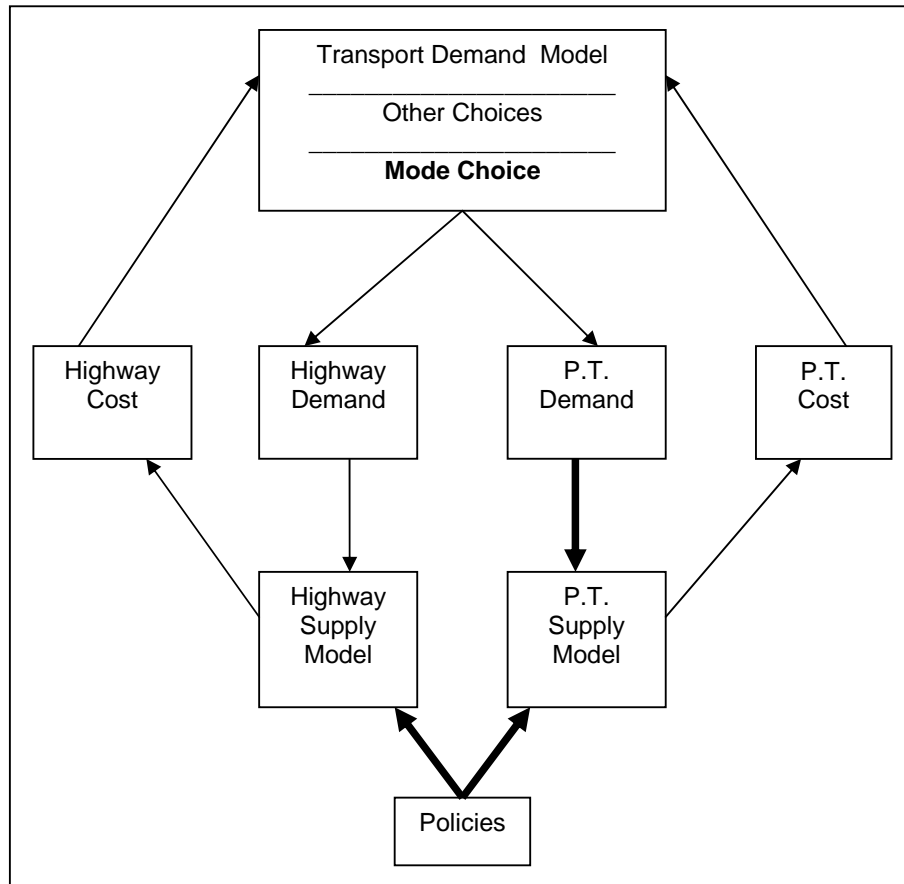


Figure 1.2: Key Aspects of Transport Model Structure

- 1.4.11 The first question is whether the model is required to appraise policies relating to both highway and public transport modes (bottom bold arrows). If this is the case, it will be unlikely that any reduction in the level of modal detail can be made. However, when policies relate only to one mode, it may be possible to concentrate on that mode.
- 1.4.12 The second issue is whether the policy is likely to impact significantly on mode choice. Note that, in principle, any change in relative generalised cost between the modes will lead to some modal shift. However, the implied mode choice parameters in Section 1.11 of **Variable Demand Modelling - Key Processes** (TAG Unit 3.10.3) suggest that the sensitivity is usually quite low. Hence, a test has been formulated to make a preliminary estimate of the likely amount of modal diversion. This is particularly important, because much of the modelling effort relates to the impact on the alternative mode, and if this can be considered small or negligible, then simplifications become more acceptable.
- 1.4.13 The third issue relates to the public transport supply model. The primary reason for requiring a public transport network is because of significant routing alternatives. In addition, when crowding is a possibility, the

generalised costs are dependent on the level of demand (see also the general discussion in **Model Structures and Traveller Responses for Public Transport Schemes** (TAG Unit 3.11.1) and **Road Traffic and Public Transport Assignment Modelling** (TAG Unit 3.11.2). When crowding is not present, and route choice is simple (because of restricted alternatives), the need for a public transport network model is greatly reduced: this applies even in the case of a policy relating to public transport.

1.4.14 Hence, based on these critical issues, a set of logical tests has been defined to give a clear assessment of how far the diagram above can be simplified. This is outlined in Figure 1.3

1.4.15 The set of tests is as follows:

- Test 1 - Do the set of schemes to be appraised relate to only one of the modes public transport and highway? If NO, a multi-modal treatment will, in principle, be required.
- Test 2 - If the scheme is highway only, does the application of the mode shift test (described below) suggest that there will be an insignificant impact on public transport demand? If NO, a mode choice model will, in principle, be required.
- Test 3 - If the scheme is public transport only, does the application of the mode shift test (described below) suggest that there will be an insignificant impact on highway demand? If NO, a mode choice model will, in principle, be required.
- Test 4 - If the scheme is highway only, and a mode choice model is not required, then a public transport network model is not required.
- Test 5 - If the scheme is public transport only, and a mode choice model is not required, then a highway network model is not required. In addition, a public transport network model may not be necessary if the level of crowding is not expected to be significant during the lifetime of the scheme, and routeing is generally straightforward.
- Test 6 - If the scheme is public transport only, then, even if a mode choice model is required, it may be possible to manage without a highway network model and use the techniques described in **MSA: Road Decongestion Benefits** (TAG Unit 3.9.5) to measure decongestion benefits if a) there is no impact from the scheme on highway capacity and b) the scheme is small. In addition, as in Test (5), a public transport network may not be necessary if the level of crowding is not expected to be significant during the lifetime of the scheme, and routeing is generally straightforward.

1.4.16 Further simplifications are acceptable for schemes below £20m – these are described in Section 1.5

1.4.17 Note that where a network model is not required for the alternative mode, this also removes the requirements for validation and hence demand estimates for that mode.

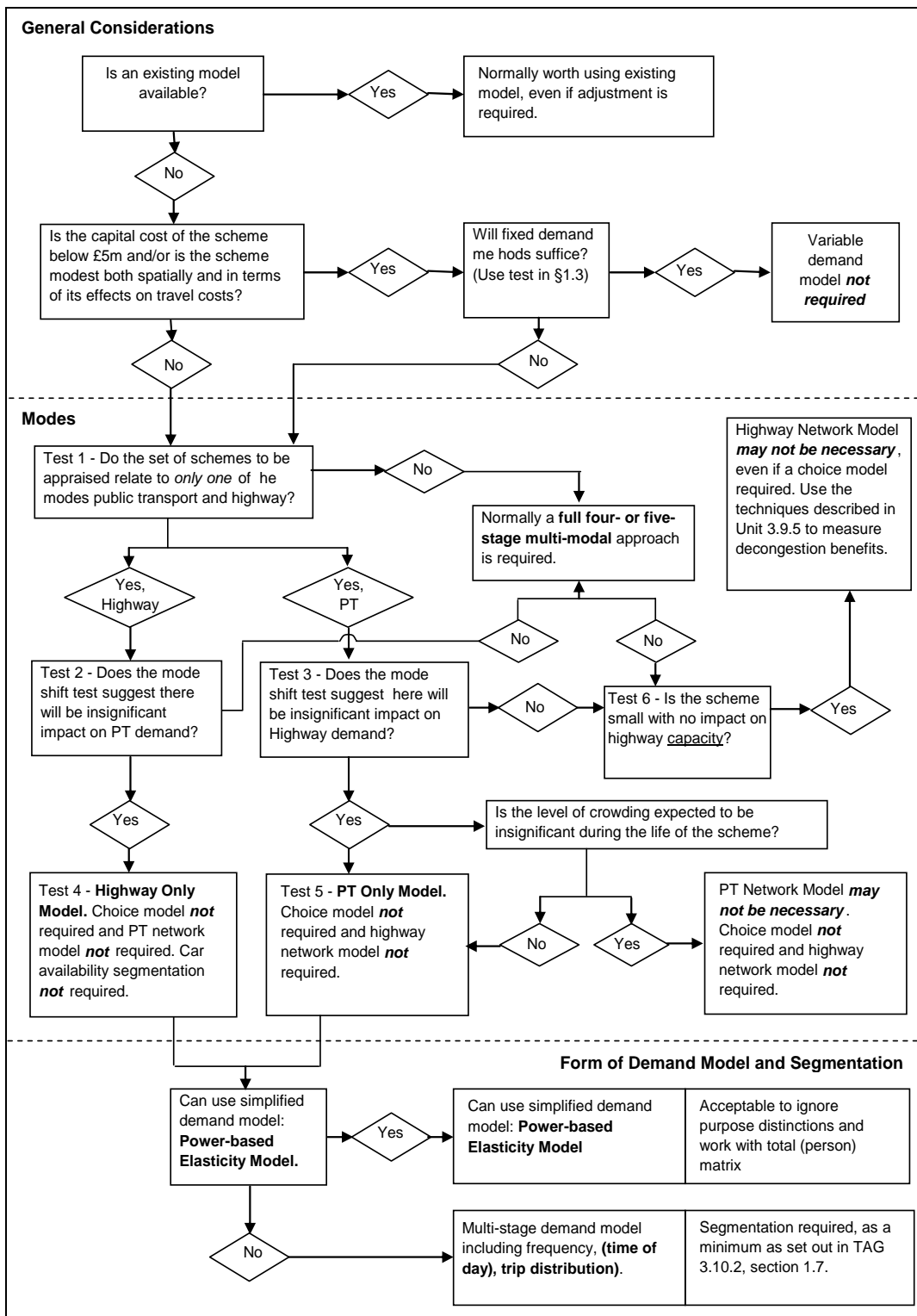


Figure 1.3: Tests for Model Simplification

Modal shift significance test

- 1.4.18 The test assumes that the proposed scheme relates to only one of the modes – car and public transport. If both modes are involved, the test is not appropriate and a more general multi-modal treatment is required.
- 1.4.19 Based on average values of the recommended parameters in **Variable Demand Modelling - Key Processes** (Unit 3.10.3), the following test may be carried out:
- For each zone-to-zone movement, estimate the approximate modal split between car and public transport, and the change, in units of generalised time, expected to arise from the scheme.
 - The modal impact may be considered significant if, for any zone to zone movement where the car share is below 75%, the cost change is more than one minute, or, where the car share is between 75% and 85%, the cost change is more than two minutes, or, where the car share is above 85%, the cost change is more than four minutes.
 - If on this basis no zone-to-zone movement demonstrates significant modal impact, then this is prima facie evidence for not requiring a mode choice model.

1.5 Further Simplifications in Demand Modelling for schemes with capital cost below £20 million

- 1.5.1 In the case of smaller schemes (here defined as those with capital cost below £20m), further simplifications to the demand model are acceptable. These simplifications are dependent on the outcome of the previous tests, and are not a substitute for them. Thus it is assumed that the scheme relates to only one mode, and that the modal shift test indicates that the impact on other modes may be ignored. Primarily, this part of the guidance is directed at highway schemes, and it is assumed that standard network models are available to reflect both the base position and the policy/scheme to be tested¹. No changes are envisaged to the highway validation procedures, and the associated derivation of vehicle matrices (with the possible exception of the level of segmentation). These should be built for as many time periods as are considered necessary, in line with general guidance. Reporting requirements are also unchanged.
- 1.5.2 The key aspects relate to:
- a) the level of segmentation; and
 - b) the level of complexity of the demand model formulation.

Both these items relate to personal travel. No change in the treatment of goods transport is proposed, nor of vehicle types (HGVs etc) in the highway assignment (it is assumed that separate goods vehicle matrices will be developed and held fixed in demand terms, apart from an allowance for growth over time).

- 1.5.3 As a simplification for smaller schemes, it will be acceptable to ignore all purpose distinctions, and to work with a total (person) travel matrix. Default growth rates are provided by TEMPRO for all purposes combined, and TAG Unit 3.5.6 already allows for vehicle values of time averaged over purposes and provides default proportions of total modal demand by the three segments required for NATA, while TUBA has the flexibility to work with a single segment.

¹ Note that for the purposes of this Section it will be essential that the assignment model makes use of a conventional generalised cost specification, as opposed to the use of time only.

- 1.5.4 In what follows, it is therefore assumed that there will be a single demand segment for person travel. On the basis of the empirical data currently available, it has been judged that the power-based elasticity form demonstrates reasonable stability in that, relative to a full VDM model, it tends to under-estimate overall benefits by an amount which appears not to vary too much with the actual scheme being appraised².
- 1.5.5 The intention behind the simplification is to develop a “conservative” estimate of benefits whereby some benefits would not be calculated and therefore ignored.
- 1.5.6 The power formulation is one of a family of “simple elasticity models” discussed in Appendix 1 of **Variable Demand Modelling - Key Processes** (Unit 3.10.3), and requires a single parameter A. Where more than one period is being modelled, it is acceptable to use different parameters by time period (to reflect the different mix of journey purposes), but the variation should not be large, and a single parameter covering all periods will be acceptable.
- 1.5.7 As noted in paragraph 1.3.5 of this Unit, some software packages allow this kind of simplified demand response to be incorporated within the assignment (“elastic assignment”): if this is the case, it is the recommended approach. However, where it is not available, it is not difficult to set up an external procedure (i.e. external to the assignment) to calculate the demand response. In addition, the DIADEM software offers such an external procedure.
- 1.5.8 Note that because the power elasticity form is uniform in its effects, the key distinction (**Variable Demand Modelling - Scope of the Model** (TAG Unit 3.10.2)) between the Production/Attraction [P/A] and Origin-Destination [O-D] matrix format is very much less important, and since the elastic assignment approach assumes an O-D basis, demand modelling on an O-D basis is, in this exceptional case, acceptable.

Convergence and Realism Testing

- 1.5.9 Whichever procedure is used, the requirements for convergence of the supply-demand loop (See **Variable Demand Modelling - Convergence Realism and Sensitivity** – TAG Unit 3.10.4 – sections 1.3, 1.4 and 1.5) should be observed.
- 1.5.10 Given an appropriate modelling system, the calibration of the parameter A should take place, in line with the “realism” tests described in sections 1.6 and 1.7 of Unit 3.10.4. For highways schemes, it is only necessary to establish the overall fuel cost elasticity (by period, where applicable), though the travel time elasticity should also be checked. The remarks relating to individual purposes in Unit 3.10.4 may be ignored.
- 1.5.11 In the case of a public transport (only) model, the requirements are generally similar, but the appropriate realism test is the fares elasticity test. Unless crowding is an issue, there is in this case no need to manage the convergence between supply and demand.

Forecasting

- 1.5.12 Given a satisfactory outcome from the realism tests, the model may be deemed fit for forecasting. It is proposed that “reference case” forecasts (see **Forecasting Using Transport Models** (TAG Unit 3.15.1) section 1.4) should be made for (at least) two forecast years. Advice on the necessary changes to generalised cost over time is given in section 1.5 of Unit 3.15.1.
- 1.5.13 Note that the advice in Unit 3.15.1 applies as much to the simplified power elasticity demand form as to the more general VDM procedures, and, as

² Based on work carried out by Mott Macdonald (ref), the average level of underestimation is about 11%.

noted, TEMPRO growth factors are available aggregated across purposes. If the demand matrices are on an O-D basis, then the growth factors will also need to be on this basis. In the case of forecasting for a public transport model, additional guidance is available in Forecasting and **Sensitivity Tests for Public Transport Schemes** (TAG Unit 3.15.3) and **Rail Passenger Demand Forecasting Methodology** (TAG Unit 3.15.4).

1.6 Reporting

- 1.6.1 It is expected that the outcome of the above assessments will be reported in the model or appraisal documentation. Details of how each criterion has been considered and all the evidence that has been compiled should be fully documented. In all cases, the analyst will need to provide a justification for any simplifications adopted.

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:	Link:
An overview of modelling issues	<i>Summary Advice on Modelling</i>	TAG Unit 2.4
An overview of variable demand modelling	<i>Variable Demand Modelling</i>	TAG Unit 2.9
Detailed advice on transport modelling	<i>Modelling</i>	TAG Unit 3.1

3 References

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

4 Document Provenance

This Transport Analysis Guidance (TAG) Unit reflects the consultation comments received on Steps 1 to 4 of the draft Variable Demand Modelling Advice produced by TRL in June 2003.

This document has been updated in October 2009 to include new guidance on Proportionate Appraisal.

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

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