Department for Transport

TRANSPORT ANALYSIS GUIDANCE

Guidance for the Technical Project Manager

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Department for Transport

Transport Analysis Guidance (TAG)

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This TAG Unit is guidance for the **TECHNICAL PROJECT MANAGER**

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Contents

1 The Overall Approach to Transport Appraisal

1.1 Introduction

1.1.1 This Unit has been prepared for the Technical Project Manager (TPM), and aims to provide the TPM with knowledge on the key components of the transport appraisal process – including option development analyses and appraisal – describing how the concepts of transparency and proportionality should be applied.

1.1.2 This Section summarises the overall approach to transport appraisal and the steps in the process, from early inception to full appraisal and delivery. More detail on this, and how each stage of the process should be undertaken in a proportionate way, is described in The Transport Appraisal Process, which is also intended for the TPM and supplements this Unit. Section 2 of this Unit gives more detail on the requirements for appraisal and Section 3 gives an introduction to the principles and the requirements of transport models.

1.1.3 For the purpose of structuring a comprehensive business case submission to the relevant decision-makers, analysts should also to refer to separate guidance published in the **Transport Business Case** [DfT, 2011], as well as other mode and investment specific guidance, discussed subsequently in this Section.

1.1.4 The relationship between the transport appraisal process and the decision-making process is summarised in Figure 1 below. This Unit will expand on the activities within the transport appraisal process (indicated by the unshaded activities in Figure 1).

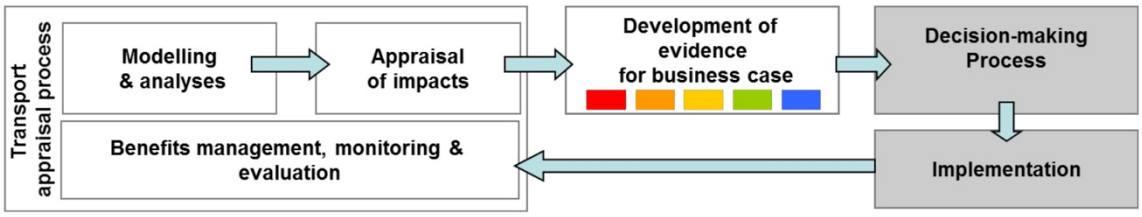

Figure 1 Relationship between the transport appraisal process and the decision-making process

1.2 What does the Transport Appraisal Process involve?

1.2.1 As illustrated in Figure 2, the transport appraisal process brings together the work required in option development/analyses and appraisal. The development of this process has been influenced by the ROAMEF concept (Rationale, Objectives, Appraisal, Monitoring, Evaluation and Feedback) in **The Green Book: appraisal and evaluation in central government** (HMT, 2007).

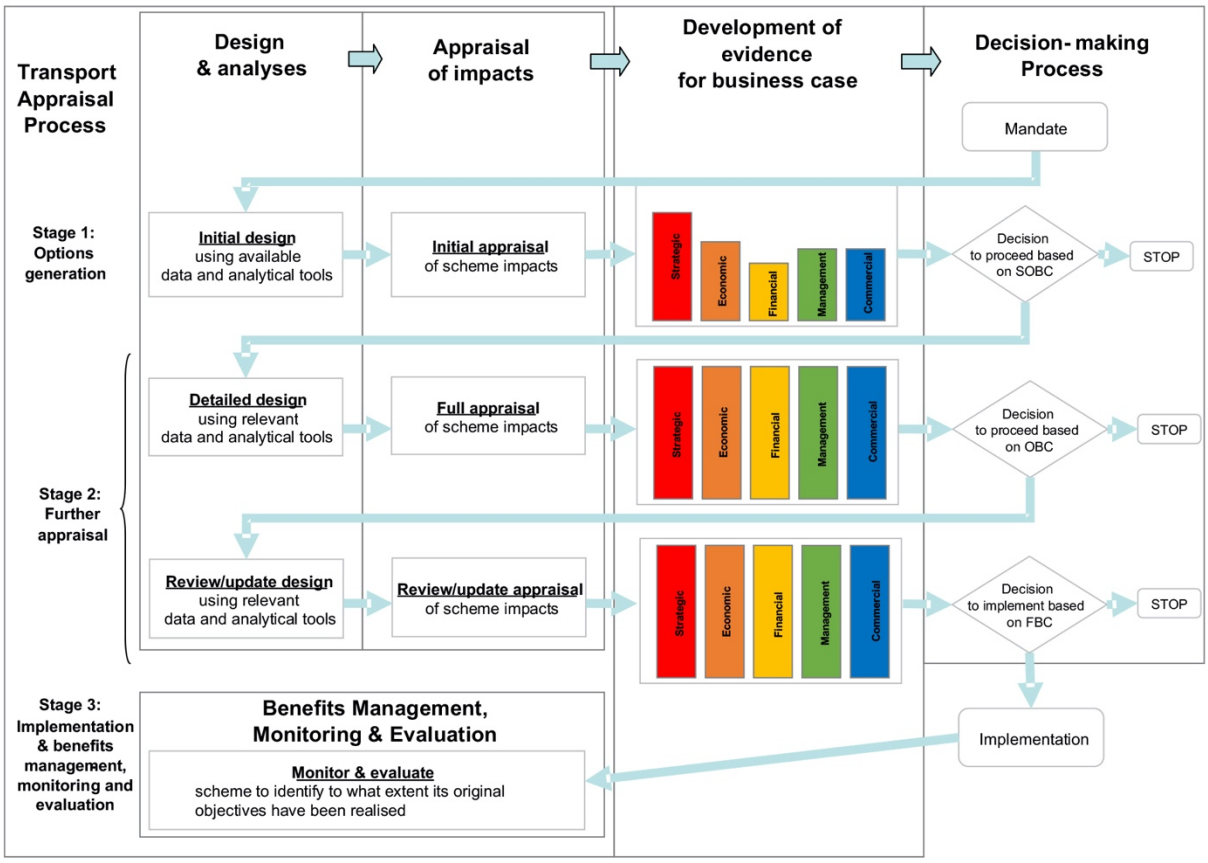

Figure 2 Detailed relationship between the appraisal and decision-making process

1.2.2 Note that the level of completion of the five cases in the Transport Business Case is indicative of broad trends only; this will vary on a case-by-case basis across schemes. The Five Case approach shows whether schemes:

- are supported by a robust **case for change** that fits with wider public policy objectives – the 'strategic case';
- demonstrate **value for money** – the 'economic case';
- are **commercially viable** – the 'commercial case';
- are **financially affordable** – the 'financial case'; and
- are **achievable** – the 'management case'.

A mandate

1.2.3 The transport appraisal process is initiated when the sponsoring organisation establishes a clear mandate and business case. This mandate sets out the rationale for the intervention, and will be an important part of the Strategic case.

Stage 1: Option development

1.2.4 The key purpose of this first stage is to develop and recommend options to proceed into the next stage of appraisal. To achieve this, stage 1 is divided into two steps.

1.2.5 First, the objectives of the transport study need to be defined, stating what would constitute a successful outcome. This is established from understanding:

- the current situation: This can be informed by current policies, current travel demands and levels of service, and opportunities and constraints within a defined study area;
- the future situation: This can be informed by future land use plans, changes to the transport system, and future travel demands and levels of service;
- the need for the intervention: This can be informed by the problems uncovered from the preceding steps, as well as stakeholder engagement and analyses of opportunities and constraints presented in the area.

1.2.6 In setting out the objectives for the transport study, analysts should also refer to the Department's guidance on developing the Transport Business Case [DfT, 2011] for advice on developing the criteria using the Five Case model framework.

1.2.7 The next step involves generating a list of preliminary options – this should also include low cost options – and undertaking preliminary assessment of their performance against the base case (i.e. without-scheme case). The initial appraisal methods employed at this stage should be proportionate (this concept will also be further elaborated in the later sections). Therefore, the initial appraisal is expected to utilise readily available data, supported by appropriate levels of stakeholder and public engagement. Whilst the use of transport models to extract evidence at this stage would be desirable, it is not generally required for promoters to build a comprehensive transport model[1] at this stage. Scheme promoters should discuss this aspect with scheme sponsors if in doubt.

1.2.8 The purpose of the initial appraisal is to produce a short-list of preferred options – that perform well in meeting the study objectives within the 5 case model framework – to recommend to the relevant decision-makers.

1.2.9 At the end of this stage, analysts should aim to achieve two key outcomes. The first outcome is to document the preferred and discarded options, as well as the overall processes undertaken to arrive at this conclusion. This guidance contains the suggested structure in the form of an Option Assessment Report (OAR), and this is located in Appendix A. The OAR is produced by the promoter, who submits the completed OAR to the assessor (who usually represents the sponsoring organisation). The second outcome is to set out the scope of further work (including modelling and appraisal) required to fine-tune the appraisal for the preferred options. The recommendations should also consider methods proportionate to the scale of the study. This guidance contains the suggested structure in the form of an Appraisal Specification Report (ASR), and is located in A.2. This report is produced by the promoter, who would need to agree the contents with the assessor from the sponsoring organisation.

1.2.10 The aspects of appraisal in Stage 2 typically requiring significant resources are modelling, environmental impact assessment, cost estimation, distributional analyses and appraisal. To ensure successful delivery, it is crucial for the TPM to consider the interdependencies of these work components in the early planning and programming of these activities. Such plans should also be included in the ASR.

Stage 2: Further Appraisal

1.2.11 The key purpose of this stage is to undertake further appraisal of the preferred options to produce evidence sufficiently robust to support the business case.

1.2.12 The scope of further appraisal conducted in this stage would have been defined in the ASR produced in Stage 1. It is in this stage that detailed analyses of the range of impacts (costs and benefits) delivered by the different options are assessed. Often, the methods employed here are more sophisticated than that used in Stage 1. Transport models and other environmental models are typically used to quantify the impacts. These quantified impacts are in turn converted into a

[1] In principle the term 'transport model' includes approaches that range from simple quantitative spreadsheet analysis to full four-stage transport models, as discussed in section 3. The term is generally used in this unit to mean a more complex type of model that would be expected to yield the appropriate appraisal output at stage 2 of the process.

monetary value using appraisal weights, wherever feasible. These weights include appraisal values of time, carbon, accidents etc. Where impacts cannot be quantified or monetised, analysts will still need to produce a qualitative assessment of these impacts. Analysts should also be aware of, and take into consideration, the requirements to undertake distributional analyses for impacts that are likely to have an effect on vulnerable transport users.

1.2.13 At the end of this stage, analysts should produce the supporting analyses for the relevant scheme impacts. These results should be used to complete the Appraisal Summary Table (AST, see Section 2). These are the key products and outcome from stage 2. One AST needs to be produced for each option; this is used directly in the assessment of Value for Money (the Economic case). Although the supporting analyses can also be used to support the other cases, analysts should also be aware of more detailed guidance in mode-specific and/or investment specific guidance (see Figure 3).

1.2.14 This stage is typically the longest stage within the overall transport appraisal process. As Figure 2 shows, stage 2 in the transport appraisal process feeds into two decision-points in the decision-making process. In addition, the duration of this stage may be affected by other factors, such as the time required to obtain interim approvals and to obtain statutory powers to implement the proposal, and, in some cases, the impact of scheme procurement processes.

1.2.15 Given the long period of this stage – and time elapsed between the decision-points in the governance process – it may sometimes be necessary for promoters to review and update input assumptions, designs, associated costs and consequently appraisal outputs. It is prudent to do so to ensure that relevant changes to assumptions are accounted for in the production of evidence used to support investment decisions. Analysts should get in touch with the Department if in doubt of when to incorporate changes to assumptions.

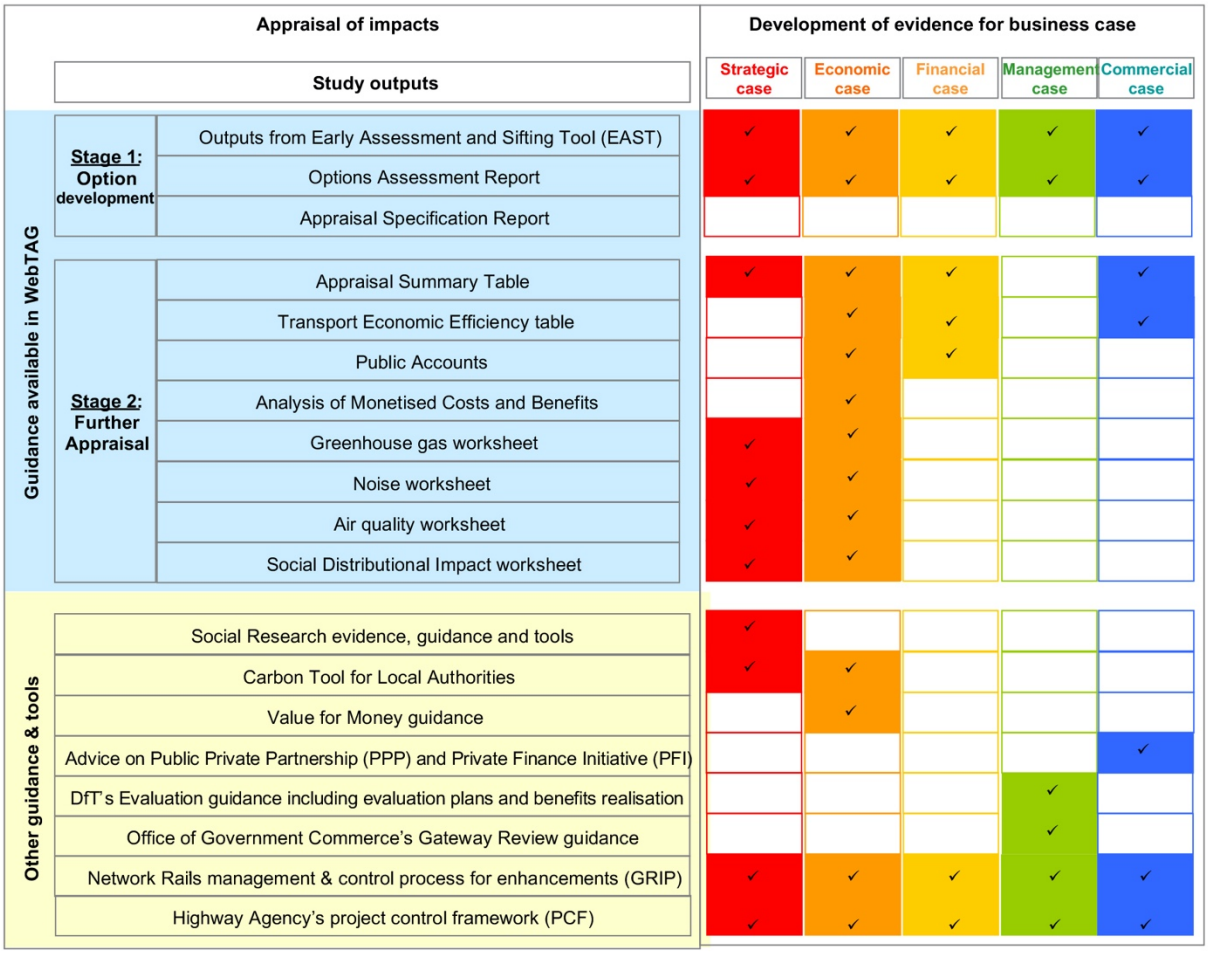

Figure 3 Tools and guidance produce evidence that can be used to answer questions posed by each case within the 'Five Case Model'

Stage 3: Implementation and Benefits Management, Monitoring and Evaluation

1.2.16 By this stage, the business case for the intervention will have been finalised. If approved by the decision-maker, the recommended proposal will be implemented. Although not the focus of this guidance, there is separate guidance on the considerations for designing the implementation programme. For example, this is available in Network Rail's GRIP and Highways England's PCF.

1.2.17 Consistent with HMT's Green Book, the transport appraisal process does not stop after the scheme is implemented. After the scheme is constructed, it is good practice to verify to what extent the intervention is achieving its intended objectives e.g. how well the actual demand matched the forecast demand.

1.2.18 It is good practice to embed planning of benefits management, monitoring and evaluation into preparation of the business case. The Management case should set out what benefits management, monitoring and evaluation will be conducted in order to assess the effectiveness of the scheme and identify to what extent its original objectives have been realised.

1.2.19 Analysts should take steps to document and store outputs from appraisal and modelling so that they can inform subsequent benefits management, monitoring and evaluation activity. This ensures that outturn benefits can be compared with forecasts so that any divergences can be learned from. The Department recommends that this is achieved through preparation of an appraisal handover pack (for further details, see Appendix D).

1.3 Transparency and Proportionality in Transport Appraisal

1.3.1 The previous section highlighted the broad purposes and work involved in the transport appraisal process. The following section describes how the key principles of **transparency** and **proportionality** need to be considered within the process. A summary of how these concepts might be applied to the different stages in the process, and more detailed guidance on the topics covered in this section, are available in The Transport Appraisal Process guidance unit.

Transparency

1.3.2 To ensure transparency, the outcomes from the transport appraisal process should be informed by stakeholder engagement. During the early stages – the option development (stage 1) - it is important to engage stakeholders not only to ensure that the proposed options are fit-for-purpose, but also to gather public support and gauge acceptability for the proposed options. During further appraisal (stage 2), it will be important to include public consultation on appraised options prior to final selection and implementation. In the final post-implementation stage (stage 3), it is good practice to engage stakeholders as part of gathering feedback and to monitor the realisation of planned benefits. Note that detailed guidance on stakeholder engagement is available in the Transport Business Case [DfT, 2011], and mode-specific guidance such as GRIP [Network Rail] and Project Control Framework [Highways England]. Hence, a comprehensive stakeholder strategy will need to be established early to draw all these activities together, addressing who to involve and when.

Proportionality

1.3.3 HMT's Green Book states that all new proposals should be subject to comprehensive but proportionate assessment, wherever it is practicable, so as best to promote public interest. There are usually trade-offs to be made between resources invested in data collection and analyses, and the pursuit of more accurate results. In balancing these trade-offs, the analyst must consider the degree of confidence that can be placed in the results of appraisal, whilst ensuring that the design process is proportionate in achieving sufficiently robust conclusions. Proportionality is brought into the process in three main aspects:

- Design and specification;

- Cost estimation; and
- Data and analyses.

Design and specification:

1.3.4 For the option development stage (stage 1) where there are a large number of options, it would be impractical and costly to undertake detailed design and specification. Instead the design should be sufficient to identify the intervention's location, and key features and characteristics that would drive cost, performance and impact.

1.3.5 For Stage 2, a greater level of design detail is expected than is undertaken at Stage 1, as the evidence derived will be used in advanced stages of the business case to seek approval for implementation. The analyses need to be sufficiently detailed to enable the comparison of intervention options, enable a quantified estimate of costs (specific to the intervention in question) to be derived and provide sufficient confidence in the feasibility of the design to be implemented.

1.3.6 At the implementation stage (stage 3), the level of design needs to be sufficient to enable procurement and implementation of proposals.

1.3.7 Note that, as well as the geographical layout, physical structure and operational characteristics of the scheme, design also includes the development of a programme for implementation, a feasible date for the start of operation and so on.

Cost estimates:

1.3.8 Cost estimates are as crucial as benefits estimation in the cost-benefit analysis that underpins the transport appraisal framework. The relevant costs include implementation, operation, maintenance, renewal and enforcement costs.

1.3.9 For the option development stage (stage 1), whilst detailed analyses to derive these cost estimates are not expected, studies will need to produce these analyses to an appropriate level of accuracy and allowing for optimism bias. The principal aim at this stage is to identify which options are unaffordable (Financial case) or which seem least likely to deliver good value for money (Economic case).

1.3.10 Once the initial assessment/appraisal results become available, it should then be possible to see where the cost estimates are particularly important to the choices that have been made. Further effort will then be directed to propose cost-effective (proportionate) ways to refine those costs which influence the choices; this is done as part of preparing the Appraisal Specification Report (ASR).

1.3.11 For further appraisal (stage 2), costs should be estimated in accordance with the approach outlined in the Appraisal Specification Report. Analysts should review the level of optimism bias applicable in the light of the extent to which risk in cost estimation has been captured in the quantified risk assessment undertaken on cost and programme.

1.3.12 Any reduction in recommended Optimism Bias factors applied should be based on a clearly reasoned and evidenced analysis of the extent to which contributory factors to optimism bias have been mitigated.

1.3.13 Advice on the treatment of costs in the cost/benefit analysis is given in TAG Unit A1.2 – Scheme Costs and emphasises the importance of robust base cost estimates including realistic cost inflation assumptions, the use of quantified risk assessments and the application of the appropriate optimism bias uplifts.

Data and analyses

1.3.14 Data and analyses are essential to the design and formulation of options, forming a vital part of informing and enabling evidence-based decisions. However, it should be emphasized that at all stages of appraisal, these should be proportionate and fit-for-purpose.

1.3.15 Generally, for Stage 1, the data and analyses are used at two levels – at the first level, it should provide analysts with sufficient information to understand current and future travel demands; at the next level, it should be used to identify the extent to which future changes or proposed options (interventions) will accentuate or alleviate identified transport problems.

1.3.16 In undertaking analyses, best use should be made of information that is already available, and care should be taken to minimise further data collection. Further detail is provided in The Transport Appraisal Process. For Stage 1 it will generally be appropriate to use a simple spreadsheet approach. Whilst existing transport models should be used as potential sources of data to inform analyses, it is not usually expected that a new model needs to be built for the purpose of stage 1.

1.3.17 Transport models are used by transport planners to aid understanding of the interactions between the complex multi-variable transport problems involving transport supply and demand. However, transport models typically consume significant cost and resource to build and validate. Before building a model, analysts should be clear about how the transport model will add sufficient value to the more basic methods of analyses which could be undertaken at this stage. Further discussion on use of transport models is available in Section 3.

1.3.18 For further appraisal (stage 2), a model presenting a sufficiently detailed representation of the transport system and market for travel will usually be required to provide sufficiently accurate detail of the impacts of proposed transport interventions. This will involve either adapting an existing model or creating a new model. In either case, the specification of the analysis, including the model approach and specification, will have been agreed with the sponsoring organisation in the ASR. See Section 3 for further details.

2 Appraisal: Principles and Requirements

2.1 Introduction

2.1.1 This section aims to provide the TPM with knowledge on key components involved in producing the required appraisal outputs and completing an **Appraisal Summary Table (AST)**. An understanding on the dependencies and relevant tools and data required to do the work is important to enable the TPM programme and project management of the required tasks, and needs to know what analyses are required to programme and manage the deliverables and resources effectively.

2.1.2 This section will focus on the production of appraisal outputs resulting from activities on option development and appraisal of impacts as indicated in Figure 1.

The Appraisal Summary Table (AST)

2.1.3 The AST presents evidence from the analysis that is undertaken to inform the economic case of an intervention. Applying the principles of HMT Green Book, the AST has been designed to record all impacts - Economic, Environmental, Social, Public Accounts and Distributional – at the national level.

2.1.4 The layout of the AST is designed to make the appraisal process more transparent by drawing together and summarising all relevant impacts to enable options to be considered in a concise and consistent manner. Those impacts that can be monetised are presented in monetary and quantitative terms. Those that cannot be monetised are presented quantitatively. No weightings are applied. The AST is typically completed by a scheme promoter, and in some cases – depending on the different treatment across modes – it can be modified by an assessor (decision-maker). The assessor should use the information provided in the AST (and, where necessary, the detailed supporting documents) to make a judgement about the overall value-for-money of the option in the Value for Money Assessment. The Guidance on Value for Money (DfT, 2017) sets this out in further detail.

2.1.5 More detail on the monetary assessment of impacts is contained in a series of standard tables that are summarised in the AST. These are:

- The Transport Economic Efficiency (TEE) Table summarises the impact on transport users and private sector providers;
- The Analysis of Monetised Costs and Benefits (AMCB) Table summarises all of the monetised impacts of a scheme that are considered sufficiently robust for inclusion in the Net Present Value (NPV) and Benefit Cost Ratio (BCR) of the scheme, including TEE impacts; and
- The Public Accounts (PA) Table, describing cost and revenue impacts of the scheme.

2.1.6 An AST should be produced for each option considered as part of the study. The evidence supporting the ASTs is first compiled for the OAR in Stage 1 of appraisal (see Section 1). At this stage, the evidence is used as input into the distillation process to shortlist preferred schemes for more detailed appraisal in Stage 2. Section 2.2 provides details on how to complete the AST for each sub-impact.

Key components in the analyses of impacts

2.1.7 As illustrated in Figure 4, the broad components within the overall appraisal process are design, cost estimation, modelling, environmental impact assessment, distributional analyses and appraisal. These are areas requiring significant resources, and it is crucial for the TPM to plan for these activities in the overall study programme.

2.1.8 Scheme design feeds into all elements of the study process, including cost estimation.

2.1.9 Transport models are typically used for option testing and development, especially in the case of major schemes. The model outputs are used to support all other components – the environmental impact assessment and distributional analyses. Section 3 describes transport modelling requirements in more detail.

2.1.10 For some projects, there is a statutory requirement to carry out Environmental Impact Assessment, to meet the requirements of the EIA Directive[2]. Other projects do not require statutory Environmental Impact Assessment, but may still require non-statutory environmental impact assessment. The aim of environmental impact assessment, whether it is to meet statutory or non-statutory requirements, is to ensure that the environmental implications of decisions on projects are made available so that they can inform the design and decision making process. Guidance in TAG addresses environmental impact appraisal. Environmental impact appraisal is the process of developing environmental impact information for inclusion in a transport appraisal. This builds on the baseline data and impact assessment work carried out as part of the environmental impact assessment, as Figure 4 below illustrates. The appraisal recommended in TAG is not intended to be an alternative to, or a replacement for the environmental impact assessment. Rather, it is intended to complement that work.

2.1.11 Wherever applicable, distributional analyses need to be conducted where there is potential impact on vulnerable groups. This analysis draws on information produced from the transport model and the Environmental Assessment.

2.1.12 Some of the impacts being appraised could be produced from the distributional analyses and environmental assessment components. Other impacts will mainly involve the use of model outputs to conduct further analyses on sub-impacts e.g. wider impacts, regeneration, accidents etc. Finally, the results are summarised within the Appraisal Summary Table. More details are provided in the next section.

2.1.13 Understanding the links between these components is vital to facilitate forward planning of modelling outputs fit for use in other dependent components. Establishing these interdependencies early would help smooth the transport appraisal process and mitigate risks of abortive work downstream of the process.

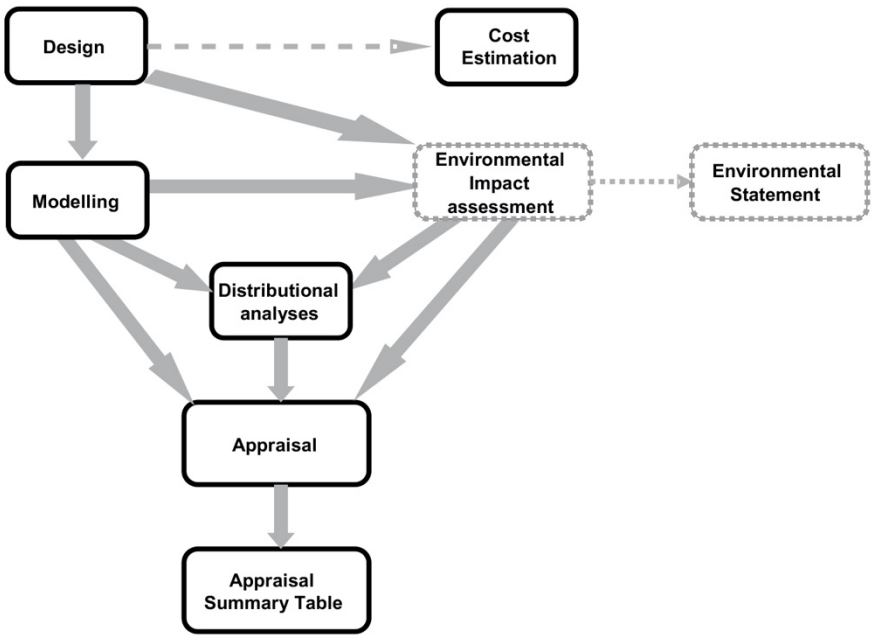

Figure 4 Relationship between the key components of appraisal work

[2] EC Directive 85/337/EEC as amended by EC Directive 97/11/EC and the Public Participation Directive 2003/35/EC

2.2 Summary of the work required in appraisal

2.2.1 This Section describes how to complete the evidence for each sub-impact in the AST.

Economy

2.2.2 The following impacts are included under this heading: impacts on business users and transport providers; reliability impacts on business users; wider impacts; and regeneration.

2.2.3 There are two distinct aspects to the analysis of impacts on **business users and transport providers** (see TAG Unit A1.3 – User and Provider Impacts). The analysis of impacts on business users focuses on changes in business user journey times, vehicle operating costs, and user charges (fares, tolls, parking charges and so on). Note that impacts on business users during periods of construction and maintenance must also be taken into account. Transport provider impacts reflect changes in private sector transport provider revenues and costs (capital and running). Note that public sector transport provider impacts should be included under the public accounts heading.

2.2.4 To produce the required analyses, a transport model would usually be required to provide estimates of changes in the numbers of trips and their journey times and costs.

2.2.5 The Department's TUBA software package can be used to carry out the analyses required, including interpolate/extrapolate these impacts over the appraisal period, and to calculate the present value costs and benefits of these impacts (see TAG Unit A1.1 – Cost Benefit Analysis).

2.2.6 Methods for the assessment of **reliability impacts on business users** are less well developed. Selection of the most appropriate analytic technique to use will depend on the nature of the scheme. A key problem is that most transport models do not provide estimates of the reliability of the network. Guidance for practitioners (see TAG Unit A1.3) provides the most appropriate methods to be used in a number of different circumstances. However, if further guidance is needed, the Project Manager should approach the Department for advice.

2.2.7 For the assessment of **wider impacts** (see TAG Unit A2.1 – Wider Economic Impacts Appraisal), the outputs of the transport model can be combined with additional data – on employment, GDP, GVA, productivity etc. – to analyse the impact on agglomeration, output in imperfectly competitive markets and labour markets. The Department's software WITA may be used to carry out this assessment. WITA incorporates all the additional data needed to carry out this analysis.

2.2.8 Depending on availability of the required information, the time required to assess regeneration and wider impacts is more variable.

Environment

2.2.9 The following impacts are included under this heading: noise, air quality, greenhouse gases, landscape, townscape, heritage of historic resources, biodiversity and water environment.

2.2.10 Analyses of **noise** and **air quality** are often required as part of the Environmental Impact Assessment (EIA) process, leading to publication of an Environmental Assessment Report (EAR) and Environmental Statement (ES). Even if these analyses are not formally required, it is good practice to carry them out. Guidance on these analyses is provided in DMRB Volume 11. This guidance is designed for use in highway projects, but is likely to be useful for other modes, too.

2.2.11 Transport models are often needed to provide estimates of link traffic flows and speeds, required as inputs to the noise and air quality impacts. The manipulation of transport model outputs to meet the needs of those carrying out noise and air quality impacts can often be time consuming at critical points in the study programme. To reduce these delays, noise and air quality specialists should liaise with transport modellers at an early stage in the project to ensure that transport models provide outputs that require minimal manipulation.

2.2.12 The analyses required to complete the noise and air quality entries in the AST build upon the analyses required for the Environmental Impact Assessment (EIA) process. In both cases, the Department has provided workbooks to carry out these analyses, incorporating the values and other parameters required (see the noise and air quality sections of TAG Unit A3 – Environmental Impact Appraisal). These spreadsheets summarise the calculations in worksheets as required. An analysis of distributional impacts may also be required.

2.2.13 Analyses of **greenhouse gases** are also required as part of the Environmental Impact Assessment (EIA) process and the remarks above apply. However, estimates of the greenhouse gas emissions are also made in the Department's user benefit estimation software TUBA. Those carrying out the environmental impact assessment and those carrying out the user benefit estimation work should liaise closely to ensure that the analyses taken forward into the AST are consistent with those used in the environmental impact assessment. Where greenhouse gas emissions estimated in the environmental impact assessment process are to be used to generate the AST entries, the Greenhouse Gases Workbook may be used (see TAG Unit A3).

2.2.14 Analyses of **landscape**, **townscape**, **historic environment**, **biodiversity** and the **water environment** are also required as part of the Environmental Impact Assessment (EIA) process and useful guidance is provided in DMRB Volume 11 (note that townscape is subsumed into landscape in DMRB Volume 11). As for noise, air quality and greenhouse gases, the analyses required to complete the entries in the AST build upon the information gather for the Environmental Impact Assessment (EIA) process.

2.2.15 In some cases, the analyses specified in DMRB are very similar to those specified in WebTAG's Practitioner level guidance, in some cases they differ. In either instance the results from the two approaches should be consistent.

2.2.16 The analytical methods recommended in WebTAG's Practitioner level guidance for these five impacts are qualitative, based on the environmental capital approach (ECA) developed by the statutory environmental bodies.

2.2.17 The environmental capital methodology builds on information about environmental character of a location by using a set of common indicators and definitions. Then the impact of the transport project on the location is assessed, again using standardised measures. These two components – the environmental character of the site and the impact of the project on the site – are then combined to produce an overall qualitative summary assessment on a seven point scale (large, moderate and slight adverse, neutral, and large, moderate and slight beneficial). Many projects will affect more than one location, so an aggregate assessment for the whole project must be made, based on the location specific assessments.

Social

2.2.18 The following impacts are included under this heading: user benefits to commuters and other users, reliability impacts on commuters and other users, physical activity, journey quality, accidents, security, accessibility, affordability, severance and option values. Detailed guidance on calculating these impacts is in TAG Unit A4.1 – Social Impact Appraisal.

2.2.19 The analyses for impacts on **commuting and other users** and **reliability impacts on commuting and other users** will be conducted as part of the same analyses for business users & transport providers under the Economy impacts. Note that an analysis of distributional impacts may also be required if there are impacts on commuting and other users.

2.2.20 The **physical activity** impact is concerned with the impacts of changes in physical activity – cycling and walking - on health. For projects specifically targeted at walking and cycling, methods are available that enable a monetised assessment to be prepared. Formal transport modelling is unlikely to be appropriate for these projects. For projects such as inter-urban road building where it can be demonstrated that the impact on physical activity is a relatively insignificant, assessment may not be needed.

2.2.21 **Journey quality** includes a wide range of impacts, including crowding on rail, transport interchange impacts, transport information impacts and other journey ambience impacts. These impacts often (but not always) require the use of modelling in their analysis. In some cases, journey quality is integrated with journey time in modelling. Where that approach is adopted, it is essential that the journey quality impacts should be separable from the journey time impacts for appraisal and reporting in the AST.

2.2.22 Transport interventions may alter the risk of individuals being killed or injured as a result of **accidents** through a variety of means. Accident impacts occur across all modes of transport and affect non-users as well as users. Standard processes exist for forecasting changes in the numbers of accidents and casualties that will result from transport interventions. These processes usually require estimates of traffic flow or similar outputs from a transport model. Accident impacts are valued using standard values for fatalities, serious and slight injuries and for other accident-related costs. For highway schemes, the Department's software package COBALT can be used to assess accident impacts. An analysis of distributional impacts may also be required.

2.2.23 Transport interventions may affect the level of **security** (freedom from crime) for road users, public transport passengers and freight (all modes). Analysis of security impacts must reflect both changes in security and the likely numbers of users affected. While changes in the numbers of users affected may be derived from a transport model, changes in security should be assessed by systematically comparing aspects of security with and without the intervention. The outcome of the assessment is a qualitative score on a seven point scale (large, moderate and slight adverse, neutral, and large, moderate and slight beneficial). An analysis of distributional impacts may also be required.

2.2.24 The appraisal of **accessibility** focuses on the public transport accessibility aspect of accessing employment, services and social networks. The method recommended identifies impacts as a result of the intervention on public transport availability and opportunities for the population living within the area to access essential services and facilities. The approach includes consideration of the physical access to and within the public transport system. Analysis should be based on accessibility mapping for with and without scheme scenarios. Accessibility mapping will often be based on the use of an accessibility planning software package. An accessibility audit should also be carried out. The outcome of the analysis is a qualitative score on a seven point scale (large, moderate and slight adverse, neutral, and large, moderate and slight beneficial). Distributional analysis is an integral part of the analysis of accessibility impacts.

2.2.25 The analysis of personal **affordability** is concerned with changes in the monetary costs of travel. The monetary costs of travel can, in some cases, be a major barrier to mobility for certain groups of people, and increases in travel costs can have particularly acute effects on their ability to access key destinations. Since the monetary costs of travel is a key component of the analysis of user impacts, the analysis of affordability draws on that analysis, using the results for commuting and other purposes only. The analysis usually depends, therefore, on the availability of a transport model and an analysis of transport user benefits based on use of the Department's software TUBA. Distributional analysis is an integral part of the analysis of affordability and the outcome of the analysis is a qualitative score on the standard seven point scale.

2.2.26 Analysis of **severance** is required as part of the Environmental Impact Assessment (EIA) process and useful guidance is provided in DMRB Volume 11. The analyses required to complete the entries in the AST build upon the information gathered for the Environmental Impact Assessment (EIA) process. The analysis is based on a comparison of the degree of severance with and without scheme scenarios and results in a qualitative score on the standard seven point scale. In some circumstances, a distributional analysis will also be required.

2.2.27 The appraisal of impact on **option and non-use values** is only likely to be of importance where an intervention will substantially change the availability of transport services within a study area. In circumstances where the lack of a transport facility could cause inconvenience, people who do not usually use the facility may be willing to pay a premium – the option value - to ensure that it is

available for unplanned trips. In addition, people may be willing to pay to retain a facility regardless of any possible use – this is the non-use value.

2.2.28 Appraisal of option and non-use values should only be undertaken where there is a step change in the level of service offered. This would include the introduction of, or loss of, a transport mode or the provision of a significantly better facility than currently exists, such as a new motorway or a high speed railway line. Valuation of transport option and non-use values is not well developed, so most analyses will be qualitative in nature, leading to a qualitative score on the standard seven point scale.

Public Accounts

2.2.29 The appraisal of "Public Accounts" describes how the scheme impacts on government (see TAG Unit A1.2 – Scheme Costs). This includes all costs incurred by central or local government bodies (including public sector agencies). The sub-impacts identified are: cost to the Broad Transport Budget (BTB); and indirect tax revenues.

2.2.30 **Costs to the Broad Transport Budget** include all costs and revenues that directly affect the funds available to central or local government for transport. Thus, it includes those capital and running costs that are paid by government bodies including public sector agencies. Grants from public sector bodies (such as the EU) should be included. Cost to the BTB also includes revenues and other income, such as payments by developers, that affects the BTB.

2.2.31 Changes in **indirect tax revenues** include all revenues that benefit government as a whole but do not directly affect the Broad Transport Budget.

2.2.32 The appraisal values for assessing these impacts, as well as the appraisal techniques, have been incorporated into the Department's TUBA software wherever feasible.

3 Introduction to Modelling

3.1 Introduction

3.1.1 This section gives an introduction to modelling for the project manager. This advice is appropriate for all major transport schemes. It sets out the minimum specification of the models and forecasting procedures that the Department expects in support of bids for funding, whether in part or whole.

3.1.2 Separate advice, providing an overview of the need for modelling, is available for the Senior Responsible Officer (SRO). More detailed advice, setting out the methods that the Department recommends, is also available for the modeller in TAG Guidance for the Practitioner.

3.1.3 Modelling is an important element in the appraisal of a transport scheme and often requires substantial effort and resources to build an appropriate, fit-for-purpose tool. This Section describes the principles of modelling, the considerations necessary and the requirements of each model component. More detailed guidance on principles is in TAG Unit M1.1 – Principles of Modelling and Forecasting.

3.1.4 It is important to emphasise that the modelling guidance in TAG is not intended as a textbook on modelling generally, nor is it aimed at those who wish to construct a state-of-the-art model from scratch. TAG provides advice aimed at ensuring that forecasts of the demand for new schemes are made on a consistent and reliable basis and that the models used are appropriate to the type of scheme and its circumstances, and provide the information required by the appraisal of a major transport scheme. It also aims to help assessors who will use appropriate modelling packages and project managers who wish to understand the issues involved when seeking experienced expert support. Where the necessary expertise exists, this advice should not be interpreted as discouraging the adoption of more sophisticated or more detailed modelling techniques.

3.1.5 This Unit provides guidance on the following:

- The principles of **model selection**, in terms of the type of scheme and its scope, the requirements and the stage of the appraisal, and resource constraints;
- Considerations and requirements for **forecasting** using transport models;
- Considering the requirements of **appraisal impacts** and their relative importance when designing a model;
- The expected **model standards** and **reporting requirements** when submitting a full business case to the Department; and
- Appendix B gives more detail on the requirements of **assignment models** and **demand models** more specifically.

3.2 Selecting the Modelling Approach

Proportionality and Appropriateness of the Approach

3.2.1 The most appropriate modelling approach for any particular scheme will depend on the type of scheme, the circumstances, its purpose or objectives and the stage of the appraisal and decision-making process. Different types of scheme may require different approaches and the same kinds of scheme in different contexts may require different approaches. However, the modelling effort for scheme appraisal at each stage needs to be related to the decisions it informs and should be proportionate to the scale of the scheme.

3.2.2 In **"Stage 1"** of the decision-making process that is required to select the best transport options to solve the identified problems, more light-touch methods and hence modelling tools may be appropriate. It is often tempting to use over-simplified modelling approaches, or models designed for

other purposes, in the early stages of project development. However, great care should be taken to ensure that the indications from such models do not give rise to unrealistic expectations of benefits that are unlikely to result from a full modelling approach.

3.2.3 In the case of highway schemes, early indicative work may be undertaken with relatively simple fixed-trip network assignment models, if available. However, the potential impact of induced traffic should be recognised and it is highly recommended to scope the need for a demand model at an early stage. For an example of public transport, many schemes will derive the bulk of their patronage by extraction from existing public transport services. These effects can be estimated by a public transport assignment model and early investment in this element would provide some useful information about the potential viability of the proposal while other parts of the model are being developed.

3.2.4 **"Stage 2"** of the process requires a fully specified appraisal, where the modelling is expected to produce robust enough analysis to be used in that appraisal. The proportionality of the modelling approach will have been discussed with the scheme sponsor at this point and agreed through use of the Appraisal Specification Report (ASR).

3.2.5 Robust analyses are expected at this stage in order to present the best evidence to the decision-maker potentially funding a project. Given the complexities of the transport system and the scope of most schemes, it is expected that a model of some or all of the transport system will be required. In very few cases, a transport intervention may be simple enough to warrant a simplified approach that may preclude the need for a model altogether, if it can be demonstrated that it is possible to make robust decisions in this way.

3.2.6 This Unit and subsequent guidance in TAG is focused primarily on modelling approaches for a full scheme appraisal. It should be remembered, however, that more proportionate methods may be appropriate where a "full" modelling approach in a particular context is inappropriate and hence not required.

Model Design Considerations

3.2.7 In summary, there are trade-offs between model complexity and sophistication of outputs versus constraints on resource, computer run-times, data requirements and expertise. The considerations when specifying the **design** of a transport model are as follows, all of which have implications for planning and implementation and the resulting quality of the outputs:

- the nature of identified problems and their likely solutions;
- the definition and size of the study area;
- the likely number of options to be tested;
- the availability of data and existing models;
- the need to update and (re)calibrate models;
- the need to conduct new surveys;
- the timescale for model development; and
- the required accuracy and robustness of results/recommendations.

3.2.8 Before commencing any model design an inventory of existing models should be made and each model should be assessed on the basis of: the structure of the overall model and its components; the age, quality and spatial coverage of the underlying data; and the model's adherence to quality criteria for calibration and validation.

3.2.9 Models can often take substantial time and resources to develop to their full specification. The complete model should be specified at the outset of the work and consideration should be given to the order in which the various elements should be developed, taking account of, among other things, their usefulness for preliminary appraisals.

3.2.10 Models should be designed with scheme scope and objectives firmly in mind and may not necessitate what is regarded as a "full" modelling specification in some circumstances. For example, on the public transport side:

- a city-wide light rail system designed to attract car travellers will require a fully-specified, city-wide, multi-modal transport model;
- a single light rail line serving an airport will require a more sophisticated mode choice sub-model but may allow simpler techniques to be adopted for other aspects of the model; and
- a bus priority strategy aimed primarily at providing a better level of service for existing bus passengers with no effect on other modes may require only a public transport supply (assignment) model to provide the necessary inputs to a relatively simple appraisal.

3.2.11 On the highway side:

- Significant strategic or urban highway improvements will require sufficient network detail and a wide enough study area to account for all impacted users, including a demand model where the impact of induced traffic is considered to be important;
- Highly localised road junction improvements may require a tightly-defined modelled area, may not require a demand model and may be more amenable to micro-simulation methods.

3.2.12 Data collection and its associated requirement and potential cost is of vital importance in the specification and implementation stages of model development (e.g. in the case of the introduction of a new mode, stated preference surveys may be necessary to determine suitable values and parameters for use in forecasting). It may also be prone to time constraints where data requires collection at specific times. Due consideration should be given to this issue at an early stage to, where possible, avoid the need for further collection and the associated costs and delays. In addition to local data needs, several national data sources are available to assist the development of models. TAG Unit M1.2 – Data Sources and Surveys gives more detail on the types of data that exist and can be collected.

3.3 Forecasting Using Transport Models

Introduction

3.3.1 This section outlines some practical considerations when forecasting using transport models, which will have significant impacts on the resulting output from the transport model and ultimately the appraisal results. Detailed guidance is available for the modelling practitioner on the specific subject of forecasting (see TAG Unit M4).

Changes in Supply

3.3.2 All expected changes to the transport network should be implemented in the highway assignment and public transport assignment models. This includes all business-as-usual improvements as well as potential schemes that may be built out that will have a significant impact on the modelled area. It is important to run sensitivity tests with different networks in future years in order to ascertain whether the impact of another proposed scheme, which may not yet have permission or funding, has a material impact on the benefits of the scheme in hand.

Travel Demand

3.3.3 Travel demand forecasts for input into transport models may be obtained from the Department's National Trip End Model (NTEM), in the form of trip ends. These data are accessible through the TEMPRO software, which is free to download. TAG Unit M4 gives guidance on its use.

3.3.4 TEMPRO may be used to adjust travel demand where the analyst has more detailed local knowledge of developments for input into the core scenario used in appraisal. To avoid bias between schemes in different areas, NTEM totals should be adhered to across the modelled area.

Uncertainty and Sensitivity Testing

3.3.5 The analyst should keep an uncertainty log to indicate the uncertainty in the travel demand forecasts and future assumptions. Uncertainty covers any aspect of a model and its inputs.

3.3.6 Sensitivity testing is key to good practice of producing a transport appraisal. This information gives a range of results around the core scenario to account for the inevitable uncertainties associated with forecasting assumptions. They allow the modeller to present the results to allow an open and transparent story to be told regarding the sensitivity to assumptions and the potential risks that scheme benefits may be prone to.

3.4 Using Model Outputs in Appraisal

Modelling in line with appraisal requirements

3.4.1 Transport schemes will have key objectives in order to address problems that have been identified and increase net welfare. The model design will be somewhat guided by these objectives in principle. The fundamental principle of the model is that it will need to be able to address all salient impacts, as set out in the Appraisal Summary Table (see Section 2**)**, in line with the scope of the appraisal required as specified in the Appraisal Specification Report (see Section 1).

3.4.2 The model selected will need to be robust enough to provide suitable outputs for each group of impacts and sub-impacts. The model also requires enough detail as demanded by the various environmental impact assessments such as local noise and air pollution, which can often be very localised problems. Finally, the model needs to be able to support the requirements of social and distributional impact analysis (see Section 2).

3.4.3 It is important to consider and have appropriate representation of the supply and demand side. These are covered in detail in the subsequent sections of this Unit.

3.4.4 The supply side represents the transport network itself (i.e. an assignment model) and requires enough detail to give results for all of the impacts being considered. A highway assignment model is required where costs of car use are important on the network. Public transport assignment models are required to derive costs for PT schemes, which may additionally require highway assignment models in the case of sufficient congestion. Further detail is given in Appendix B section B.1.

3.4.5 The demand side will be important where the change in transport conditions, with or without a scheme in place, causes changes in traveller choices. This is largely choice of destination, time of travel, mode of travel and whether or not to travel at all. If these impacts are material a demand model is required alongside the supply model. Further detail is given in Appendix B section B.2.

3.4.6 Rail improvements can provide a considerable challenge to modelling and is often treated separately from or along-side 'traditional' transport modelling approaches. This is because rail schemes often affect wider areas and have a relatively smaller proportion of the mode share relative to other modes. More detailed guidance for those modelling for rail improvements is available – see TAG Unit A5.3.

3.4.7 Some issues may not lend themselves to conventional modelling in the present state of the art. Quantification may be possible on an ad-hoc and external basis (see Section 2.2).

3.5 Model Standards and Reporting

Modelling Standards

3.5.1 Guidance in the Practitioner tier of TAG describes best practice in model development. As part of producing an appropriate analytical tool, it is important that models are based on up-to-date evidence and are demonstrated to produce realistic results when tested. Without this assurance, results from a model may not be sufficiently robust to be used to adequately assess impacts of a potential intervention.

3.5.2 Obtaining this assurance is done via **model validation**. This ensures that sufficiently accurate traffic and passenger flows are reproduced on the transport network in the model base year and that the model responds appropriately to changes in costs when used to forecast i.e. that changes in behaviour (demand) are realistic. TAG contains suggested benchmark criteria in order to test this realism. However, the key concern of the analyst is to ensure that the model is fit for the purpose to which it is being applied and that there is appropriate evidence to support the conclusion that it is.

3.5.3 **The achievement of the validation acceptability guidelines described in TAG does not guarantee that a model is 'fit for purpose' and, likewise, a failure to meet the specified validation standards does not mean that a model is not 'fit for purpose'.** A model which meets the specified validation standards may not be fit for particular purposes and, conversely, a model which fails to meet to some degree the validation standards may be usable for certain applications. The test of fitness for purpose of a model is: can robust conclusions be drawn from the model outputs?

Reporting Requirements

3.5.4 Reporting must demonstrate in a clear, consistent and balanced way that the reported models make effective use of data, are fit for purpose, and provide a sound basis for the estimation of the key economic, environmental and social impacts of projects.

3.5.5 The reporting requirements presented in Appendix C are in line with the core requirements expected of transport models at the full appraisal stage. The technical work required that underpins these requirements and more detail in the precise nature of what to present is described in detail in the TAG Modelling guidance for the practitioner.

3.5.6 For transport project business cases, the following modelling reports are expected, where relevant, as a minimum:

- A **data and traffic surveys report**, detailing the data obtained for the modelling of the intervention (for development, calibration and validation), including assessments of the appropriateness of those data;
- An **assignment model validation report**[3], detailing the approach taken to model the supply side, including details of how the network was constructed, segmentation, matrix construction and fitness for purpose, particularly with reference to validation criteria; there should be a report prepared for the highway and PT models as appropriate;
- A **demand model report**, where variable demand responses are being modelled, including details of design, choices modelled and segmentation and fitness for purpose against realism tests and the results of sensitivity tests.

[3] Often referred to as the 'LMVR' (Local Model Validation Report), in the case of local major schemes.

- A **forecasting report**, including forecasting assumptions on the supply and demand sides and their appropriateness, diagnostics of outturn results, the treatment of uncertainty and sensitivity testing.

Appraisal Handover Pack

3.5.7 The final reports of the modelling should be stored as part of an appraisal handover pack to ensure that modelling assumptions can be understood in subsequent benefits management, monitoring and evaluation work (see Appendix D).

4 References

The Overall Approach

A detailed list of references for the appraisal process can be found in The Transport Appraisal Process.

Appraisal

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- Traffic Appraisal Manual, DMRB Volume 12.1.1. The Traffic Appraisal Manual (TAM)
- Traffic Appraisal in Urban Areas, DMRB Volume 12.2.1.

Department for Transport (2011), NTEM Planning Data Guidance Note.

John Fearon Consultancy (1998). Strategic Transport Modelling and Strategic Multi-Modal Studies: review report.

Institution of Highways and Transportation (1996). Guidelines on Developing Urban Transport Strategies.

The MVA Consultancy (1996). Improved Car Ownership Models. Report to the Department of Transport.

Evaluation

Department for Transport, 2016, Strengthening the links between appraisal and evaluation, Available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/540733/strengthening-the-links-between-appraisal-and-evaluation.pdf

5 Document Provenance

The guidance in this TAG Unit builds on advice in the Guidance for the Senior Responsible Officer.

The modelling section of this TAG Unit combines several Units from the previous version of TAG from April 2011. These include:

- 2.9.1 – Variable Demand Modelling – Advice Overview (reflecting the consultation comments received on the Introduction Step 1 of the draft **Variable Demand Modelling Advice** (TRL, in June 2003));
- 2.9.2 – An Introduction to Variable Demand Modelling (as above);
- 2.10.1 - Introduction to Forecasting Models for Public Transport Schemes (replacing Major Scheme Appraisal in Local Transport Plans Part 3: Detailed Guidance on Forecasting Models for Major Public Transport Schemes);
- 2.10.2 - Introduction to Model Structures for Public Transport Schemes (as above);
- 3.1.1 – Introduction to modelling (based initially on Chapter 2 of Guidance on the Methodology for Multi-Modal Studies Volume 2 (DETR, 2000)). This is largely contained, in edited form, in Annex A.

Appendix A Option Assessment and Appraisal Specification Reports

This Appendix outlines the Option Assessment Report and the Appraisal Specification Report. Further details are given in The Transport Appraisal Process unit.

A.1 Option Assessment Report (OAR)

A.1.1 A suggested structure of this report is as follows:

- Problems and challenges of the transport study and the evidence used to frame these problems.
- Define the future 'without scheme' scenario
- Present a sound body of analysis to provide evidence of the problems and challenges and need for intervention. .
- Clearly state the study or intervention-specific objectives and intended outcomes, and enough information to facilitate an understanding of the links between issues and context and the final statement of objectives. Define the geographical area to impact to be addressed by the intervention.
- Stakeholder strategy: documents who to involve, when and how. The latter relates to mode of involvement e.g. leaflets, exhibitions. The strategy should also distinguish between:
- Information provision – a one way process to keep interested stakeholders informed
- Consultation – views of the general public or sectional interests are sought at particular stages and the results are feedback to the study process.
- Participation – enabling stakeholders to have a direct influence on the outcome of the study
- Stakeholders involved and their role in informing the option development process.
- Options generation and sifting: document the process of option generation (Step 5), sifting (Step 6), and assessment (Step 7). Decisions made on discarded options should be recorded, along with supporting evidence. The format outlined in EAST, or any comparable alternative[4], could also be used. Analysts should also document how environmental considerations have been taken into account in this process, particularly during the initial sifting stage.
- Produce evidence and assessment against the criteria in the 5 Case Model: this is required for each option being considered. See the Option Assessment Framework in Appendix A of The Transport Appraisal Process.
- Conclusion: this will summarise the headline results across all options considered and identify the better performing options, including lower cost solutions, to progress into Stage 2.

A.2 Appraisal Specification Report (ASR):

A.2.1 A suggested structure of this report is as follows:

Scope of modelling:

- Proposed approach to modelling and forecasting;

[4] https://www.gov.uk/government/publications/transport-business-case

a) TAG Unit M2 - Variable Demand Modelling provides guidance on the requirements for variable demand modelling, and describes the conditions under which certain elements of the model can be simplified or removed.

b) The TAG Units in the M5 family provide further guidance for schemes that are mode-specific.

Scope of further appraisal:

- An Appraisal Specification Summary Table needs to be completed for each preferred option, setting out information on:

  a) Description of assessment of each option against each sub-impact, as presented in the OAR

  b) Level of uncertainty of assessment

  c) Proposed proportionate appraisal methodology

  d) Type of assessment output (quantitative/qualitative/monetary/distributional)

- Note that the evidence presented in the OAR might also indicate that no further appraisal is required for certain sub-impacts.

Appendix B Assignment and Demand Models

B.1 Assignment Models

Introduction

B.1.1 Assignment models are responsible for the route choice component of forecasting, identifying future flows of traffic and public transport vehicles on the network. This is responsible for providing transport costs and flows across the network, which contribute to much of the analysis undertaken in a transport appraisal. Assignment model output is also often extracted and input to a demand model, which iterates with the assignment model to an equilibrium state where supply and demand balance.

B.1.2 The nature of the interventions to be modelled should be established at the outset. This is important in the case of assignment models for either general or specific purposes. Without clarity at the outset about the interventions to be modelled, it is possible that a model may not be suitable for some of the interventions which are later identified.

B.1.3 Public transport and highway assignment models share similar principles. Therefore, the advice provided here should be assumed to be applicable to both unless otherwise stated. The following sections describe the factors to be taken into account at the outset when designing an assignment model. Detailed guidance for highway and public transport assignment models are given in TAG Unit M3.1 – Highway Assignment Modelling and TAG Unit M3.2 – Public Transport Assignment Modelling.

Modelled Area and Convergence

B.1.4 The geographic coverage of assignment models generally needs to allow for the strategic re-routeing impacts of interventions where applicable, ensure that areas outside the main study area, which are potential alternative destinations, are properly represented, and also ensure that the full length of trips are represented for the purpose of deriving costs. The second and third requirements are particularly important where an assignment model will be linked to a demand modelling system.

B.1.5 The modelled area should ideally be no larger than is necessary to meet these requirements, particularly in terms of the number of zones. A larger than necessary modelled area will add to model run times and satisfactory convergence will be harder to achieve.

B.1.6 Other important considerations are as follows:

- The area covered by the assignment model, often called the study area, should be appropriate relative to the scale of the intervention and its potential impacts;
- Within the modelled area, the geographical location of the proposed intervention should be central and not peripheral, since the accuracy of models in peripheral areas is designed to be more limited. This consideration will usually occur when considering using or developing from an existing model;
- Convergence levels may affect the robustness of the appraisal results, in that a poorly converged model may mean that the modelled impacts of interventions vary materially between model iterations. Models must be ensured to converge in the forecasts years for which it is used, as well as the base year;
- Models must converge adequately, but run times should be practical. These will be directly related to the detail of the model in terms of its spatial resolution and segmentation.

Model components

B.1.7 There are several considerations when deciding on the appropriate assignment model to use and how it should be constructed. The following considerations should be borne in mind when deciding on the composition of the highway or public transport assignment model.

B.1.8 For highway assignment models it is recommended that:

- an explicit quantification of decongestion benefits should be made for every scheme where these benefits are claimed as part of the justification;
- use of existing local assignment models should be encouraged where it is possible to update the model to be fit for purpose for the options(s) to be tested; otherwise a new assignment model should be set up to provide the required quantification;
- The choice of assignment method will depend mainly on the level of congestion on the network and the availability of alternative routes; and
- The two main methods of modelling the restraining effects on demand of capacity limitations are junction modelling and speed/flow relationships. Junction modelling requires longer computing times than models which use only speed/flow relationships. However, speed/flow modelling is more approximate than junction modelling in urban areas and models which are based on speed/flow relationships alone are often more difficult to calibrate and validate to acceptable standards.

B.1.9 For public transport assignment models it is recommended that:

- The method of PT assignment is an important consideration that can have practical implications on run times and for the appraisal implications. Schedule-based methods run PT services to precise timetables, which can pose coding difficulties and longer run times, although a more realistic representation. A compromise, which may be more appropriate for good reason, is to use a headway-based method, where waiting and interchange times are simplified functions of that headway;
- Fares need not be included in the assignment unless they influence route choice, as these can be added to generalised costs in the demand model. Some user classes, however, may need to be defined separately, such as travel pass owners or those benefiting from concessionary fares;
- Crowding should only be modelled where it is likely to have a significant effect on traveller behaviour or where an impact on crowding is one of the scheme's objectives; even where crowding is not modelled volume to capacity ratios should be monitored;
- For sub-modes that run on-street, the journey times in the PT assignment model are consistent with the level of traffic congestion, which will require some linkage with the highway assignment model;
- Appropriate weights should also be applied for interchanging between public transport services and times of wait at PT stops. Mechanisms in the model for including quality factors (e.g. real time passenger information) should also be considered, particularly if integral to the scheme; and
- The extraction of costs from the PT assignment model must be considered carefully to ensure consistency with the assumptions made to split flow between routes, particularly where a new route is introduced.

Dimensions of the Assignment Model

B.1.10 An assignment model with greater dimensions will in theory represent behaviour in more detail than a coarser model. However, more detail in terms of zones, networks, segmentation, etc. will cause

longer run times. There are therefore inevitable trade-offs to be made between the level of detail and the practicality of running the model.

B.1.11 Where a demand model is used, iteration between a demand model and the assignment models is required to ensure that demands and generalised costs are in balance, that is, that the demand/supply loop converges. If the time required to run the assignment models to convergence is substantial, it may be necessary to consider a tiered modelling system in which simplified versions of the detailed assignment models are used to operate with the demand model.

B.1.12 Traffic conditions generally vary sufficiently throughout the day to warrant separate models of peak and inter-peak periods. In some circumstances, there may be a case for modelling two or three hours in each peak period. However, the greater the number of time periods, the longer the run times will be. A balance will therefore need to be struck between the desirability of a greater number of distinct time periods and the time taken to run the model.

B.1.13 Values of time vary by the purpose of the trip being made. Values of time may also vary by income group. For highway assignment models, operating costs vary by vehicle type. This means that different users (and, for highway assignment models, vehicle types) may choose different routes through the network. The total trip matrix should therefore be split into a number of 'user classes'. These user classes should be assigned separately in a multi-user class assignment.

Data Sources

B.1.14 Data sources should be identified at the model design stage. The feasibility of creating a model for a particular area will depend on the availability of suitable data and whether sufficient new data of acceptable quality can be afforded and collected. Also, data quality may differ depending on the source. These issues will influence the validation standards of the model and, crucially, its potential fitness for purpose. Further detail on data sources for modelling is given in TAG Unit M1.2 – Data Sources and Surveys.

B.1.15 The proximity with which the validation standards can be approached will depend on the quality of several key elements of the model as follows, which will need consideration at the design stage:

- **Network data** from existing models may need to be audited while new network data coding will require effort to minimise errors. The resources available for either auditing or coding should be considered.
- **Count data** will be used in the model calibration. It is possible that inconsistent or inaccurate counts will pose some degree of risk to the quality of the model.
- The development of trip matrices is a critical process in model development that requires considerable skill and resource from modelling practitioners. It also requires good quality data that samples origin to destination movements by mode and purpose. The availability and suitability of **in vehicle interview survey data** should be established, including where the data were collected, how long ago, the sizes of the interview samples, and the factors that are likely to have caused a significant change in travel patterns since the data were collected. Other sources of observed trip data such as **household surveys** or **mobile phone data** could be considered; the latter is a developing area and requires synthesis to derive trip purpose and careful consideration of the integrity of the data.
- **Trip synthesis** to establish trip matrices where movements have not been observed through surveys requires thorough consideration and careful design. Trip ends used in this process will need to be sourced, as will travel data (trip length distributions and sector level movements) against which the model is to be calibrated. Extraction of data from existing models should also be considered.

B.1.16 While the source of the network data may have only a relatively small impact on the design of the model, all the other elements could have substantial implications. For instance, in cases where in

vehicle interview data are either not available or cannot be collected, greater reliance would need to be placed on trip synthesis and matrix estimation, which in turn would increase the need for good quality count data.

B.2 Demand Models

Background

B.2.1 All assessments of Government-funded investments in transport schemes need to consider the effects of variable demand (and the resultant induced or suppressed traffic) on the justification for intervention. As any changes in travel times or costs will affect the demand for travel, changes over time in the level of congestion should be reflected in the forecasts of travel both with and without the proposed intervention. Detailed guidance is given in TAG Unit M2 – Variable Demand Modelling.

B.2.2 **Any change to transport conditions will, in principle, cause a change in demand.** Travel will become faster or slower, cheaper or more expensive, and this will be reflected in the **generalised costs of travel** for some journeys. Generalised cost is the sum of both time and money cost, and other potential components such as journey quality and reliability. Any modelling of demand will depend upon how the generalised cost of travel changes. Take as an example a highway improvement which removes delays for those travelling by car:

- this reduces the generalised cost of some journeys;
- some people will therefore decide that the journey is now acceptable, whereas without the improvement they were likely to make other journeys or travel by other modes;
- the total number of people taking advantage of the scheme will be more than would have travelled without the improvement;
- the extra demand will add to the traffic flow on roads leading to and from the scheme as well; resultantly speeds at the improvement and surrounding routes may fall because of the higher flow; and
- The purpose of variable demand modelling is to **predict and quantify these changes.**

B.2.3 It is important to establish a realistic scenario in the absence of a planned intervention, i.e. the extent of travel suppression in the without-scheme case, and the extra traffic **induced** in the with-scheme case[5].

B.2.4 “Induced traffic” thus refers to the additional traffic, beyond the level of traffic that would use the network without the intervention. An alternative way to look at this is in the reverse: this is actually suppressed traffic that is released through a scheme improvement. Demand can also be induced on public transport modes where effective capacity is increased, the limits of which previously constrained demand.

B.2.5 This demand response also has important implications on scheme benefits. In congested conditions, say, since more people can take advantage of the scheme, the benefits per user are eroded (due to lower speeds) and more externalities may be produced in the form of noise and air pollution, for example.

B.2.6 Any response in the demand for transport of **freight** is not considered here, as often it is sufficient to assume that total freight traffic is fixed, but susceptible to re-routeing.

B.2.7 Modelling of demand should be used unless it can be robustly demonstrated that ignoring the effects of suppressed and/or induced trips and traffic will not affect the assessment of the economic,

[5] The Standing Advisory Committee on Trunk Road Appraisal (SACTRA), having considered all these effects in 1994, strongly emphasised this.

environmental or social impacts of the scheme. A basic method to test the need for a model with demand responses at the preliminary stage is described in TAG Unit M2.

B.2.8 For more general demand forecasting tools the multitude of uses will generally lead to complex and expensive model forms and supporting data collection. Clearly model developers will often find themselves under difficult constraints, such as time, data and budgetary constraints, or the lack of available skills. In these cases there are opportunities that need to be investigated to undertake an appraisal that is proportionate. This should be done in the initial stages of the project, where collaboration with the scheme sponsor is encouraged (see Section 1).

Dimensions of the Model

B.2.9 A key feature of demand models is the ability to segment transport users into distinct groups, based on their travel behaviour and response to supply changes, as well as segmenting by trip purpose, time of day and mode of travel. Broadly, the more segments in the demand model, the more intricate the response to changes in costs on the supply side (for example, to model the effect of a road toll scheme, one would need to include segmentation by household income, since there will be the expectation that households with differing abilities to pay will react differently in terms of travel behaviour). In general, a **minimum** of three purposes is required: home-based work, employers' business, and other.

B.2.10 Increased segmentation comes at the cost of increased computational burden as well as increased requirements of data collection for calibrating the model and requirements of the evidence base to back up the responses and sensitivity of the model.

Model Calibration and Realism Testing

B.2.11 It is **essential** that the demand model be subjected to **realism tests** to ensure that its response to changes in travel times and costs is plausible. If the responses differ from the accepted norms the advice explains how the model should be adjusted until an acceptable performance is achieved. The sensitivity of the result to the more uncertain parameter values should also be tested. TAG Unit M2 provides details of such tests.

B.2.12 The **degree of convergence** between demand and supply is very important, and needs to be stringently monitored to ensure that any uncertainty in the final result is acceptably small. TAG Unit M2 sets out appropriate convergence standards.

Appendix C Contents of Required Modelling Reports

C.1.1 The following report descriptions act as a check-list of reporting requirements, in this case for local major schemes. Precise requirements may vary by type of scheme and its scope as well as the sponsoring organisation. The guiding principle is that the reporting adequately represents the case that the modelling tools are fit for the purpose to which they are being applied and any sources of uncertainty are tested, ameliorated or explained.

C.1.2 A **data and traffic surveys report** should include the following:

- Details of the sources, locations (illustrated on a map), methods of collection, dates, days of week, durations, sample factors, estimation of accuracy, etc.
- Details of any specialist surveys (e.g. stated preference).
- Traffic and passenger flows; including daily, hourly and seasonal profiles, including details by vehicle class where appropriate.
- Journey times by mode, including variability if appropriate.
- Details of the pattern and scale of traffic delays and queues.
- Desire line diagrams for important parts of the network.
- Diagrams of existing traffic flows, both in the immediate corridor and other relevant corridors.

C.1.3 An **assignment model validation report** should include the following:

- Description of the road traffic and public transport passenger assignment model development, including model network and zone plans, details of treatment of congestion on the road system and crowding on the public transport system.
- Description of the data used in model building and validation with a clear distinction made for any independent validation data.
- Evidence of the validity of the networks employed, including range checks, link length checks, and route choice evidence.
- Details of the segmentation used, including the rationale for that chosen.
- Validation of the trip matrices, including estimation of measurement and sample errors.
- Details of any 'matrix estimation' techniques used and evidence of the effect of the estimation process on the scale and pattern of the base travel matrices.
- Validation of the trip assignment, including comparisons of flows (on links and across screen-lines/cordons) and, for road traffic models, turning movements at key junctions.
- Journey time validation, including, for road traffic models, checks on queue pattern and magnitudes of delays/queues.
- Detail of the assignment convergence.
- Present year validation if the model is more than 5 years old.
- A diagram of modelled traffic flows, both in the immediate corridor and other relevant corridors.

C.1.4 A **demand model** report should include the following:

- Where no demand model has been developed, evidence should be provided to support this decision following guidance in TAG Unit M2.
- Description of the demand model.
- Description of the data used in the model building and validation.
- Details of the segmentation used, including the rationale for that chosen. This should include justification for any segments remaining fixed.
- Evidence of model calibration and validation and details of any sensitivity tests.
- Details of any imported model components and rationale for their use.
- Validation of the assignment model sensitivity in cases where the detailed assignment models do not iterate directly with the demand model.
- Details of the realism testing, including outturn elasticities of demand with respect to fuel cost and public transport fares.
- Details of the demand/supply convergence.

C.1.5 The forecasting **report** should include the following:

- Description of the future year transport supply assumptions (i.e. networks examined for the without-scheme scenario, core scenario and variant scenarios).
- Description of the travel cost assumptions (e.g. fuel costs, PT fares, parking).
- Presentation of the forecast travel demand and conditions for the core scenario and variant scenarios including a diagram of forecast flows for the without-scheme scenario and the scheme options for affected corridors.
- If the model includes very slow speeds or high junction delays evidence of their plausibility.
- An explanation of any forecasts of flows above capacity, especially for the without-scheme scenario, and an explanation of how these are accounted for in the modelling/appraisal.
- Presentation of the sensitivity tests carried out (to include optimistic and pessimistic tests).
- Description of the methods used in forecasting future traffic demand.
- Description of the future year demand assumptions (e.g. land use and economic growth - for the without-scheme scenario, core and variant scenarios).
- Comparison of the local forecast results to national forecasts, at an overall and sector level.

Appendix D Contents of Appraisal handover pack for benefits management, monitoring and evaluation

D.1.1 To enable benefits management and evaluation to build on appraisal assumptions, it is recommended that a 'handover pack' be developed at the time of the appraisal[6]. This should include key information which will enable forecasts, and the basis on which they were developed, to be understood when comparing them against actuals. It should be stored alongside the benefits management or monitoring and evaluation plan.

D.1.2 Examples of the types of information to include in a handover pack are set out below:

- Scheme background information and planned opening date
- Stage of appraisal (outline or full business case)
- Name of appraisal lead
- Appraisal period (e.g. 2015 to 2075)
- Geographical area covered by the model
- TAG version used
- Scenarios and sensitivities for which model outputs produced
- Names, types and versions of models used
- Software and formats of outputs (excel, csv etc.)
- File of transport capacity coded into the model
- List of metrics that have been forecast in the appraisal (e.g. passenger number by mode, traffic volumes etc.)
- Output files for forecasts e.g. after year 1, 5 and whole appraisal period
- Input files for all assumptions and parameters (including values of time, population, land use planning, fuel costs etc.)
- Links to external sources used (e.g. population data)
- Costs output files (split by capital and operating costs
- Forecast report

DI.1.3 It is recognised that most schemes will have outturns which differ from those that were forecast to some extent. By storing the sorts of information listed above, analysts can make it easier to interpret the causes of any discrepancies, to improve the learning for future appraisals. For example, a cause of discrepancy may be that economic growth turns out to be lower than projected in the central case. If forecasts for a low growth scenario are stored in the pack, these can help the evaluator to check to what extent the variation in outturn can be explained by the incorrect growth assumptions.

6 This and other recommendations in this section are discussed in the report 'Strengthening the links between appraisal and evaluation', DfT (2016): https://www.gov.uk/government/publications/strengthening-the-links-between-appraisal-and-evaluation