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Forecasting and Uncertainty

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This TAG Unit is guidance for the Modelling Practitioner

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1. Introduction

1.1 Scope of this unit

1.1.1 This TAG Unit gives practical guidance for forecasting the impact of transport projects including option testing and appraisal. Typically, this involves running mathematical models with different sets of assumptions. For major transport schemes, it is expected that these models will have been developed in line with TAG Unit M2.1 – Variable Demand Modelling, TAG Unit M2.2 – Base Year Matrix Development, TAG Unit M3.1 – Highway Assignment Modelling and TAG Unit M3.2 – Public Transport Assignment Modelling, with exceptions where other modelling methods have been demonstrated to be more effective (for example, the use of uni-modal models for rail and aviation modes). Simpler "light touch" approaches, typically used for traffic impact assessments are also discussed.

1.1.2 Forecasts are used to predict the future benefits and costs of different schemes. The accuracy of the forecast decreases for later years in the forecasting period. In transport scheme appraisal, models are used to establish the difference between two forecasts (without-scheme and with-scheme). In order to do this, the modeller must establish whether the comparison between the forecasts is significant by understanding the errors and associated uncertainty and what impact this may have on the analysis. Uncertainty around assumptions creates a risk that the scheme will not be as successful as forecast, or that the forecasts will hide some side effects (including some environmental and social impacts) which could occur.

1.1.3 The scope of the uncertainty considerations within this TAG Unit are for benefits only. Uncertainty in costs is considered in TAG Unit A1.2 – Scheme Costs.

Definitions

1.1.4 Throughout this TAG Unit, we have used the following definitions:

- A **forecast** is a single run of the transport model for a single year, under a set of forecasting assumptions that may or may not include the scheme in question.
- A **background assumption** is an assumed change between the base year and future year conditions (e.g. national demographic changes, or changes to the transport network) that are assumed to happen independently of the scheme.
- **Uncertainty log:** This is a record of assumptions made in the model that will affect travel demand and supply (This is described in Section 2).

- A **scenario** is a set of forecasts under a single set of assumptions. It is likely that this will include two forecasts for each of several designated modelled years (the with scheme and without-scheme forecasts).

- **Core scenario** is a scenario based on central assumptions for the exogenous drivers of future demand, and reflecting 'firm and funded' government policy commitments. This underpins the core appraisal results presented in the appraisal summary table (AST), and provides a 'common comparator' to assess all projects and options against. The approach to defining the assumptions used in the core scenario is set out in section 3.

- **Alternative scenario** is the set of background assumptions and with scheme and without scheme forecasts that may have different supply and/or demand assumptions form the core scenario. These differences will reflect the uncertainties in the core scenario assumptions. The approaches to developing alternative scenarios is set out in sections 4 and 5.

- **High and Low Growth Scenarios** are part of the set of **alternative scenarios**. The high and low growth alternative scenarios will test the impact on the schemes of high and low background growth (Section 4). The envelope of the High and Low is calibrated from the Common Analytical Scenarios.

- **Common Analytical Scenarios** are a set of seven consistent, off-the-shelf, cross-modal scenarios exploring national level uncertainties which have been developed by DfT for use in forecasting and appraisal. They are preferred substitutes for the High and Low Growth Scenarios. More detail on the Common Analytical Scenarios and their application (including a Proportionality Framework) can be found in the TAG Uncertainty Toolkit.

- **Reference Forecast** is a term specific to setting up a forecast with a variable demand model and is an intermediate step to producing the without-scheme and with-scheme forecasts. It uses the growth in trip ends over the forecasting period (which should be controlled to NTEM levels at a suitable level of spatial detail, see below), but does not take into account changes in cost. (See Section 7).

- **Firm and funded** refers to policies to which the government is already committed and which have funding (where funding is needed).

- **Scheme options** refers to a set of different schemes that may be considered as part of the process to select the preferred scheme.

- **NTEM:** national assumptions about background growth in travel demand, provided by the Department through the National Trip End Model (NTEM) dataset (See Section 7).

- **PDFH (Rail schemes only):** National Assumptions about background growth in rail travel demand. Analysis of rail schemes should be based on the Passenger Demand Forecasting Handbook (PDFH) (See Section 8).

1.2 Forecast Years

1.2.1 This Unit gives guidance on the production of forecasts for different scenarios. An important initial consideration in model design is the years for which forecasts will be produced. The Appraisal TAG Units set out the analysis work that usually needs to be undertaken to appraise a scheme. For most schemes, forecasts of economic benefits will be calculated for the scheme opening year and at least one other forecast year.

1.2.2 For economic appraisal it is best if the final forecast year is as far into the future as possible. This may be restricted to how far into the future standard forecasting datasets will allow (including NTEM, items on the uncertainty log, and data used to calculate economic impacts and environmental impacts that may be monetised).

1.2.3 Additional forecast years between the scheme opening year and the final forecast year are desirable and should be modelled where appropriate (for example, just before and after major step changes in demand or supply that will significantly affect the profile of benefits). Having forecasts for the scheme opening year and one final modelled year allows only a linear assessment of the stream of costs and benefits accruing to a scheme. Even without explicit step changes expected, having intermediate forecasts will allow more a more accurate understanding of the profile of cost and benefits, particularly where non-linear features exist, such as demand growth or supply constraints.

2. Uncertainty and the Uncertainty Log

2.1.1 There are two sources of forecast error: uncertainty in the inputs (such as size of new housing development) and error in the model parameters and specification (how these inputs propagate through the model). The practitioner should summarise all known assumptions and uncertainties in the modelling and forecasting approach in an uncertainty log. The uncertainty log will also be the basis for developing a set of alternative scenarios. Alternative scenarios are used to understand the possible impact of significant sources of local uncertainty in assumptions.

2.1.2 Consideration of model errors is set out in TAG Unit M2. Understanding these will form the basis for the development of the core scenario.

2.1.3 Consideration of the impact of uncertainty around input assumptions on demand forecasts should be assessed using alternative scenarios. Examples of input uncertainty include size of new housing development or assumptions about supply side. The development of alternative scenarios is set out in sections 4 and 5.

2.1.4 It is essential that all assumptions made are fully documented in a Forecasting Report.

2.2 Uncertainty log

2.2.1 The purpose of the uncertainty log is to record the central forecasting assumptions that underpin the core scenario and record the degree of uncertainty around these central assumptions. These assumptions will be the basis for developing a set of alternative scenarios. An example of an uncertainty log is shown in Appendix A Table A1.

2.2.2 When there is no quantitative information about the certainty of an input assumption the categorisations set out in Appendix A: Table A2 can be used to inform whether the assumptions should be included in the core, or an alternative scenario and what the range of potential outputs might be. The 'firm and funded' definition should be used to identify which government policy commitments to reflect in the core scenario, and covers policies to which the government is already committed and which have funding.

2.2.3 Where analysis covers a wide geographical area, it is usually sufficient to focus on the area in the vicinity of the scheme being considered.

2.2.4 The uncertainty log should summarise all known uncertainties in the modelling and forecasting approach. As well as listing each source of uncertainty, the uncertainty log should also list the following information for each source:

- the core assumptions. This should describe the assumptions that will be made for the central case. This should only include schemes where the likelihood of them going ahead is near certain, or more than likely (See Appendix A: Table A2);
- where appropriate, the likelihood that the scheme or development will **ever** go ahead, which can be categorised using Appendix A: Table A2. This should help inform whether it should be included in the core or an alternative scenario and what the range of potential outcomes might be; and
- the range of assumptions around each input or parameter, and if possible information about the distribution (e.g. a 95% confidence interval).

2.2.5 A comments column should also be provided, explaining the source of the assumptions, the reasoning behind the stated level of uncertainty and any major interactions and dependencies on other input assumptions.

2.2.6 An example of an uncertainty log is given in Appendix A Table A1. Other layouts can be used, but the layout here shows clearly which assumptions are included in the Core Scenario and how they might vary in alternative scenarios.

2.2.7 As well as specifying forecasting assumptions for the benefit of analysts, the uncertainty log is a useful tool for wider consultation with the public, statutory bodies, and non-government organisations, in order to reach a consensus that all the sources of uncertainty have been identified and treated appropriately.

Key stakeholders (such as local planners, National Highways, and so on) should be consulted to reach an agreed position on the likelihood of any given input. Any evidence used to arrive at the uncertainty log assessment should be carefully recorded, and conclusions should be kept under review and revised as necessary. Significant changes in the uncertainty log may necessitate some of the alternative scenarios being repeated.

2.2.8 Common sense should be applied in estimating the likelihood of each source of uncertainty in the log. For example where one input, A, depends on another, B, then A will not go ahead unless B does, and therefore may be expected to have a lower probability of ever going ahead than B.

2.2.9 The example of an uncertainty log given in Appendix A Table A1 shows how most sources of forecasting uncertainty can be classified into one of five categories:

- **Model Parameter Errors**: This is determined from the sensitivity tests in the model reports, as described in TAG Unit M2;

- **National uncertainty in travel demand**, due to uncertainty in demographic projections and traveller's behaviour and tastes;

- **National uncertainty in travel cost** - typically due to uncertainty in fuel prices or government policy;

- **Local uncertainty (within the vicinity of the scheme) in travel demand** – the most common cause being uncertainty surrounding whether proposed developments (for example housing, employment, schools, or retail) are built. Intense application of Smarter Choice measures within the vicinity of the scheme could also influence demand; and

- **Local uncertainty (within the vicinity of the scheme) in travel supply/cost** – potential sources of uncertainty include whether other transport construction projects materialise. There can also be uncertainty over the implementation of new or existing transport schemes, such as their performance (for example public transport service provision) and their costs (for example, the levels of tolls and fares).

2.2.10 Model parameters or simplifications in model responses are sources of uncertainty that should have been identified when building the model in accordance with TAG Units M2, M3.1 and M3.2. Uncertainty in the models often results from:

- Calibrated or imported model parameters; TAG Unit M2 provides guidance on the uncertainty around calibrated or imported model parameters that might be expected;

- Standard values; an example is the value of time, which can be compared with other sources, such as **The demand for public transport: a practical guide - TRL Report TRL593** (TRL 2004).

2.2.11 **National uncertainty** concerns national projections such as demographic data (population, households and employment), GDP growth and fuel price trends. In the core scenario, it is assumed that the impact of changes in demographic data will be based on the NTEM dataset, whilst growth in most other parameters will be based on the values given in the TAG Data Book. Some other scenarios may use a range around the NTEM projections, discussed further in section 4; these can be added to the uncertainty log if desired, but it is not necessary to appreciate these ranges in order to model the core scenario.

2.2.12 **Local uncertainty** typically depends on whether developments or other planned transport schemes go ahead in the vicinity of the scheme being built. When transport schemes are evaluated after opening, the evaluation results often suggest that benefits can be extremely sensitive to local sources of uncertainty, so careful consideration is essential.

2.2.13 The uncertainty log should highlight all sources of uncertainty that are likely to affect the traffic/patronage, revenues and delivery of scheme benefits. This may include planned land-use developments (not just housing, but also employment and retail; also distribution centres which may affect freight traffic) and transport schemes. Sources that have an individually minor effect may need to be included, as their cumulative effect may be a material consideration in the appraisal.

2.2.14 Details of planned developments and transport schemes should be obtained from local planning documents (for example Local Development Plan, Local Transport Plan). Discussion should also take place with key stakeholders (such as local planners and National Highways). Information should be obtained not only on the existence of development plans but details such as:

- Planning status;
- Political or Commercial uncertainty as to whether a development or transport project (other than the one being appraised) will go ahead;
- Local economic or planning uncertainty, e.g. as to the success of local regeneration initiatives;
- Policy initiatives that affect travel demand (e.g. plans for Smarter Choices schemes);
- Timing; and
- Location, including access points and, for transport schemes, interchange arrangements.

2.2.15 The following additional considerations could apply for developments:

- **size;**
- **nature of development** (office, retail, leisure, residential, etc.); and

- **phasing of development** (i.e. where a proportion of the development is in use before the full development is completed).

whilst the considerations for transport schemes are covered mostly by the following:

- **the physical layout of the network;**

- **travel time**, including capacity (reallocation of road space, traffic signal times, parking supply and restrictions, and public transport capacity) and level of service (traffic management schemes or public transport frequency);

- **financial cost** (including parking charges, any road user charging and public transport fares);

- **journey quality** (including public transport quality factors and walking and cycling schemes); and

- **operational considerations**, including effects of competition (for example, a new bus scheme may persuade other bus operators either to reduce their service in line with lower demand or increase their service to provide more competition with the new scheme).

2.2.16 Note that it is important to consider the units carefully when estimating the size of developments. In particular, when estimating employment density, Gross Floor Area and site area are different units with different rates of travel.

2.2.17 Whilst some or all of these details are likely to be available in published plans there may not be much information to determine the likelihood of whether a scheme or development will go ahead. Such developments and schemes should be classified using the categories described in Appendix A Table A2 and any other assumptions used when deciding whether this should form part of the core or an alternative scenario should be recorded in the uncertainty log. It is important to draw on local knowledge and experience to reach a final categorisation. The assumptions should be justified with a short piece of explanatory text. Dependencies on other sources of uncertainty should also be noted.

2.2.18 Longer term proposals or proposals identified for future consideration will have a higher level of uncertainty. As a result it is essential that the allocation of likelihoods to proposals be carried out in a way that is realistic and based on local knowledge, avoiding “optimism bias” as far as possible.

3. The Core Scenario

3.1 Introduction

3.1.1 The core scenario will form the basis for the analysis reported in the Appraisal Summary Table (AST) and is a consistent, common comparator scenario for decision-making, to assess all projects and options against. It is intended to be:

- **based on published plans** (not including speculative proposals);
- **reflect 'firm and funded' government policy commitments** (meaning all policies to which the government is already committed and which have funding (where funding is needed));[1]
- **reflecting central projections of key exogenous demand drivers such as GDP, population and fuel prices** (based on official sources such as the Office for Budget Responsibility and other government departments);
- **unbiased** (reflecting a central view of future exogenous demand drivers, given existing plans, 'firm and funded' policy commitments, and other evidence);
- **coherent and self-consistent** (if X is unlikely to go ahead unless Y also goes ahead, then X should only be included if Y is also included); and
- **realistic and plausible.**

3.1.2 Although the core scenario should be based on central projections of exogenous demand drivers and 'firm and funded' government policy commitments, it is still essential to consider various sources of uncertainty as an integral part of the process of defining a core scenario. For this reason, the uncertainty log, described in section 2.2, needs to be compiled in advance of defining the core scenario.

3.1.3 The core scenario represents a world in which future deviation from historic trends in the key drivers of demand and current government policies is minimal; not a world that is necessarily desirable. It does not represent a statistical 'expected value', but one possible outcome amongst many. Importantly, it is constrained to align with 'firm and funded' policy commitments only, and does not incorporate non-committed possible future government policies (even if they would appear likely).

3.1.4 In practice we expect that, over a period of decades, many unanticipated events will occur and have significant consequences for travel demand. The

[1] This concerns national policy uncertainty, and not other transport projects/transport supply assumptions (considered later in this unit). Local uncertainty, including uncertainty around land-use developments and other transport projects, should be assessed using the Uncertainty Log approach demonstrated at Appendix A.

core scenario does not seek to model fundamental shifts in the underlying relationships between drivers of travel demand, nor major technological, environmental, or economic shocks.

3.2 Defining the core scenario

3.2.1 It is fairly straightforward to define the core scenario, which should be based on:

- NTEM growth in demand, at a suitable spatial area;
- sources of local uncertainty that are more likely to occur than not; and
- appropriate modelling assumptions.

3.2.2 The modeller must establish that the core scenario is robust to the key model uncertainties (model sensitivity analysis) that have been listed in the uncertainty log. This will demonstrate that the core scenario model results are significant given the model sensitivity tests, and the approach appropriate.

3.2.3 As we forecast into the future, the accuracy of the modelling approach declines and uncertainty increases. The approach to dealing with this uncertainty for rail schemes is described in TAG Unit A5.3 – Rail Appraisal. For other scheme appraisals, models will usually be used to forecast as far ahead after the opening year as input data sources allow, and then suitable assumptions should be made about extrapolation (See TAG Unit A1.1 – Cost Benefit Analysis).

3.2.4 Local sources of uncertainty categorised as **near certain** should be included in the core scenario, whilst all sources categorised as **hypothetical** should be excluded. Between these two categories, an element of judgement may be required, but usually it would be expected that those inputs categorised as **more than likely** will be included in the core scenario, whilst those categorised as **reasonably foreseeable** will be excluded.

3.2.5 Local sources of uncertainty that depend on the transport scheme (for example, dependent developments) should follow guidance in A2.2 Induced Investment.

3.2.6 The core scenario should include unbiased assumptions on economic growth and other trends that may influence transport demand and costs. The national assumptions from the TAG Data Book should not normally be varied without very strong evidence. This includes the following tables:

- A1.3.1 – Values of Time per person
- A1.3.11 – Forecast Fuel Consumption parameters
- A1.3.15 – Forecast Non Fuel Costs

3.2.7 Modelling parameters that do not vary by year, such as calibrated or transferred mode choice or distribution parameters, should be held constant from the base year model.

3.2.8 A 'firm and funded' approach should be used for incorporating uncertainty around government policy. This means the counterfactual should include all policies to which the government is already committed and which have funding.[2]

3.3 Adapting the core scenario to large scale changes

3.3.1 An important potential source of uncertainty to consider is any significant changes that may have occurred to trip patterns and travel behaviour since the construction of the base year model. TAG Unit M2.2 – Base Year Matrix Development describes the importance of establishing an appropriate base year model from which to forecast. Unexpected and significant events, for example the COVID-19 pandemic, will have an impact on model forecasts where travel patterns have markedly changed since the base year.

3.3.2 Ideally, analysts should consider rebasing their model in these situations. However, since this can come at considerable cost and takes time to achieve, more proportionate approaches may be considered, as set out in Proportionate Update Process. Appendix B provides practical guidance for accounting for large changes in travel patterns and behaviours, such as the impact of the COVID-19 pandemic, for upcoming decision-points.

3.3.3 As also described in Appendix B, further consideration may be required of the sustained impact, or otherwise, of these large changes to travel patterns; whether they will endure or revert, in the absence of empirical evidence. Analysts should consider additional sensitivity tests or scenarios to demonstrate the potential impact of different scenarios around potential future demand trajectories where this may be of importance to the scheme and the decision in hand. This should be part of national uncertainty testing and the uncertainty log described in Section 2. The Uncertainty Toolkit provides additional advice.

4. Defining Alternative Scenarios

4.1 Introduction

4.1.1 The core scenario, as discussed in section 3, is intended to provide a sensible, consistent basis for decision-making given current evidence, and provides a

[2] See https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

'common comparator' to assess all projects and options against. For all interventions, a core scenario appraisal should be undertaken. However, there are significant and often unquantifiable uncertainties associated with forecasting travel demand, such that it is not possible to robustly identify a 'most likely' or expected outcome with any certainty. Key questions include:

- Under high demand assumptions, is the intervention still effective in reducing congestion or crowding, or are there any adverse effects, e.g. on safety or the environment?
- Under low demand assumptions, is the intervention still economically viable?
- Under a wide range of possible futures, does the intervention still provide value for money?

4.1.2 The Common Analytical Scenarios (CAS) are a set of seven standardised, off-the-shelf, cross-modal scenarios exploring national level uncertainties which have been developed by DfT for use in modelling, forecasting and appraisal. They are preferred substitutes for the High and Low Growth Scenarios (defined in section 4.2) and their use is expected for 'high impact' schemes. Where the CAS are used, promoters should demonstrate that the scenarios chosen are at least as stretching as the High and Low Growth Scenarios for the project being appraised. In practice, for most highway projects where the CAS are applied, this means the 'behavioural change' and 'technology' scenarios should be run at a minimum (in addition to the core scenario).

4.1.3 The TAG Uncertainty Toolkit provides guidance on applying the CAS. Unlike the High and Low Growth Scenarios, in the CAS, various demand levers are altered. Some of these only affect trip generation, and are reflected in the TEMPro datasets provided for each CAS. Others, such as vehicle operating costs, modelling values of time and car occupancy will impact demand and assignment modelling. See the CAS Data Book for further details and recommended parameter values.

4.1.4 Subject to considerations of proportionality, the CAS should also be used for 'low' and 'medium' impact projects (see TAG Uncertainty Toolkit, Chapter 3 for details, including definitions of low, medium and high impact projects). The CAS provide input assumptions as part of plausible scenarios for key national level uncertainties, thereby provide deeper insights into uncertainty than generated through the simplified arithmetic representation used in the High and Low Growth Scenarios.

4.1.5 Where the High and Low Growth Scenarios are used, details of their impact of should be given in the Forecasting Report. Section 4.2 explains the standard method for applying the High and Low Growth Scenarios.

4.1.6 The High and Low Growth Scenarios should be subject to a full appraisal in accordance with the guidance in the Appraisal TAG Units, using the same modelling structure as the core scenario but with different demand assumptions. For the CAS, guidance in the TAG Uncertainty Toolkit explains what level of analysis is expected.

4.2 Defining High and Low Growth scenarios

Treatment of National Growth in Demand

4.2.1 The High Growth Scenario should consist of forecasts that are based on a **proportion of base year demand** added to the demand from the **core scenario**.

4.2.2 The proportion of base year demand to be added is based on a parameter p which varies by mode. The proportion is calculated as follows:

- for 1 year after the base year, proportion p of base year demand added to the core scenario;
- for 36 or more years after the base year, proportion 6*p of base year demand added to the core scenario;
- between 1 and 36 years after the base year, the proportion of base year demand should rise from p to 6*p in proportion with the square root of the years. (So, for example, 16 years after the base year the proportion is 4*p).

4.2.3 For highway demand at the national level, the value of p is **4%**, reflecting uncertainty around annual forecasts from the National Transport Model (NTM), based on the macro-economic variables that influence the main drivers of travel demand. For public transport modes, at present we can only provide rule of thumb recommendations and further research may be needed in this area. Results from the National Transport Model suggest that the uncertainty ranges for public transport should be lower than those for highway, because public transport usage is less sensitive to both fuel price and income than car travel:

- the relationship between income growth and bus travel is complex – as income grows, bus may lose trips to car as car ownership grows, but gain trips from walk;
- rail travel gains from income growth in the same way that car travel does, but gains only some of the reduction in car travel as fuel prices increase.

4.2.4 As such, it is suggested that a comparative value of p for bus travel is **3%**,. For multi-modal demand matrices in the demand model, p=**3.5%** may be sensible taking into account the different ranges for car and public transport, although this is not supported by evidence. For rail travel, we do not recommend using the M4 High & Low Growth Scenarios. Instead, please refer to Section 8 Modelling a Scenario – Rail Schemes for how to deal with uncertainty when modelling rail schemes.

4.2.5 Box 1 describes the use of this method for highway and local schemes.

Box 1 Implementing National Traffic Forecast Uncertainty

National traffic forecast uncertainty ranges quoted are for traffic (vehicle-kilometre) growth. Therefore, when variable demand modelling is being used, the most appropriate approach to carrying out the necessary sensitivity tests is as follows:

- Extract corresponding post-variable demand model trip matrices from the core scenario forecast and the base year model outputs. The core scenario forecast should have been run to convergence;
- Adjust this post-variable demand model matrix, on a cell by cell basis, to reflect the range of uncertainty by taking the appropriate proportion of the model base year matrix and adding it to or subtracting it from the converged future year core scenario matrix*. For example, for a forecast of highway demand nine years from the base, add or subtract 12% of the base year matrix.
- When using absolute models applied incrementally, the adjustment should be made by taking the appropriate proportion of the model base year matrix and adding or subtracting it from the incremental adjustment.
- Using these adjusted matrices, iterate the demand and supply models to convergence in the usual way to provide the required future year sensitivity tests;
- Compare the outturn estimates of vehicle-kilometre growth for the sensitivity tests with that for the core scenario to confirm that the sensitivity tests do provide the appropriate range about the core scenario. Note, however, that the outturn range may be significantly narrower than that input when considering a heavily congested network. This is acceptable, since the impact of uncertainty in national trends is likely to be muted in such conditions.

* To understand why this approach is correct, consider a matrix cell with value A in the base year matrix and B in the (fully converged) future year matrix. Central growth is, therefore, G=B/A. We wish to test variants based on growth G^{high}=G+U and G^{low}=G-U, where U is the range appropriate for the given future year. Thus, for the 'high' variant, we need to calculate the value B^{high}= G^{high}*A= (G+U)*A=B+U*A. Similarly, B^{low}=B-U*A.

4.2.6 Most scenarios will require model runs of more than one year, with forecasts at the opening year and a defined forecast year. Separate ranges need to be calculated for each modelled year. For example, where a scenario has forecasts at 1 and 16 years after the base year, the proportion of base year highway demand that should be added in each forecast year is 4% and 16% respectively.

4.2.7 The Low Growth Scenario should be based on the same ranges **below** the core scenario demand as the High Growth Scenario is above it.

Treatment of Local Uncertainty

4.2.8 It may be appropriate to vary **local** assumptions about demand in the High and Low Growth Scenarios, and in the CAS where they are used. For example:

- in the High Growth scenario, including some of the most likely sources of growth that had not been included in the core scenario;
- in the Low Growth scenario, excluding some of the less likely sources of growth that were included in the core scenario.

4.2.9 Total growth, however, should be constrained to that calculated using the method in Box 1 in the case of the High and Low Growth Scenarios, or the relevant NTEM projections for each CAS.

4.2.10 In the High and Low Growth Scenarios, local assumptions about **supply** (the transport network) should **not** usually be changed from the core scenario, as this may hide important impacts that decision-makers need to be aware of. There are, however, two exceptions to this:

- access roads to additional developments that have been included (but **not** changes to the existing network on which these developments depend);
- in paragraph 7.4.4, provision is made for minor changes to the network in the core scenario to accommodate growth in demand. Since these are not an official part of the definition of the core scenario, it may be appropriate to vary these assumptions in the High and Low Growth Scenarios.

4.3 Reporting the Alternative Scenarios

4.3.1 All alternative scenarios, including the High and Low Growth Scenarios and the Common Analytical Scenarios, should be subject to a proportionate appraisal, and scenarios critical to decision making should be presented in separate ASTs. Exceptional results of non-critical scenarios should be presented in the qualitative column of the AST (but quantifying the difference where possible). Currently, it is not possible to calculate Wider Economics Impacts in WITA for all of the CAS. The Department is undertaking work to expand the capabilities of WITA to permit this, but in the meantime there is no requirement to undertake Wider Economic Impacts appraisal for the CAS.

5. Defining Additional Alternative Scenarios

5.1 Introduction

5.1.1 In addition to the High and Low Growth Scenarios described in section 4, and the Common Analytical Scenarios, other scenarios may be required to test the impacts of significant sources of local uncertainty. These scenarios should also be subject to a full appraisal.

5.1.2 Appreciation of every possible permutation of sources of uncertainty would require a very large number of model runs that would take an unacceptable amount of time to run. Therefore, it is important that analysis of alternative scenarios is proportionate as well as sufficiently comprehensive.

5.2 Defining alternative scenarios

5.2.1 There may be circumstances under which local uncertainty may need to be tested independently of national uncertainty, although this might create the need for a very large and disproportionate number of scenarios to be modelled. To avoid this situation, it may be appropriate to consider whether more uncertain developments (such as housing, employment and retail) are more likely to go ahead under high assumptions of economic growth (which might also be associated with higher growth in transport demand).

5.2.2 In areas where it is not appropriate to assume local uncertainty correlates with national uncertainty, it may be appropriate to carry out additional tests in which the core scenario assumptions are adjusted to include “reasonably foreseeable” local inputs or to exclude “more than likely” local inputs.

5.2.3 Each scenario should be self-consistent. In particular:

- if one input A depends on another input B, then A should only be included if B is also included;
- where there is uncertainty about the nature of an input (e.g. its location), then assumptions will need to be made about what is most likely to happen.

5.2.4 For example, if there is a reasonably foreseeable housing development of 1,000 dwellings that could appear in one of three locations, its impacts should be tested at the most likely location. Certainly, it would not be appropriate to appraise a scenario in which the full housing development of 1,000 dwellings was included at all three locations simultaneously.

5.2.5 Where sources of local demand and local supply uncertainty are independent of each other, **it may be important to test uncertainty in local demand inputs separately from uncertainty in local supply inputs.** This is because testing both in combination may hide some of the risks which the decision-maker should be aware about - for example, if high demand is only tested with high supply, the decision-maker may not be aware of chronic impacts of increased congestion if the high demand assumptions materialised in conjunction with low or moderate supply assumptions.

Significant sources of local uncertainty

5.2.6 Some sources of local uncertainty may have a significant impact on the transport network if they go ahead (for example, a housing development of 1,000 dwellings). It may be appropriate to test these individually, even if they are only hypothetical, so that decision-makers are aware of any risks that could arise. This is particularly important if the source of uncertainty is very close to the scheme itself.

5.2.7 In some cases, there may be a plan for a development but uncertainty about its precise location (this is most likely for “reasonably foreseeable” and “hypothetical” developments). If the development is reasonably small, or all its potential locations are not within the vicinity of the scheme, it may be proportionate to test it at the most likely location only. However, if the development is large and may happen at one of several locations within the vicinity of the scheme, it may be appropriate to test it at more than one location.

5.3 Other scenarios required for Rail schemes

5.3.1 See Section 8 for guidance on approaching rail forecasting uncertainty.

6. Reporting the Core and Alternative Scenarios

6.1 Reporting the core scenario

6.1.1 The core scenario should be appraised in accordance with the guidance in Appraisal TAG Units and form the basis of the Appraisal Summary Table (AST).

6.1.2 The assumptions used to define the core scenario should be reported in the Forecasting Report. This should include details of:

- the development of future year planning scenarios and assumptions. This is likely to include the NTEM data used (in particular the NTEM version, spatial areas, and type of growth factors used) and the uncertainty log and the reasoning behind uncertainty ranges;

- the changes made to the base year network to produce the without-scheme forecast network. This includes details of any changes made to the network where the network capacity based on planned improvements would be insufficient for the demand, as discussed in paragraph 7.4.4;

- the changes made to the without-scheme forecast network to make the with-scheme forecast network (i.e. the representation of the scheme itself);

- sources and assumptions for updating of generalised costs (assumptions for value of time, vehicle operating costs; assumptions of public transport fares and related costs); and

- details of model parameters, together with uncertainty ranges, and any other modelling assumptions and simplifications;

6.1.3 The Forecasting Report should also give details of the model outputs, including:

- presentation of the forecast travel demand and conditions, including diagrams of forecast flows on affected corridors for the Without-Scheme forecast and the scheme options; and

- an explanation of any results that may appear counterintuitive, such as very slow speeds, high junction delays and forecasts of flows above capacity.

6.2 Reporting the Alternative Scenarios

6.2.1 All alternative scenarios (including the CAS) should be subject to a full appraisal, but they do not each require a separate AST. Exceptional results should be presented in the qualitative column of the AST (but quantifying the difference where possible).

7. Modelling a Scenario – Surface Schemes other than Rail

IMPORTANT NOTE: For modelling Rail schemes, please refer to section 8.

7.1 Introduction

7.1.1 This section sets out how to model a scenario (this applies to both core and alternative scenarios).

7.1.2 Before modelling future scenarios, it is essential to define the forecasting assumptions. Usually, the Department expects the following tools to be used to appraise major transport interventions:

- A transport model;
- NTEM (or PDFH (Rail schemes only)); and
- Uncertainty Log (This was set out in section 2).

Transport models

7.1.3 As a prerequisite to all model forecasting, it is assumed that the model will be developed and validated for a recent year (the base year). Validation to the standards given in TAG Unit M3.1 – Highway Assignment Modelling and TAG Unit M3.2 – Public Transport Assignment Modelling provides some assurance of the credibility of the model, and also against bias which would be transferred to the forecasts within the forecasting process.

7.1.4 The model also needs to be tested for realism and sensitivity to ensure it responds sensibly to changes in inputs. Further guidance on realism testing and sensitivity testing is given in TAG Unit M2 – Variable Demand Modelling.

NTEM dataset

7.1.5 The NTEM dataset represents the Department's standard assumptions about growth in demand, expressed in units of Trip Ends. Trip Ends (which are described further in TAG Unit M1.1 – Principles of Modelling and Forecasting) are an initial estimate of the total number of trips to or from a zone. In NTEM, these trip ends are split by trip purpose, mode and **either** time period **or** car availability. Spatially they are split into the NTEM zoning system, which covers the whole of Great Britain with at least one zone for each Local Authority / District area.

7.1.6 The NTEM dataset can be viewed using the TEMPRO software (Trip End Model Presentation Program). Both are available free of charge on the TEMPRO website.

7.1.7 NTEM represents the Department's central assumption of growth in travel demand between any two given years. When modelling for business cases is submitted to the Department, scenarios assuming central growth in demand (such as the core scenario, described in section 3) **must** be controlled to the growth in travel demand in the NTEM dataset at an appropriate spatial area (usually Local Authority / District level). There is a standard way of adjusting growth in demand to represent high and low growth assumptions, described in section 4.

7.1.8 The NTEM dataset makes no assumptions about whether or not individual developments go ahead. Full appreciation of the spatial distribution of travel demand requires consideration of local uncertainty, discussed from paragraph 2.2.12 onwards.

7.2 Producing a forecast

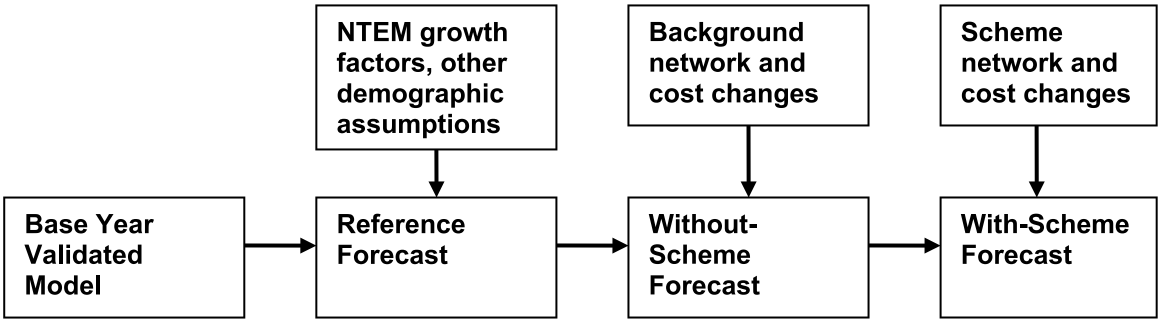
7.2.1 TAG Unit A1.1 – Cost Benefit Analysis provides guidance on the forecasts that are required to analyse an intervention under a given set of forecasting assumptions. Briefly, at least four future forecasts are usually required:

- appraisal of an intervention for a given year requires the comparison of two model runs – a **without-scheme forecast** excluding the intervention, and a **with-scheme forecast** that includes it;
- usually it will be necessary to appraise the intervention for at least two different future years, and make a sensible assumption about the profile of the change in benefits over time.

7.2.2 Before either of these two forecasts are prepared, another forecast – the Reference Forecast – is constructed for each year. Essentially this updates the demand data from the base year to the forecast year under the assumption that the cost of travel is unchanged from the base year. The without-scheme and with-scheme forecasts then take account of the changes to the transport network, and hence changes in costs to transport users. The reference forecast is distinct from the notion of the reference (appraisal) scenario, and a separate reference forecast will generally be needed to implement each of the CAS.

7.2.3 Figure 1 shows the inputs required for each of these forecasts:

Figure 1 Basic approach to forecasting using a transport model



7.2.4 When multiple scheme options are being run, it may not always be necessary to run all three forecasts for each option. For example, where different scheme options are being tested with common demand and background network assumptions, the reference forecast and without-scheme forecast only need to be run once. Similarly, if developing the core scenario and an alternative scenario, if the scenarios have the same demand assumptions but different network assumptions, the reference forecast only needs to be run once.

7.2.5 Impacts (including economic benefits and environmental and social impacts) are analysed by comparing the with-scheme forecast with the without-scheme forecast for each modelled year.

7.3 The Reference Forecast

7.3.1 The Reference Forecast needs to incorporate the changes in travel demand from the base year, as a result of **demographic changes only (e.g. population, households, car ownership and employment)**. Changes in travel cost (e.g. congestion or fares) or other parameters (e.g. value of time) should **not** be included in the Reference Forecast. The reference forecast is distinct from the notion of the 'core scenario' discussed above.

7.3.2 The Reference Forecast should take into account the impact of both national changes (e.g. population growth and GDP) and local changes (e.g. housing developments) on travel demand. Overall demand in the forecast should be constrained to the Department's projections to ensure that different schemes are being compared on consistent assumptions about total demand. Local changes influence the spatial distribution.

7.3.3 To maintain consistency with national projections, the reference forecast should be based on trip end growth factors from the NTEM dataset. This dataset is itself consistent with the definition of a Reference Forecast – it considers changes in demand resulting from demographic changes, but not changes to economic parameters, income, fuel prices, the accessibility of each location, or travel behaviour.

7.3.4 In most cases, some adjustments to the NTEM dataset will be required at a local level:

- NTEM also makes no assumptions about whether or not individual land use developments go ahead. Adjustments may be required based on local uncertainty assumptions, but at an appropriate spatial level growth must be constrained to NTEM to avoid optimism or pessimism bias;

- NTEM trip attractions do not include surface travel made by airline passengers.

Adjusting NTEM data to incorporate land-use developments

7.3.5 If land use developments are a source of uncertainty, the spatial distribution of trip ends at a detailed level will need to be adjusted in accordance with likely travel from the development, based on the evidence available. Over a wider spatial area, growth in demographic data must be constrained to the appropriate Department-based projections (NTEM for the Core Scenario and the Common Analytical Scenarios).

7.3.6 Forecast trip ends for land use developments should be consistent with a Transport Assessment where such evidence is available. Where insufficient evidence on trip ends from developments is available from Transport Assessments, a separate trip generation model may be required.

7.3.7 The TEMPRO software (described in paragraph 7.1.6) provides an **alternative assumptions** facility to adjust NTEM trip ends to exclude development sites (for which the trip ends will be calculated separately). This can be used as follows:

- calculate the number of households and/or jobs in the NTEM zone resulting from developments (dwellings are often taken as a proxy for households);

- subtract the number of households and/or jobs thus calculated from the zone totals in NTEM;

- enter these data into TEMPRO (alternative planning assumptions) and rerun, to calculate the growth in trip ends **excluding** the developments;

- add the development trip ends based on the Transport Assessment; and

- check and report the total trip ends. These should be very close to the NTEM total for the given NTEM zone.

7.3.8 An example is given in Box 2. Appendix C sets out the calculation in some more detail.

Box 2: Applying Alternative assumptions in TEMPRO

A local model is constructed to represent the spatial area within NTEM zone A. The model has a number of detailed zones within NTEM zone A and is required to forecast from 2010 to 2025.

NTEM Zone A has the following planning data for these two years:

Year	**2010**	**2025**
Households	10,000	12,000
Employment	5,000	6,000

However, the analyst has identified two developments from the uncertainty log which are expected to be built by 2025:

- one with 1,000 dwellings in local model zone a;
- the other with 1,000 jobs in local model zone b.

Both of these have trip generation forecasts from transport assessments.

The analyst therefore uses the alternative assumptions facility within TEMPRO, and subtracts 1,000 households (making the assumption that each dwelling is occupied by one household) and 1,000 jobs from the standard assumptions to calculate the trip end growth factors **excluding** the new developments.

Year	**2010**	**2025**
Households	10,000	11,000
Employment	5,000	5,000

The analyst then runs TEMPRO using these alternative assumptions to obtain revised production/attraction growth factors, and then **adds** the trip generation forecasts from the transport assessments.

In this instance, the development in zone b is so large that it takes up all the employment growth between 2010 and 2025. The analyst would be well advised to check with the scheme promoter that this is realistic.

Adjusting NTEM data to take account of surface transport for air passengers

7.3.9 Surface travel demand for airports should be considered for all schemes, but where there is no major airport within or near to the study area, it may be sufficient to assume that such travel is minimal and make a case to the Department for not analysing it explicitly.

7.3.10 The NTEM dataset includes all trip end productions for surface access trips to airports. However, the NTEM trip end attractions **exclude** surface travel for airline passengers and those escorting them. This may mean that the spatial distribution of the trip end attractions may need to be modified from NTEM levels if there is a major airport within the vicinity of the scheme.

7.3.11 The exact approach used should be fully documented and included in the Forecasting Report.

Application of NTEM controls for different types of model

7.3.12 The NTEM control needs to be applied in different ways for different models. In **variable demand models**, it should usually be applied to trip end productions and attractions as follows:

- the approach for applying growth in trip end productions depends on whether the model is multi-modal or uni-modal (i.e. representing a single mode):
  - for **multi-modal** models, all-day trip end productions should be factored using NTEM growth in trip end productions by trip purpose and car availability;
  - for **uni-modal** models, all-day trip end productions should be factored using NTEM growth in trip end productions for the given mode by purpose for an appropriate time period (usually an average weekday). No split by car availability is required;
- all-day trip end attractions should be factored using the NTEM growth in trip end attractions by purpose for an appropriate day (usually an average weekday). The NTEM growth should be based on the modes modelled. No split by car availability is available;
- the demand matrix should then be updated using the **Furnessing** (also referred to as biproportion), procedure described below.

7.3.13 **Fixed demand models may also require a further adjustment discussed in paragraph 7.4.13.** This adjustment should **not** be used in variable demand models.

7.3.14 There is another application of NTEM data to obtain traffic growth factors (based also on National Transport Model data) where no formal model is being used. However, this method is very approximate and would not normally be used in the appraisal of major schemes. Further details are given in section 9.

7.3.15 The **Furnessing** procedure can be used to adjust a matrix to match row and column totals, by alternately factoring the matrices to match row totals and column totals. Since the procedure only converges when row and column totals each have the same number of trips, the two estimates of the total trips in the matrix (one from the rows, one from the columns) need to be reconciled. This may be done by simply taking the average of the two estimates, and controlling both row and column totals to this total. Alternatively, if the matrix is held in production-attraction form, the productions may be deemed more reliable, as the data on which they are based (population and households) is more stable.

7.3.16 Where Furnessing the whole matrix is not possible because some movements (external – external) are not fully observed, the standard method is to Furness the fully-observed (internal – internal) movements and growth the remainder by the mean of the relevant row and column growth factors.

7.3.17 Use of growth rates taken from a higher-tier model is also acceptable, especially for models of urban areas, providing the higher-tier model is itself in accordance with the NTEM growth factors at that level and has itself been thoroughly validated. The higher-tier model will account for the impacts of land use changes and major transport interventions over a wider area than the local model.

Reference Forecast – Freight Traffic

7.3.18 Most local models will not be able to forecast changes in freight traffic in detail. Usually, simpler methods, such as applying a single growth factor for the whole matrix will suffice. The annual regional traffic forecasts from the National Transport Model (NTM), published by the Department, may be useful for forecasting freight growth (OGVs and LGVs) at regional level between 2003 and 2035. Beyond this period, these forecasts should be extrapolated to the required modelled year. If more guidance is required, please contact the Department.

7.3.19 There may be circumstances where such simple factoring methods may not be appropriate because a major development, such as a distribution centre or retail park, will affect freight demand. TAG does not currently provide guidance on this; analysts who wish to use an alternative approach are advised to engage early with the Department.

7.4 The Without-Scheme Forecast

7.4.1 The Without-Scheme forecast in the core scenario should represent a realistic view of what is likely to happen in the absence of the scheme proposals. It will usually correspond to maintaining existing transport facilities and implementing the more certain aspects of regional and local transport strategies.

7.4.2 There are two main considerations when updating the Reference Forecast to the Without-Scheme Forecast:

- changes to transport policy and travel behaviour (usually represented as parameters);
- changes to the network that have an impact on travel cost (both time and money).

7.4.3 Although the changes between the Reference Forecast and the Without-Scheme Forecast principally relate to transport supply, it should be noted that changes in economic parameters (such as value of time or fuel costs) will also have an impact on the demand model.

7.4.4 The Without-Scheme Forecast should be updated from the Reference Forecast by incorporating all the core transport supply assumptions identified in the uncertainty log. In some cases, it may be clear that further improvements to the transport system, that had not been identified in the published plans, are likely to be required to accommodate future demand. Such improvements should be included, provided they do not involve large expenditures (up to say 20% of the proposed scheme cost) as this could distort the appraisal severely. Where greater expenditure would be required, the impact should be established by use of a sensitivity test. **Any such changes should be reported**.

7.4.5 It is advisable to retain a copy of the network representation **without** such improvements, as not all the improvements may be needed for some of the alternative scenarios.

7.4.6 The Without-Scheme forecast will need to reflect historic trends in transport provision. For example, if public transport service improvements or changes in the real cost of fares can be identified, there may be a case for extending these trends into the future.

National impacts on transport policy and travel behaviour

7.4.7 Changes in transport costs and travel behaviour are usually represented through economic parameters. These include values of time, vehicle operating costs and vehicle occupancies and may include GDP, incomes and car ownership levels.

7.4.8 It is important that these parameters are taken into account appropriately for the schemes being modelled. This means that the parameters in the demand model **must** be updated between the base year and the Without-Scheme forecast, and (with the occasional exception of car occupancy) they **must not** be updated between the Without-Scheme and With-Scheme forecasts.

7.4.9 In addition, these parameters should be updated in the assignment model where appropriate. Updating the value of time may be particularly important for study areas with significant changes in user charges (e.g. road user charging, parking charges or fares).

7.4.10 In variable demand models, changes in values of time and vehicle operating cost are usually represented by model parameters which will need to be updated. The proportional growth in parameters from TAG Unit A1.3 - User and Provider Impacts should be applied.

7.4.11 Where models use a standard value of time per vehicle, both the value of time and occupancy can change. The growth in value of time per vehicle will need to be established by calculating the value of time per vehicle in the base year and forecast year and dividing the forecast year value by the base year value. The value of time per vehicle is obtained by multiplying the value of time per occupant by the average number of occupants; where values of time differ by driver and passenger, it should be assumed that one occupant per vehicle is a driver.

7.4.12 Vehicle operating costs include fuel prices, future fuel efficiency levels and any future changes in non-fuel operating costs. Operating costs for public transport vehicles may affect operators, but will not have a direct impact on passengers.

7.4.13 Where fixed demand take values of time and vehicle operating costs into account, these parameters should be updated in a similar way to variable demand models. Where there is no demand model, the trip matrix should be multiplied by two factors, one for growth in income, the other for growth in fuel. The factors are given in the TAG Data Book Table M4.2.1 – Use of TEMPRO data as growth factors **from 2010**, and should be applied as shown in Box 3 below.

Box 3 Example of using NTEM growth for fixed demand models

A matrix is required to be factored up from 2017 to 2022.

NTEM trip-end growth should be supplemented with:

Overall income adjustment factor = 1.025 / 1.012 = 1.013

Overall fuel cost adjustment factor = 1.050 / 1.026 = 1.023

Therefore the initial growth factor for each origin and destination trip end of the matrix should be:

Adjusted **TEMPRO** trip-end growth * 1.013 * 1.023 = 1.036

7.4.14 Forecasting assumptions underlying the fuel and income factors are:

- Car vehicle kilometres increase proportionately to income per car owning household with elasticity of 0.2 (or equivalently to GDP per household with elasticity of 0.16). Note that the NTEM trip-ends take account of the expected impact of income on car ownership, so this elasticity figure excludes the effect of income on car stock, to avoid double-counting.

- Fuel price, vehicle fuel efficiency and market share of diesel in accordance with TAG Unit A1.3, although some recent fluctuations in fuel price have been smoothed.

- Elasticity of car vehicle kilometre per car to fuel cost of -0.25 (note that the current NTEM trip- ends do not take account of the impact of fuel cost on car ownership, so this elasticity includes the effect of fuel cost on car stock).

Local changes resulting from other transport schemes

7.4.15 The Without-Scheme scenario requires consideration of the following:

- **physical changes** to highway or public transport networks, including new links and the removal of existing links;
- other interventions that will affect travellers' **journey time**, such as changes to the number of lanes on a link (including bus priority), traffic management, or changes to public transport service provision in terms of routing, frequency, capacity provision stopping times and interchange times;
- changes to **financial charges** faced by the user, including parking charges, road tolls, and public transport fares;
- changes in **journey quality**, for example through improvements in the quality of public transport vehicles or interchange;
- changes in **public transport operator profitability and commercial response**. This could include consideration of **operating costs, revenues and subsidies**, typically for public transport schemes.

7.4.16 For more information on forecasting the generalised cost for rail specifically, see section 8.

7.4.17 **Physical changes to the network** and **interventions affecting travellers' journey times** can be represented by updating the base year assignment network models, in line with the guidance in TAG Unit M3.1 and TAG Unit M3.2. Some public transport schemes (e.g. bus lanes, level crossings) may reduce highway capacity and have a significant impact on highway congestion which should be represented carefully in the highway network. It is important that journey times are calculated accurately, as they affect not only the model response but also have a dominant impact on the eventual appraisal results.

7.4.18 Forecasting **financial charges to users** (such as road tolls, parking charges and public transport fares) is likely to depend on future charging policy, which may be uncertain. A sensible approach may be as follows:

- if charging policies are known, implement them in the core scenario. This is quite possible for road tolls and parking charges; it is less likely for public transport fares if they are at the discretion of the operator;
- if charging policies are not known but there are reasons to expect that charges will not be held constant and sensible assumptions exist, these assumptions should be implemented. Examples are as follows:
  - for public transport services, it may be expected that a constant operating surplus (for public sector services) or margin (for private sector services) will be maintained, and fares will vary taking into account the impact of passenger numbers and vehicle operating costs;

- for parking charges, if it is likely that charges will need to be changed to manage the demand for parking, such changes should be included;

- if it is likely the charging policy will be to hold the charge constant in nominal terms until the forecast year (e.g. at a constant £1), the charge will be decreasing in real terms because of the impacts of inflation. This impact should be taken into account in the forecast;

- if none of the above cases apply, it may be best to assume the charge remains constant in real terms.

7.4.19 Changes in **journey quality impacts** will usually be limited to public transport or (where modelled) active modes. Typically this will include improvements to comfort, safety and security; for example, reduced crowding on, or improved quality of, public transport vehicles, real time passenger information, off-road cycle lanes that are safer and more appealing and security considerations such as improved CCTV or lighting.

7.4.20 The impacts of **crowding** may be represented in the model using the techniques described in TAG Unit M3.2. For other impacts where adequate evidence exists, it may be appropriate to adjust the model as follows:

- where the impact of the change is proportional to journey time (such as improved quality bus vehicles or off-road cycle lanes), it may be appropriate to apply factors to travel time over the sections of the journey where the change exists;

- where the impact of the change is proportional to wait time (such as improved lighting and CCTV at public transport stops) it may be appropriate to factor wait times or interchange times;

- where the impact of the change applies once per trip (for example, real time information or improved customer service from bus drivers) it may be appropriate to apply a one-off cost reduction for the trip.

7.4.21 Some of these approaches are similar to the modelling of Smarter Choices, and TAG Unit M5.2 – Modelling Smarter Choices gives further guidance on these approaches. The journey quality section of TAG Unit A4.1 – Social Impacts provides further guidance and evidence for modelling the journey quality impacts on public transport.

7.4.22 The approach to modelling the **profitability and commercial response of public transport operators** should have been established as part of the scope of the variable demand model or the assignment model. Response to public transport fares is discussed above. Changes in **operating costs** may also be relevant, including:

- labour costs, which may increase at a rate exceeding the rate of inflation. Guidance on calculating values of time from TAG Unit A1.3 may be useful in forecasting these values from the base year;

- improved technology, such as cashless ticketing and pre-payment methods, which may reduce costs;
- vehicle operating costs. Estimated values for a generic highway public service vehicle (bus or coach) are given in the TAG Data Book Table A1.2.6 – Values of Time per vehicle. For greater detail on fuel consumption for different PSV vehicle types, see the report Road Vehicle Emissions Factors 2009, published by the Department at: http://www.gov.uk/government/publications/road-vehicle-emission-factors-2009.

7.4.23 The impacts of improved technology may be estimated using analysis of historic data and consideration of future plans, but the effort may be disproportionate. Unless significant changes are obvious, a sensible approach may be to assume no real change in the core scenario, but to consider the implications of change as a sensitivity test.

7.4.24 In some cases, there may be more than one outcome of operator response consistent with the definition of a core scenario. Where this is the case, the most likely outcome should be chosen for the core scenario, and any other outcomes should be tested by means of sensitivity tests.

7.5 With-Scheme Forecast

7.5.1 The With-Scheme Forecast must use the same assumptions as the Without-Scheme Forecast, except with the transport scheme itself included. In particular, housing or other developments that depend on the scheme **must not** be included in the with-scheme forecast unless they have also been included in the without-scheme forecast, as this will distort the appraisal results. Further guidance on dependencies between land-use and transport are given in TAG Unit A2.3 – Transport Appraisal in the Context of Dependent Development.

7.5.2 If there is any uncertainty about the precise definition of a scheme option, sensitivity analysis should be used to assess the impacts of variations from the basic scheme definition. These tests are required to ensure that the basic scheme definition represents the optimum configuration (the best solution), but also to determine the impact of unforeseen changes on the scheme’s value for money.

7.5.3 The impacts of the following measures are likely to be subject to uncertainty, so if they are included as part of the scheme the Department expects to see an assessment of their impacts on mode choice by means of a sensitivity test:

- Smarter Choices;
- Park and ride schemes;
- Parking controls;
- Congestion Charging and other road user charging schemes.

7.5.4 In some cases it may be desirable to make simplifications in the modelling, particularly for public transport schemes. Such uncertainty should be considered, although removing the simplifications altogether would defeat the purpose of the simplification. It is recommended that:

- where simplifications in network coding cannot be clearly supported by the modeller's previous experience, tests should be undertaken of increasing the complexity of the coding in a selection of instances;

- where simplifications in modelling traveller responses have been applied, the analyst should consider conducting one or more tests in which a range of simple factors are applied which are considered to encompass the possible effects of the missing traveller response.

7.5.5 Where public transport is modelled, consideration of the response of existing public transport service operators should form part of the appraisal of the new scheme. New public transport services may well extract patronage from existing public transport modes, which can result in a reduction in operating surplus or an increase of operating subsidy to unacceptable levels. It is not necessary to attempt to rectify this by adjusting the design within the scheme forecasting process, but the Promoter may wish to include such adjustments as part of the scheme.

7.5.6 As changes in cost between the Without-Scheme Forecast and the With-Scheme Forecast will be used directly in the appraisal of the scheme, accuracy of the scheme representation is **even more crucial** than accurate representation of other changes to the network between the base year and Without-Scheme Forecast.

8. Modelling a Scenario – Rail Schemes

8.1 Introduction

8.1.1 The **Passenger Demand Forecasting Handbook** (PDFH) provides the general framework for forecasting rail passenger demand. It summarises collective rail industry knowledge of the effect of various influences on passenger demand, and draws forecasting parameters from previous experience and research. It also provides guidance on applying this knowledge to the preparation of passenger demand forecasts.

8.1.2 PDFH is maintained and developed by the Passenger Demand Forecasting Council (PDFC), which consists of all the Train Operating Companies, Network Rail, Department for Transport, Transport Scotland, the Office of Rail and Road, Transport for London and the Passenger Transport Executives Group and other devolved bodies. It procures research into demand forecasting issues relevant to the rail industry[3].

8.1.3 In order to remain state-of-the-art, the PDFH is periodically updated to incorporate the findings from recent peer reviewed primary research. TAG rail forecasting guidance is an amalgam of the recommendations in PDFH and some references to DfT specific research.

8.1.4 The most effective structure for forecasting rail schemes is an elasticity-based model, in contrast to the approach used for other surface schemes. TAG guidance is based on the PDFH and used elsewhere within the rail industry, but with a small number of amendments to reflect the strategic and longer term forecasting needs of DfT. Applications of the methodology include:

- strategic planning – where ;
- franchise analysis - specification, bid assessment, ad-hoc initiatives;
- financial forecasts - forecasting Train Operating Company (TOC) revenue; and
- option appraisal - of programmes, projects and policies.

8.1.5 All rail passenger demand forecasts that are submitted to DfT for funding are required to adhere to the methodology set out in this section. As a consequence, funding applications need to be preceded by a demand forecasting methodological statement which clearly states the data sources, assumptions and methodology used. This should be incorporated within the Appraisal Specification Report.

8.1.6 There are a small number of circumstances where alternative approaches may be more appropriate. Section 8.2 distinguishes between the two principal approaches to modelling rail passenger demand and describes how the most appropriate approach should be determined. Where this is proposed, the suggested methodology should be discussed with the Department.

8.1.7 Sections 8.3 and 8.4 describe how the PDFH approach is used (and varied from) in TAG, and section 8.4 provides conclusions.

8.2 Establishing a Demand Forecasting Approach

8.2.1 As noted in TAG Unit M1.1, rail passenger demand can be modelled either using an elasticity based model or a variable demand choice model approach. In contrast to highway and local schemes, however, the elasticity-based model approach is most commonly used for rail schemes, because:

[3] Further information on PDFC and PDFH can be found at https://www.raildeliverygroup.com/pdfc.html

- it is often difficult and expensive to collect sufficient data of adequate quality to construct a choice model for rail schemes, which usually cover a large geographical area;
- rail is a minority mode, and so its demand is not expected to be constrained in proportion with population growth in the same way as more common modes, such as car or walk.

8.2.2 Elasticity based models also have the advantage of being simpler to build, maintain and use than variable demand choice models.

8.2.3 However, if a variable demand choice model of the area already exists, it can be used to appraise rail schemes using the method discussed in section 7. Variable demand choice models can also be useful where rail services are in direct competition with another mode (e.g. a major road parallel to a railway route). Variable demand or choice models may also be appropriate to applications where there is a very large change in supply or there are no direct services or little demand on the services at present. In addition, gravity models may also be appropriate for these cases. Finally for new stations alternative models should be considered[4].

8.2.4 The remainder of this section describes the own-cost elasticity approach, which determines a statistical relationship between the observed demand for travel (in this case rail services) and variables representing those factors (income, employment, service quality, fare, etc.) that affect the demand for travel on a mode-by-mode basis. For example, if improvements to rolling stock result in a more comfortable journey, the number of trips generated will be estimated by reference to the volume previously using the unimproved service, and the scale of change in service quality delivered by the new rolling stock.

8.3 Using the DfT Forecasting Methodology

8.3.1 The elasticity-based forecasting approach is usually simplified into two main categories. Firstly, background (exogenous) changes to rail demand that are caused by factors assumed to be outside the direct control of the rail industry. These include factors such as employment and population changes, GDP growth and changes to other modes (such as increased congestion or new highway schemes). The current rail TAG/PDFH approach covers 10 exogenous growth factors/drivers as described below. These factors are also included in the Demand Driver Generator (DDG) set of inputs which are available on request for work being done on behalf of the DfT. The DDG set of drivers is designed to be used in the EDGE[5] forecasting tool which has been developed to implement rail forecasting elasticities and assist in producing exogenous demand forecasts.

[4] See https://www.gov.uk/government/publications/passenger-demand-forecasting-for-third-party-funded-local-rail-schemes

[5] EDGE (Exogenous Demand Growth Estimator) is a flexible model developed by DfT that allows user to enter customised driver growth forecasts and elasticity parameters, as well as to choose any zoning system. EDGE can be made available free of charge to anyone. Please contact the DfT for the latest version of EDGE.

- GDP
- Employment or EmpIndex (a new variable in the RDFE[6] study and PDFH 6 that combines employment with socioeconomic factors)
- Population or PopIndex (a new variable in the RDFE[6] study and PDFH 6 that combines population with socioeconomic factors)
- Car Costs
- Car Journey Time
- Bus Cost
- Bus Journey Time
- Bus Headway
- Underground Cost
- Air Passengers

8.3.2 Secondly, scheme or policy-related (endogenous) initiatives which are assumed to be within the direct control of the rail industry and Government. These include changes to rail services, reliability and performance, new stations, terminal or lines, and changes in rail fares levels or freight grants. The endogenous variables included in the current PDFH approach are given below.

- Fares
- Generalised Journey Time (GJT) incorporating in-vehicle time, frequency and interchange
- Performance; and
- Non-timetable related service quality (focusing mainly on crowding, station facilities and new/refurbished rolling stock)

8.3.3 GDP Series: In 2012 the composition of the GDP deflator was altered which increased real GDP growth. For the GVA per capita elasticities in earlier versions of PDFH, adjustments have been made to forecast growth rates to account for this fact. These adjustments are no longer required when using the elasticities in the Rail Demand Forecasting Estimation (RDFE) study[6] or PDFH6.

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[6] The Rail Demand Forecasting Estimation (RDFE) study is a DfT commissioned study by Systra, Leigh Fischer and RAND into forecasting and some of the recommendations in PDFH 6.0 are based on it https://www.gov.uk/government/publications/rail-demand-forecasting-estimation-study-phase-reports

8.3.4 The application of incremental demand techniques requires detailed information on the level of demand in the base year (to which the increments are then applied). LENNON[7] ticket sales data are typically used as a proxy for rail demand. Additional information on the demand for rail travel can be obtained from TOC management accounts, passenger surveys, passenger counts and MOIRA[8].

8.3.5 When using raw Lennon data there are some gaps in the station to station matrix for UK rail trips. In particular there are significant gaps in travel within urban areas due to the large proportion of journeys which are carried out on cross-modal Travelcard products. Adjustments to account for these trips and for London trips using Travelcard products are now available in the Moira 1 and Moira 2.2 base matrix.

8.3.6 In the base matrix or base data in the analysis, the analyst will need to ensure that the assumptions about how many journeys are made with each season ticket are correct. The recommendation from the Journeys per Season Ticket Study[9] should be used unless better local evidence is available. These recommendations are available in the TAG Data Book tab M4.2.5. In due time, it is possible that these will be added into the standard base matrix in many models and could be included in Lennon itself. In the meantime, adjustments should be made in the base matrix by dividing by the old assumptions (10.3 for a weekly, 46 for a monthly and 480 for an annual) and then multiplying by the new assumptions. For high level national analysis, it is acceptable to use the national recommendations but when the analysis is detailed or concentrated on specific flows the flow category and distance band breakdowns should be used. It should also be noted that when the original source of the journeys does not use the Lennon factor (such as London and some PTE infills) then these recommend values do not apply and the Moira values should instead be used.

These values are given in:

M4.2.5: Average rail journeys per season ticket

8.3.7 The **Without-Scheme forecast** can be defined according to exogenous factors outside the control of government and train operators, including any committed initiatives (endogenous drivers) which are due to be implemented during the forecast period.

8.3.8 At least one **With-Scheme forecast** will also be required. These should retain the same exogenous growth characteristics of the Without-Scheme case, but also include any changes in endogenous factors specific to the intervention

[7] LENNON (Latest Earning Networked Nationally Over Night) is the rail industry's ticket sales database through which the vast majority of the rail ticket data is processed. Due to commercial confidentiality requirements access to the LENNON system is restricted to train operating companies and a handful of other organisations.

[8] MOIRA is a software tool that models the impact of timetable changes on both the overall rail market, and individual train operating companies. It is available to full members of the Passenger Demand Forecasting Council (PDFC) and, with permission, third parties working on their behalf. The data in MOIRA is based on LENNON with uplifts for those areas where LENNON does not provide adequate coverage.

[9] Further information on the publication is available here: https://www.gov.uk/government/publications/rail-journeys-per-ticket-study

under scrutiny. Examples include service enhancements, fare changes and rolling stock improvements.

8.3.9 A range of software tools are available to assist the practitioner in producing forecasts of rail passenger demand. Of these, EDGE and MOIRA deserve special attention.

8.3.10 The impact of timetable changes (represented as changes to GJT) upon rail demand are generally modelled using MOIRA. Moira 2.2 allows for the modelling of timetable changes incorporating crowding impacts.

8.3.11 Forecasts should use the sources of data as recommended in TAG unless there is sufficient good-quality evidence to suggest otherwise. As ever, any divergence from standard assumptions must be discussed with DfT prior to implementation, and should be fully described within the Appraisal Specification Report.

8.3.12 Forecasting parameters should be taken from the TAG Data Book and PDFH 6.0 and 5.1 as set out in Table 1.

Table 1 PDFH Recommended Forecasting Parameters

	TAG Data Book / PDFH Version	Chapter	Tables	Notes
Journey purpose/ticket type splits by flow category	See TAG Data Book table A5.3.2	N/A		See TAG Data Book
External Environment Excluding intra London Travelcard area and airports	TAG Data Book table M4.2.4 and text below	N/A		See 8.3.12 – 8.3.13
External Environment – Intra London Travel card area and airports	6.0	B2	B2.1 and B2.5	See 8.3.14 – 8.3.17
Inter Modal Competition	6.0	B2	B2.1- B2.5	See 8.3.18 -3.19
Fares	6.0	B3	B3.1 to B3.7	See 8.3.20 – 8.3.22
Generalised Journey Time (GJT) elasticities	5.0 for airport flows, otherwise 6.0	B4	6.0: B4.2 – B4.6 5.0: B4.6	See 8.3.23
Service Interval Penalties	6.0	B4 and C4	B4.10 and section C4.5.4	See 8.3.24

Interchange	6.0	B4	B4.13 unless above elasticities not used in which case B4.15	See 8.3.25
Performance	6.0 (except for large changes)	B5	B5.1	See 8.3.26
Crowding	6.0	B6	Formula above table B6.1	See 8.3.27
Rolling Stock	6.0	B7	B7.1 (apart from seating layout)	See 8.3.29 – 8.3.32
Station Facilities	6.0	B8	B8.1	See 8.3.33 – 8.3.36

Journey purpose/Ticket type splits

8.3.13 As part of the Rail Demand Forecasting Elasticities (RDFE) study,[10] journey purpose / ticket type splits by flow category have been estimated from NTS data. These are constrained to LENNON ticket sales data.[11] The NTS is an annual survey of households and contains a relatively small sample of rail trips given rail trips are only around 2% of total domestic trips. However, by aggregating the evidence from 2005 and 2014 and aggregating up to PDFH flow category level, the sample sizes are large enough for the estimated splits to be robust (between 1,200 and 17,000 rail trips by flow category).

8.3.14 Where more disaggregated or more recent data is available (for example flow level NRTS data) or a more up to date local survey that may be used instead.

External Environment

8.3.15 For external factor forecasting for all flow categories apart from within the London Travelcard area and airport stations the recommendations from the RDFE study should be used. These are presented in the TAG Data Book Table M4.2.4.These are broadly the same as the recommendations in PDFH6 apart from for EmpIndex elasticities for to and from cities outside of London where PDFH 6 recommends lower elasticities. Our guidance is that the RDFE elasticities in the TAG Data Book should be used[12].

8.3.16 The GJT trend (a reduction in the value of GJT of 1% per year compounding) was used in the RDFE study regressions (apart from for season tickets between the Network South East area and London), and we believe this is

[10] https://www.gov.uk/government/publications/rail-demand-forecasting-estimation-study-phase-reports

[11] Lennon is the UK rail industry's central ticketing system. Further information is available at: https://www.gov.uk/government/publications/rail-passenger-miles

[12] If it can be demonstrated that you are using an employment forecast which would have anticipated the high employment growth in the centre of cities over the last two decades then you may be justified in using lower EmpIndex elasticities (see guidance in PDFH6.0).

partly accounted for by endogenous quality changes over the estimation period. So, where any quality endogenous improvements are separately forecast (such as mobile connectivity, station improvements, rolling stock enhancement, marketing, branding or fare policy) then we recommend this GJT trend is not used in forecasting. For strategic forecasts that do not separately account for those endogenous quality features we recommend that the GJT trend is used in full up to the year 2030/31 in the central case. In the latter case, we recommend that sensitivity tests are run with no GJT trend and with a GJT trend that ends in the final forecast year.

8.3.17 For flows within the London Travelcard area and flows to and from airports we recommend that the PDFH 6 parameters are used and no GJT trend is applied.

Inter Modal Competition

8.3.18 To model the impact of car competition on rail demand, car cost, car ownership, and car time should be used. It is recommended that car cost variable is defined as the perceived cost per km – as described in Values of Time and Operating Costs (TAG Unit A1.3 – User and Provider Impacts) – to which the PDFH 6.0 car cost elasticity should be applied. A forecast car cost series, car time series and bus time series by PDFH flow category, calculated on this basis is provided in TAG Data Book M4.2.2 – Car cost series for rail demand forecasting. This series is provided for financial years in index form (2010/2011 = 100) and represents the real change in car costs per kilometre, combining changes in fuel prices, vehicle efficiency, fleet mix and forecast speeds. Where PDFH 6.0 elasticities are used, the CPI real version of these car cost forecast should be used and CPI real forecasts of bus cost forecasts should also be used.

8.3.19 Although PDFH 6.0 does not recommend specific air cost and air headway elasticities, practitioners should still model the impact of these factors on rail flows where there is air competition. London Underground RPI real forecasts should be used to be compatible with rail fare assumptions.

Fares

8.3.20 The elasticity recommendations in Chapter B3 of PDFH 6.0 should be applied to high level assumptions regarding changes to fares. This means an overall change which is applied across all ticket types. For anything more complex and detailed than an overall fares change a bespoke fares model should be considered[13]. In line with PDFH 6.0, RPI real fare forecasts should be used in conjunction with these elasticities.

8.3.21 When modelling the impact of high level fare changes it should be assumed that the broad basket of fares changes at the same rate as the regulated fares. It should be ensured that the assumption on regulated fare changes is in line

[13] Details on how to use own and cross elasticities or fares choice models are provided in PDFH 6.0 chapter D13

with latest regulated fare policy. If you are unsure as to what this is please check with the Department for Transport.

8.3.22 For large changes in fares, the standard constant elasticity functional form may not be appropriate (as discussed in PDFH 6.0 B3.1). In these circumstances it may be sensible to consider alternative functional forms; appropriate guidance on these can be found in PDFH 6.0 D2.

Generalised Journey Time

8.3.23 The option settings in MOIRA which are closest to the guidance requirements should be used. Where there are significant airport flows and/or changes to service to airports MOIRA should not be used and alternative modelling approaches should be discussed with the Department.

8.3.24 The representation of the service interval penalty in Moira and Moira 2.2 is preferred as it accounts for irregular service patterns. For simple analysis the values given in PDFH 6.0 table B4.10 may be used.

8.3.25 Whenever standard PDFH 6.0 GJT elasticities are used, the standard PDFH 6.0 interchange penalties (PDFH 6.0 table B4.13) should be used as the GJT elasticities have been estimated using the standard interchange penalties. However, where different elasticities have been used or non-elasticity based model (such as a gravity model or a mode choice model) has been applied then a new set of interchange penalties based on more recent information should be used (PDFH 6.0 table B4.15). These interchange penalties only cover non commuting tickets so the standard ones still need to be applied for season tickets. The table B4.15 interchange penalties should also be used as a sensitivity test in cases where standard GJT elasticities have been used and the removal or creation of interchanges is important to the scheme.

Crowding

8.3.26 Practitioners can choose their own approach to modelling crowding as long as it is consistent with PDFH 6.0 recommendations. It should be noted that Moira 2.2 has been developed to provide allocation in a way to take account of the crowding of services.

8.3.27 Performance: PDFH 6.0 moves to a direct demand response to performance using constant elasticities. These should be applied to measure the impact of demand changes but only for proportional changes of less than 25% of Average Performance Minutes (APM). For larger proportional changes other functional forms should be used and discussed with the Department. PDFH 6.0 values cannot be used to measure benefits per passenger and instead the ratios in PDFH 5.1 should continue to be used for that passenger see TAG Unit A5.3 – Rail Appraisal.

Final Forecast Year

8.3.28 Details of the Final Forecast year are in TAG Unit A5.3 – Rail Appraisal.

Rolling stock

8.3.29 PDFH 6.0 B7 recommends that the demand impact of rolling stock quality is determined as a weighting on in-vehicle time. Whilst the Department recommends using the values attributed to rolling stock improvements, it is worthwhile clarifying how DfT expect these values to be applied. In particular, how the without-scheme scenario should be specified.

8.3.30 Firstly, promoters must describe their without-scheme scenario as carefully as possible. The market for rolling stock is active and has orders for new carriages, stock cascades and refurbishments taking place on a regular basis. Over the appraisal period the Department for Transport would therefore expect improvements to rolling stock to take place regardless of any specific initiative. This gradual process of improvement must be reflected within the appraisal base-case and only the net demand impact should be attributed to the specific intervention being considered. For example, if a particular proposal brings forward rolling stock improvements by five years (on an identical basis) the benefits attributable to the intervention can only last for this period of time.

8.3.31 Secondly, careful consideration of the dynamic impact of new or refurbished rolling stock should be made. The Oxera report **How Long do the Impacts of New Rolling Stock Last?** (Feb 2009) suggests that there is considerable variation in the scale, nature and durability of demand uplifts due to rolling stock changes. When submitting a proposal that involves changes to rolling stock, promoters should explicitly state how they have determined the most appropriate profile of demand response to be used.

8.3.32 In doing this it is important that due care and attention is paid to the text accompanying table B7.1 in PDFH 6.0. This provides important contextual information that should be considered when determining the appropriate value of time multiplier to be applied. Since qualitative judgement regarding the current and future level of rolling stock specification introduces risk to the cost-benefit analysis process, a full justification for the uplifts used must be provided. It should be noted that the Department would expect improvements to rolling stock to exhibit diminishing marginal returns to investment and for package effects from investment across multiple rolling stock attributes to be observed (as reflected in PDFH 6.0).

8.3.33 Where the seating layout values are used we recommend that the distance bands from the original study AECOM "Demand impacts of seating layouts for rolling stock on commuter routes"[14] are used, rather than the standardised ones in the PDFH 6.0 table.

[14] Available from RDG's website for PDFC members https://www.raildeliverygroup.com/pdfc.html .

Station facilities

8.3.34 PDFH 6.0 recommends direct demand uplifts from improvements to a range of station facilities. However, care should be taken when determining the appropriate base demand to which uplifts should be applied. As with the Department's recommendations regarding rolling stock modification, it is imperative that a full justification of the demand uplifts and base demand to which these apply is provided. Once again, due care and attention must be paid to the text accompanying table B8.1 in PDFH.

8.3.35 In light of previous revealed preference evidence[15] the Department retains its previous recommendation that total long-term net demand uplifts (i.e. after the impact of abstraction has been taken into account) above 2% are unlikely and would need detailed justification. This restriction is intended to provide a simplified representation of a range of factors that may suppress the demand uplift from station enhancements.

8.3.36 For example, the Department would expect improvements to station facilities to exhibit diminishing marginal returns to investment and package effects (as reflected in PDFH 6.0). The Department would also expect to observe both a period of demand ramp-up and subsequent decay as passengers adjust their expectations of incremental station upwards. In practice the demand uplift generated by station enhancements may exceed the 2% cap in the short to medium term. However, over the entire appraisal period the maximum uplift would be expected to be binding.

8.3.37 Finally, there are close linkages between chapters **B8 Station Facilities** and **B9 New and Competing Services and Stations** in PDFH 6.0. Many of the improvements to access set out in table B9.4 may also be considered as station enhancements e.g. secure parking. Promoters are therefore advised to read both chapters in conjunction and to be careful to avoid double counting.

Sensitivity Testing, Uncertainty and Scenarios

8.3.38 Rail demand forecasting is inherently uncertain so presenting the uncertainty around our forecasts is essential. Where there is particular uncertainty around an input parameter this must be presented as a sensitivity test (see guidance above on when this applies to the GJT trend and interchange penalties). Where there is also uncertainty about a driver, specific uncertainty tests should also be used.

8.3.39 In addition to carrying out sensitivity tests, ways should be considered of presenting broader uncertainty. The Department has developed a tool called the Rail Uncertainty Model (RUM) that represents top down demand forecasting uncertainty. This is available upon request for work done on behalf

[15] See: The Effects of Station Enhancements on Rail Demand – Phase 2 Final Report (2008); University of Southampton, Accent Market Research and Institute for Transport Studies – University of Leeds

of the DfT. Alternative scenarios based on possible future states of the world may also be of interest for large projects.

8.4 DfT Forecasting Requirements

8.4.1 All rail passenger demand forecasts that are submitted to DfT for approval are required to adhere to the methodology set out in this document. However, exceptions may be permitted where any of the following apply:

- superior parameter estimates exist that better reflect the specific region, TOC or flow under scrutiny;
- the recommended methodology is proven not to provide credible forecasts based on historic experience; and
- alternative forecasting methodologies are considered more suitable to the specific circumstances (see section 8.2 of this TAG unit and chapter B9 of PDFH 6.0).

8.4.2 Any divergence from the forecasting methodology set out in this document must be supported by appropriate, robust evidence in favour of the change. This should be described within the Appraisal Specification Report (see TAG Guidance for the Technical Project Manager) alongside a clear statement of the data sources, assumptions and demand forecasting methodology to be used. We strongly recommend that the forecasting approach is discussed with DfT prior to carrying out any detailed programme of work.

8.4.3 This Unit has been updated following publication of version 6.0 of the Passenger Demand Forecasting Handbook (PDFH) and the RDFE study and will continue to be updated in light of new evidence. However, practitioners should keep abreast of emerging evidence to ensure they can respond to changes as soon as they are implemented.

9. Simpler Traffic Forecasting Approach

9.1 Using NTEM without a formal model

9.1.1 There are some circumstances where a formal transport model is not available and a simple traffic growth factor may be required. Typically, this might be a transport impact assessment, where a growth factor is needed for traffic on a single road or junction.

9.1.2 In this instance, use of NTEM growth factors alone would not be appropriate, as they do not take into account the impacts of fuel cost, values of time, and changes in trip length. However, it is possible to combine NTEM data with growth factors from the National Transport Model (NTM) to estimate a very approximate growth factor. **It should be emphasised that this is a very approximate approach which would not normally be used in forecasts for the appraisal of major transport schemes.**

9.1.3 NTM forecasts are available from the Department's web site and are updated periodically. These have replaced what were formerly called National Road Traffic Forecasts (NRTF).

9.1.4 The NTM forecasts give traffic growth by region, road type and area type (urban or rural). NTEM factors should be used to tailor this published traffic forecast to local circumstances. Versions of TEMPRO software from 6.1 onwards have a facility to calculate this factor automatically, as follows:

- Calculate a growth factor indicating how car driver trip-ends for the region in that time period compares to average day national car driver trip-end growth (both from NTEM);
- Multiply this factor by the NTM traffic growth for the particular road type.

Example:

Estimating AM peak period traffic growth from 2010 to 2017 on an uncongested rural trunk dual-carriageway road which in the judgement of the user primarily serves County B within Region A.

NTM growth on rural trunk & principal dual carriageway roads in Region A = 1.15

TEMPRO AM peak hour car driver trip end growth for County B = 1.097 (average of origins and destinations)

TEMPRO average day car driver trip end growth for the Region A = 1.086 (average of origins and destinations)

Adjusted local peak period growth factor = 1.15 x 1.097 / 1.086 = 1.162

9.1.5 While this functionality was disabled for TEMPRO version 8, it has been added to TEMPRO version 8.1. All other results from TEMPRO version 8 are preserved in TEMPRO version 8.1.

9.1.6 The user is responsible for choosing which spatial area is appropriate for calculating the factor. For a local minor road, NTEM zones may be adequate; however, for a significant stretch of strategic motorway or trunk road a more aggregate level of geography (e.g. districts or counties) may be appropriate.

10. References

DfT (November 2007), English Regional Traffic Growth and Speed Forecasts, http://webarchive.nationalarchives.gov.uk/20070305103412/http://www.dft.gov.uk/foi/responses/2007/february07/regionaltrafficforecast/

DfT (2017), 'Rail Demand Forecasting Estimation Study', available at: https://www.gov.uk/government/publications/rail-demand-forecasting-estimation-study-phase-reports

DMRB 12.2.1 – Traffic Appraisal in Urban Areas – part of DMRB Volume 12A

Mott MacDonald, RAND Europe, CEPOG, Highways England (May 2005), PRISM – A 21st Century Transport Model for the West Midlands, http://217.206.77.231/prism/Downloads/2011/TechPapers/Prism%20-%20Modelling.pdf

TRL (2004), Report TRL593, The demand for public transport: a practical guide., TRL Ltd,

AECOM (2013) Demand impacts of seating layouts for rolling stock on commuter routes

ATOC (August 2002), Passenger Demand Forecasting Handbook (version 4.0)[16]

ATOC (June 2005), Passenger Demand Forecasting Handbook (version 4.1)

ATOC (August 2009), Passenger Demand Forecasting Handbook (version 5.0)

ATOC (July 2013), Passenger Demand Forecasting Handbook (version 5.1)

Dargay J and Wardman M (March 2007), External Factors Data Extension and Modelling, Institute for Transport Studies - Leeds University

Department for Transport (July 2007), Delivering a Sustainable Railway: White Paper

Eddington R (December 2006), Transport's Role in Sustaining the UK's Productivity and Competitiveness, Department for Transport and HM Treasury

Faber Maunsell | AECOM (July 2007), Saver Fares: Differentiation and Potential Deregulation

[16] The Passenger Demand Forecasting Handbook is restricted to members (and those carrying out analysis on behalf of members) of the Passenger Demand Forecasting Scheme. This scheme is administered by the Association of Train Operating Companies (ATOC). Please contact PDF Scheme Manager for further details (https://www.raildeliverygroup.com/pdfc.html)

Hugh Gunn Associates, RAND Europe and Scott Wilson (August 2008), Modelling Longer Distance Demand for Travel: Feasibility Study

ITS Leeds, Leigh Fischer, RAND and Systra (2016) Rail Demand Forecasting Estimation study https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/610059/phase2-rail-demand-forecasting-estimation-study.pdf

MVA Consultancy (March 2007), Rail Passenger Demand Forecasting Research

MVA Consultancy (November 2009), Valuation of Overcrowding on Rail Services

Oxera (Oxera (February 2009), How Long do the Impacts of New Rolling Stock Last?

Rail Delivery Group (July 2013), Passenger Demand Forecasting Handbook (version 6.0)

Steer Davies Gleave (May 2008), Modelling Value for Money in Franchise Specification

University of Southampton, Accent Market Research, Institute for Transport Studies - University of Leeds (May 2008), The Effects of Station Enhancements on Rail Demand - Phase 2 Final Report

Wardman M (March 2007), Analysis of London-Based and South East Flows to Support MVA's Interim Demand Forecasting Methodology, Institute for Transport Studies, University of Leeds

11. Document Provenance

This Unit consists of much of the text from former TAG Units 3.15.1: Forecasting Using Transport Models, 3.15.2: Use of TEMPRO Data, 3.15.3: Forecasting and Sensitivity Tests for Public Transport Schemes, 3.15.4: Rail Passenger Demand Forecasting Methodology, and 3.15.5: The Treatment of Uncertainty in Model Forecasting.

This unit supersedes the following information:

DMRB Section 12.1.12 (The forecasting section of the Traffic Appraisal Manual (TAM));

DMRB Section 12.2.1 (Traffic Appraisal in Urban Areas): part 5, Traffic Forecasting.

Former TAG Unit 3.11.4 (later replaced by 3.15.3).

The following information from the former TAG Unit 3.15.4: Rail Passenger Demand Forecasting Methodology was reinstated:

- Information about inter-modal competition, large fare changes and demand cap in Section 8.4 (added in March 2014);
- Information about application of GDP elasticities/deflator in Section 8.3 (added in May 2014).

In November 2014, Section 8.3 of this unit was updated upon a Department review of PDFH 5.1. This section now reflects recommendations adopted into TAG.

An updated example in Box 3 of using NTEM growth for fixed demand models is provided. In May 2017 this document was updated for the Department's position on PDFH 6.0 and the RDFE study.

Appendix A: Uncertainty Log

Table A1 Example of Uncertainty Log for scheme with 2014 Opening Year and 2029 Modelled Year

Input	Forecast Year	Description of Model Central Assumption	Uncertainty Assumption (Alternative Scenario Options)	Comments
Model Parameter Uncertainty				
Sensitivity of mode choice to cost	2014	-0.3	±5% (Normal	Able to apply quantitative range
	2029	**-0.3**	Distribution)	
National Uncertainty				
Growth in demand	2014	NTEM	±4.3% (Standard uncertainty ranges from TAG)	Able to apply quantitative range
	2029	NTEM	±10.6% (Standard uncertainty ranges from TAG)	
GDP Per Capita	2014	National OBR (National ONS Population is Denominator)	High long-term growth rate scenario from the OBR	Able to apply quantitative range
	2029	As Above	As above	
Local Uncertainty: Factors affecting underlying demand:				
Housing Location X. Due 2014, 400 Units	2014	400 hh (Included as a central assumption as 'Near Certain', See Table A2)	+50 hh to -50 hh Narrow Range because identified as near certain (see Table A2)	Near Certain (See Table A2) Land identified in local plan for housing provision. Application submitted to local planning authority. Applies to XX Model Zone
	2029	400 hh (as above)	As above	As above
Large housing development	2014	0 hh	0 hh	Housing Development Not Opened

Location X, Due 2020, 10,000 Units	2029	Not included as 'hypothetical' (from Table A2)	"+10,000hh to 0 hh" Wide range as identified as hypothetical (Table A2)	Hypothetical Stage (See Table A2) This is identified as one of 5 locations by local authority for new town development. Part of initial consultation process prior to inclusion in structure plan. Applies to XX Model Zone
Superstore Location Y, Due 2020, 10,000 sq. m	2014	0 sq m	0 sq m	
	2029	Not included as 'Reasonably Foreseeable from Table A2'	"0 to +10,000 sq. m"	Reasonably Foreseeable (See Table A2) Currently speculative project – land-use identified in structure plan (fairly high uncertainty about timing, exact location and size) Applies to XX Model Zone
Local Uncertainty: Factors affecting supply for transport:				
Increase in Rail capacity Location Z from 2016	2014	Not included (Near Certain so under construction)	Not included (Under Construction)	Near Certain (See Table A2)
	2029	Included	Included	Near Certain (See Table A2)
Road pricing scheme, Location Y from 2013	2014	Not included as 'Reasonably Foreseeable from Table A2'	Pricing Range as defined by scheme promoter	Reasonably Foreseeable (See Table A2) (Business Case Under Construction)
	2029	As above	Pricing Range as defined by scheme promoter	As above

Table A2 Classification of Future Inputs

Probability of the Input	Status	Core Scenario Assumption
Near certain: The outcome will happen or there is a high probability that it will happen.	Intent announced by proponent to regulatory agencies. Approved development proposals. Projects under construction.	This should form part of the core scenario
More than likely: The outcome is likely to happen but there is some uncertainty.	Submission of planning or consent application imminent. Development application within the consent process.	This could form part of the core scenario [Refer to Section Developing the Core Scenario]
Reasonably foreseeable: The outcome may happen, but there is significant uncertainty	Identified within a development plan. Not directly associated with the transport strategy/scheme, but may occur if the strategy/scheme is implemented. Development conditional upon the transport strategy/scheme proceeding. Or, a committed policy goal, subject to tests (e.g. of deliverability) whose outcomes are subject to significant uncertainty	These should be excluded from the core scenario but may form part of the alternative scenarios
Hypothetical: There is considerable uncertainty whether the outcome will ever happen.	Conjecture based upon currently available information. Discussed on a conceptual basis. One of a number of possible inputs in an initial consultation process. Or, a policy aspiration	These should be excluded from the core scenario but may form part of the alternative scenarios

Appendix B: Adapting the core scenario to large scale changes

B.1 Background

B.1.1 The COVID-19 pandemic has had a significant impact on the pattern and volume of travel, with overall volumes for most modes still below pre-pandemic levels, as can be seen in DfT official statistics, and importantly below pre-pandemic projected demand levels. There are a multitude of drivers of behaviour and demand; it is difficult to isolate the individual impact of COVID-19 and the extent to which impacts will be sustained long term is unclear. However, it is the Department's view and recommendation that this evident suppression of travel demand relative to a pre-pandemic projection of demand at this time should be appropriately represented in transport analysis. This is important particularly in appraisal and analysis supporting transport investment decisions.

B.2 The TAG approach

B.2.1 The principles of establishing transport models and calibrating/validating them to observations is clearly set out in the modelling units of TAG. TAG Unit M2.2 – Base Year Matrix Development, Section 4.4, provides guidance for analysts considering using models with base years established in the past and assessing their validity for future forecasting. Analysts are advised to assess the validity of the trip matrices developed in the past against present day observations. Where there are significant changes from when the matrix was developed and the present day, the model should ideally be rebased. More proportionate approaches may be acceptable if sufficient evidence is provided that these appropriately cover most of the risks of not rebasing.

B.2.2 The COVID-19 pandemic has led to marked changes in travel demand relative to pre-pandemic projected demand, even if there is uncertainty over the long-term impacts. In transport modelling terms, therefore, the guidance in TAG Unit M2.2 applies. That is, this is an event of a significant change in trip patterns. To account for COVID-19 related changes, trip matrices based before the beginning of the pandemic should ideally be rebased, or if this is not possible, an appropriate adjustment applied to model inputs or outputs in a proportionate way (see section B.3.4 for potential options).

B.2.3 The implication of this advice is that for analysts creating new or future models, basing their models to 2023 onwards, do not need to apply any further adjustment to account for COVID-19. The impact of COVID-19 on trip-making will in general be internalised into the base year trip matrix and vehicle/passenger flows. Sensitivity tests or scenarios will remain important and prudent to test the further potential for change, in particular the potential long-term impacts of COVID-19, for example potential recovery versus permanent changes in behaviour. This is in line with the DfT's Uncertainty Toolkit. This may be particularly relevant for certain modes.

B.2.4 The Department continues to monitor and collect statistics of travel demand since the start of the pandemic. We will also undertake further research to understand the full extent of the impacts of the pandemic, which we will use to inform further evidence-based guidance in the future. This may include considering modelling parameters recommended in TAG for demand forecasting, and whether these have substantially changed. This essentially involves the established past evidence of sensitivities of different groups and trip purposes to aspects of generalised travel cost changes.

B.2.5 Therefore, the Department continues to recommend the forecasting methods described in TAG Unit M4 – Forecasting and Uncertainty as a basis for analysts to create future year trip matrices. In summary, analysts should continue to use the growth factors from the National Trip End Model data set (NTEM) to grow demand from their base year. The main drivers of trip end growth in NTEM are demographic and economic. Whilst we acknowledge that household trip rates in NTEM 8.0 may have changed due to COVID-19, the growth rates should remain robust, since they remain in-line with official socio-economic projections.

B.2.6 In addition, the guidance in section 2 of TAG Unit M4 recommends how to record uncertainty and assumptions. Further details on understanding uncertainty can be found in the DfT's Uncertainty Toolkit. The guidance in this document should also be followed to understand modelling sensitivities.

B.2.7 Schemes modelling rail demand should continue to use the guidance released with the Demand Driver Generator (DDG), as well as Section 8 of TAG Unit M4.

B.3 Proportionate accounting for COVID-19 in prior-calibrated models

B.3.1 The Department recognises that in the near future, the large majority of transport models used to provide evidence for schemes appraisals will be based on years prior to the pandemic. Rebasing of models takes time and resources; the Proportionate Update Process in TAG allows judgments of proportionality to be made when considering to what extent models need to be updated relative to the scope of decisions required and the surrounding risks. Indeed, it is very plausible that travel patterns at the current time are in themselves subject to some change in following years (such changes being outside of the direct scope and functionality of the model). Therefore the Department accepts that, in many circumstances, the practical course of action is to make proportionate and transparent adjustments at this time.

B.3.2 The summary recommendation is, where model rebasing is judged not to be practical, for analysts to assess the extent of the divergence of travel patterns and volumes from pre-pandemic projections, using the best available data and evidence. If it is clear COVID-19 has had an impact on travel, this should be represented using an appropriate change in travel demand across the trip matrix, considering trip purpose and patterns as appropriate, and apply this to produce an updated core forecast.

B.3.3 The analyst should aim to adjust their model to appropriately forecast travel demand and traffic and/or passenger kilometres to a high-level proportionate adjustment observed from national statistics. Alternatively, where appropriate, use of more specific local data is recommended. The analyst should carefully consider scheme specific adjustments, including adjustments specific to trip purpose, customer segmentation, mode of transport, and locally-led COVID-19 recovery. For example, observed data shows that freight travel patterns have changed in a different way to personal travel.

B.3.4 There are several options as to how appropriate adjustments to transport models may be accomplished. There are examples of possible approaches set out below. It should be noted that other approaches may be acceptable, based on the best judgement and careful consideration of the analyst. Either way, it is important to clearly set out the assumptions and evidence used for any approach. If the analyst is unsure, they may wish to discuss with their scheme sponsor.

1. **Create a forecast to the present day by applying adjustments to include a COVID-19 impact, based on observed data. This forecast can be used as a “new base year” as a substitute basis for scheme forecast.**

   This effectively provides a “new base year” where the costs and demand are maintained in the initial base year. This allows analysts the potential for a check of travel patterns and/or traffic flow against current observations or statistics in their modelled area. Validation checks can be undertaken to provide greater assurance that their present-day forecast model is a suitable basis for future forecasting, and a revision to the adjustment made if needed. Some judgment will be required here; whilst it may not necessarily be expected to fully align with validation standards set out in TAG, some evidence of suitability is required. This approach may also be required if it is of importance to obtain appraisal results during the 2020-2022 period, although the profile across this time should be handled with due care and transparency.

2. **Apply adjustments to a forecast year model to produce a new scheme opening year forecast, or the first required forecast year, that include a COVID-19 impact to that point. This will be the new pivot off which further forecast years are based.**

   This approach removes the need to produce a present-day forecast model (as a new/reset base year). Analysts should make use of any official statistics or observed data after the model base year where possible and account for changes after that point up to the opening year, such as the use of NTEM growth factors. However, it comes with the significant disadvantage that there will be no existing observed data (trips and traffic) to ensure validity of the opening year forecast. Analysts should ensure that the model assumptions made are sufficiently transparent and tested and that the arising uncertainty is explored and clearly presented in an appraisal.

3. **Apply the adjustment globally to model results as a post-model adjustment.**

This method is the simplest way of applying adjustment. However, as well as including all the issues with the previous method(s), it also presents the most risk to the model results and appraisal. This is because applying adjustments to model results means that the model has effectively not used the change in travel patterns, reflecting the changed conditions. Care should also be taken that adjustments are made consistently across the model results so as not to distort the appraisal (e.g. demand and costs). It will be expected in these cases that assumptions made are extremely clear and that a series of sensitivity tests will be undertaken to mitigate the risks around potentially unreliable model results. This method should only therefore be considered if quick, proportionate decisions need to be taken, so long as the risks to analytical assurance are explicitly highlighted. There may be situations where a simpler approach is appropriate, for example when looking at short-term projections that are likely to be updated regularly.

B.3.5 A judgment should be made on the most appropriate action relative to the risks to be mitigated.

B.3.6 Any adjustment made, or any decision to not apply an adjustment, must be supported by evidence and appropriately explained in an uncertainty log and the relevant modelling reports that support the business case (i.e. the local model validation report and the data collection report where relevant).

B.3.7 Analysts should consider the potential for further changes in future trip patterns in their area of interest when considering the most appropriate and proportionate action (for example, further potential of ‘recovery’ towards pre-pandemic trip rates). Regardless of the approach adopted, this is an issue that is relevant to all transport model forecasting. It may be prudent to accommodate potential scenarios to test different assumptions in post- pandemic trip-making relevant to the case in hand. TAG Unit M4 and the Uncertainty Toolkit both provide advice on defining alternative scenarios and sensitivity tests.

B.4 Recommended data sources

- Transport use during the coronavirus (COVID-19) pandemic - DfT statistics on transport use by mode since 1st March 2020

- Travel behaviour, attitudes and social impact of COVID-19 - a study into the travel behaviour of people during and following the COVID-19 pandemic (also known as ‘All Change’)

- National Travel Survey (NTS) - a household survey that collects information on how, why, when and where people travel as well as factors affecting travel

- National Travel Attitudes Study (NTAS) - a study of attitudes towards different aspects of travel including safety, the environment and congestion.

B.5 Example of applying a COVID-19 adjustment

B.5.1 Example: Applying a post-model adjustment in the National Road Traffic Projections 2022

B.5.2 The analysis for NRTP 22 was undertaken in March 2022, using the National Transport Model with a base year of 2015. Trip rates were calculated at 2016 levels, then compared to 2019 to confirm they were still valid. Analysts then applied an adjustment to the projections after they had been produced in the NTM.

B.5.3 This approach was based on the best evidence at the time (March 2022), and was to produce national modelling, rather than scheme specific appraisal. The Common Analytical Scenarios were also analysed in line with advice on uncertainty. It is included here as an example of a case where the Core has been adjusted to account for COVID-19 impacts.

B.5.4 Analysts considered data collected over the pandemic. Multiple sources were considered, including DfT Statistics on Transport use during the Pandemic, the National Travel Attitudes Study, the ‘All Change’ study and the National Travel Survey. The observed levels of travel were compared to a counter factual expected level of travel, had the pandemic not occurred. This was calculated by taking the February 2020 observed demand and applying an expected increase of 3% over two years, based on historical expected growth. The observed travel was compared to this counterfactual and the difference is assumed to be the impact of the pandemic.

B.5.5 The observed data was considered over mode and travel purpose. These figures were considered carefully and with contextual knowledge about the restrictions on transport and current attitudes to travel. The tables in the NRTP document show the results.

B.5.6 Careful consideration and consultation with stakeholders led analysts to conclude that a reduction of 5%, applied post model, to car traffic was an appropriate adjustment to the model outputs, in line with option 3 above. This reflected the reductions observed for commuting trips (6%), business trips (9%) and other trips (4%). Therefore, if needed, we could have applied these separate reductions to trips based on purpose.

B.5.7 For full details, please refer to Annex C of National road traffic projections 2022 (publishing.service.gov.uk).

Appendix C: TEMPRO Alternative assumptions calculation

C.1.1 The alternative assumptions facility in TEMPRO applies a very simple adjustment to productions and attractions, based on the proportional difference in households and jobs. It then recalculates the origins and destinations from first principles.

C.1.2 The calculation does **not** balance the attractions with the productions, or the destinations with the origins. Such balancing needs to be done by the analyst, once the total trip-ends (including the trip- ends from the developments) have been assembled.

C.1.3 The first step is to calculate two factors for each NTEM zone:

A Household factor: Alternative households / NTEM households

B Jobs factor: Alternative jobs / NTEM jobs

C.1.4 Factors A and B are applied to productions and attractions according to the assumption that the household factor should apply to trip ends to or from home, whilst the employment factor should be applied elsewhere (since the vast majority of non-home trip ends are based on total jobs or a subset of jobs). In practice, this means the factors are applied as follows:

Purposes	Production factor	Attraction factor
Home-based Visiting Friends and Relatives	A	A
All other Home-based purposes	A	B
All Non-Home-based purposes	B	B

C.1.5 The origins and destinations are then derived from the productions and attractions in the same way as for the NTEM dataset itself.